WORKSHOP / MANUFACTURING PRACTICES

WITH LAB MANUAL

Veeranna D. Kenchakkanavar

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ISBN: 978-93-91505-33-2
Book Code: UG006EN

Workshop/Manufacturing Practices
by Veeranna D. Kenchakkanavar
[English Edition]

First Edition: 2021

Published by:

Khanna Book Publishing Co. (P) Ltd.
Visit us at: **www.khannabooks.com**
Write us at: **contact@khannabooks.com**
CIN: U22110DL1998PTC095547

To view complete list of books, Please scan the QR Code: KPH

Printed in India.

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FOREWORD

Engineering has played a very significant role in the progress and expansion of mankind and society for centuries. Engineering ideas that originated in the Indian subcontinent have had a thoughtful impact on the world.

All India Council for Technical Education (AICTE) had always been at the forefront of assisting Technical students in every possible manner since its inception in 1987. The goal of AICTE has been to promote quality Technical Education and thereby take the industry to a greater heights and ultimately turn our dear motherland India into a Modern Developed Nation. It will not be inept to mention here that Engineers are the backbone of the modern society - better the engineers, better the industry, and better the industry, better the country.

NEP 2020 envisages education in regional languages to all, thereby ensuring that each and every student becomes capable and competent enough and is in a position to contribute towards the national growth and development.

One of the spheres where AICTE had been relentlessly working from last few years was to provide high-quality moderately priced books of International standard prepared in various regional languages to all it's Engineering students. These books are not only prepared keeping in mind it's easy language, real life examples, rich contents and but also the industry needs in this everyday changing world. These books are as per AICTE Model Curriculum of Engineering & Technology – 2018.

Eminent Professors from all over India with great knowledge and experience have written these books for the benefit of academic fraternity. AICTE is confident that these books with their rich contents will help technical students master the subjects with greater ease and quality.

AICTE appreciates the hard work of the original authors, coordinators and the translators for their endeavour in making these Engineering subjects more lucid.

(**Anil D. Sahasrabudhe**)

Acknowledgement

The author(s) are grateful to AICTE for their meticulous planning and execution to publish the technical book for Engineering and Technology students.

We sincerely acknowledge the valuable contributions of the reviewer of the book Prof. Manish Chaturvedi, for making it students' friendly and giving a better shape in an artistic manner.

This book is an outcome of various suggestions of AICTE members, experts and authors who shared their opinion and thoughts to further develop the engineering education in our country.

It is also with great honour that we state that this book is aligned to the AICTE Model Curriculum and in line with the guidelines of National Education Policy (NEP) -2020. Towards promoting education in regional languages, this book is being translated in scheduled Indian regional languages.

Acknowledgements are due to the contributors and different workers in this field whose published books, review articles, papers, photographs, footnotes, references and other valuable information enriched us at the time of writing the book.

Finally, we like to express our sincere thanks to the publishing house, M/s. Khanna Book Publishing Company Private Limited, New Delhi, whose entire team was always ready to cooperate on all the aspects of publishing to make it a wonderful experience.

Veeranna D Kenchakkanavar

Preface

The text book on "Workshop / Manufacturing Practices" is designed to cater the needs of young minds of 21st century. The Workshop is the place where the core of learning about different materials, equipment, tools and techniques. Basically the workshop is used to prepare the small components by hand/power tools. Sometimes they may be parts of the large machines or may be parts for replacement / repairs. The advancement in technology leads all technocrats and professionals to use the advanced tools and technology in manufacturing but without knowing the basics it becomes nothing. So in this text book an attempt has been made to connect the basic principles of workshop technology to advanced machine tools.

The theoretical and practical blend is achieved in all the topics of the content with relevant examples. The AICTE model curriculum is fallowed in designing the content of this text book. The New National Education Policy will become path breaker in the technical education; it demands to incorporate student centric and self learning activities in the curriculum. Such initiatives are very much incorporated here to make this book more meaningful and relevant to current scenario.

The text book will take you in five modules of theory in Part-A and laboratory experiments in Part-B separately. The **Unit-1** deals with the manufacturing methods like casting, forming, machining, joining and advanced machining processes. Many of the products what we use in day today basis may not be knowing their manufacturing processes. For example the alloy wheel of automobile, temple bell is made from casting! Such interesting examples are quoted to raise the curiosity of the readers. **Unit-2** deals with advanced manufacturing machineries like CNC machining and additive manufacturing. The 3D printing and rapid prototyping are discussed in length. The Fitting operations and Power tools is the one more topic in this module gives insights about hand tools to power tool usage in the workshop. **Unit-3** discusses about the electrical and electronic engineering, where the basics to applications were discussed. The electricity and its connectivity is explained with relevant applications. **Unit-4** will focus on carpentry, plastic moulding and glass cutting operations. The various industrial applications were discussed. **Unit -5** is meant for casting design, welding and brazing operations. The casting types and applications were discussed in detail. The welding and brazing applications and identification of the need is discussed elaboratively.

The text book is made according to the new generation readers; the relevant of each topic is discussed in sub title rationale of each topic. The interesting facts in each topic will tell you about unheard facts about that topic. The brief summary at the end of each module may give the instant glance of the content of that module. The video resources are added keeping in view of digital natives, who are well verse with the digital usage of the topics. The exercise is prepared with increasing order of Blooms taxonomy and in line with the AICTE exam reform document.

Although every care has been taken to avoid misprints and mistakes, yet it is difficult to claim perfection. I will be grateful to the readers if any errors are pointed out. Suggestions for further improvement of the book will be thankfully acknowledged.

Veeranna D. Kenchakkanavar

Outcome Based Education

For the implementation of an outcome based education the first requirement is to develop an outcome based curriculum and incorporate an outcome based assessment in the education system. By going through outcome based assessments evaluators will be able to evaluate whether the students have achieved the outlined standard, specific and measurable outcomes. With the proper incorporation of outcome based education there will be a definite commitment to achieve a minimum standard for all learners without giving up at any level. At the end of the programme running with the aid of outcome based education, a students will be able to arrive at the following outcomes:

PO-1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO-2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO-3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO-4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO-5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO-6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO-7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO-8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO-9 **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO-10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO-11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO-12 **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes

After completion of the course the students will be able to:

CO-1: Differentiate among the Manufacturing Methods like casting, forming, machining, joining and advanced manufacturing methods.

CO-2: Practice the CNC machining, classify different Additive manufacturing processes and perform various fitting operations using hand/power tools.

CO-3: Make electric circuits and comment on basic Electrical & Electronics components.

CO-4: Demonstrate the usage of Carpentry, Plastic moulding and glass cutting operations and related tools.

CO-5: Practice of Metal casting operations and various Welding (arc welding & gas welding), brazing operations.

Mapping of Course Outcomes with Programme Outcomes to be done according to the matrix given below:

Course Outcome	Expected Mapping with Programme Outcomes (1- Weak Correlation; 2- Medium correlation; 3- Strong Correlation)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1												
CO-2												
CO-3												
CO-4												
CO-5												

Abbreviations and Symbols

Symbol	Details
A	Semi taper angle
D	Diameter of work piece
I	Current
K	Conicity
L	Length of taper
N	Spindle speed
P	Power
R	Resistance
V	Cutting Speed
V	Volt
d1	Original diameter of the work piece
d2	Final diameter of the work piece
t	Depth of cut
α	Semi taper angle
ρ	Specific resistance

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Guidelines for Teachers

To implement Outcome Based Education (OBE) knowledge level and skill set of the students should be enhanced. Teachers should take a major responsibility for the proper implementation of OBE. Some of the responsibilities (not limited to) for the teachers in OBE system may be as follows:

- Within reasonable constraint, they should manipulate time to the best advantage of all students.
- They should assess the students only upon certain defined criterion without considering any other potential ineligibility to discriminate them.
- They should try to grow the learning abilities of the students to a certain level before they leave the institute.
- They should try to ensure that all the students are equipped with the quality knowledge as well as competence after they finish their education.
- They should always encourage the students to develop their ultimate performance capabilities.
- They should facilitate and encourage group work and team work to consolidate newer approach.
- They should follow Blooms taxonomy in every part of the assessment.

Bloom's Taxonomy

Level	Teacher should Check	Student should be able to	Possible Mode of Assessment
Creating	Students ability to create	Design or Create	Mini project
Evaluating	Students ability to Justify	Argue or Defend	Assignment
Analysing	Students ability to distinguish	Differentiate or Distinguish	Project/Lab Methodology
Applying	Students ability to use information	Operate or Demonstrate	Technical Presentation/ Demonstration
Understanding	Students ability to explain the ideas	Explain or Classify	Presentation/Seminar
Remembering	Students ability to recall (or remember)	Define or Recall	Quiz

Guidelines for Students

Students should take equal responsibility for implementing the OBE. Some of the responsibilities (not limited to) for the students in OBE system are as follows:

- Students should be well aware of each UO before the start of a unit in each and every course.
- Students should be well aware of each CO before the start of the course.
- Students should be well aware of each PO before the start of the programme.
- Students should think critically and reasonably with proper reflection and action.
- Learning of the students should be connected and integrated with practical and real life consequences.
- Students should be well aware of their competency at every level of OBE.

Contents

Part-A

MANUFACTURING PRACTICES

1 Manufacturing Methods

UNIT SPECIFICS

This unit elaborately discusses the following topics:

- Casting
- Forming
- Machining
- Joining Process
- Advanced Manufacturing

The practical applications of the topics are discussed for generating further curiosity and creativity as well as improving problem solving capacity. The demonstration of the models can be easily carried out based on the theory covered in each topic.

RATIONALE

Dear Friends!

We are all living in a technologically advanced world wherein we have seen one or the other manufactured goods/services in the **journey womb to tomb!**

If you recollect the activities of one single day from morning to night then you will realize how many products/services you will come across. Tooth brush, bathroom taps, buckets, mugs, soap box, clothes, kitchenware, home appliances, Television, mobile phones, furniture, sports equipment, car, bike, books so on and so forth the list is endless, are all manufactured by one or the other method used in the industry. Now it becomes interesting to know what manufacturing activity is, in simple engineering terms it is a value adding activity in an industry where the conversion of raw material into finished/semi-finished product is made with certain machineries. There are so many activities which will govern the manufacturing process. Now a day the focus is "zero defect and zero effect" is practiced in most of the industries.

PRE-REQUISITES

- Drawing
- General safety measures
- Hand tools
- Information about materials-Steel, Wood, Plastic and Glass

UNIT OUTCOMES

The students will be able to:

U1-O1: Identify the different casting parts

U1-O2: Understand forming processes.

U1-O3: Demonstrate the machining operations in workshop

U1-O4: Practice the different joining processes in workshop

U1-O5: Compare some of the advanced manufacturing methods.

Mapping of the Unit Outcomes with the Course Outcomes.

Unit-1 Outcomes	Expected Mapping with Course Outcomes *(1 – Weak Correlation; 2 – Medium Correlation; 3 – Strong Correlation)*				
	CO-1	CO-2	CO-3	CO-4	CO-5
U1-O1	1				
U1-O2	1				
U1-O3	2				
U1-O4	2				
U1-O5	1				

INTRODUCTION

Manufacturing is a universal activity, depending upon the availability of raw material, human resource, climatic conditions; consumer market etc decides the existence of manufacturing plants. Manufacturing is a global activity, the objective of an industry engaged in manufacturing is to add value in the most efficient manner, with the least amount of waste in terms of time, material, money, space, resources even the labour. To accomplish the waste minimization and productivity enhancement, the processes and operations need to be properly selected and arranged for smooth and controlled flow of resources in the industry. To meet these goals requires an engineer who can understand, design and operate an efficient manufacturing system. So, there are three types of the features which need to be there in any product which is being made for use by the human being. So, for sizing and shaping one set of the processes are used, for imparting the desired properties another set of the manufacturing processes are used, and similarly for surface finishing and achieving the desired close tolerance the different set of the manufacturing processes are used.

1.1 CASTING

Temple bell

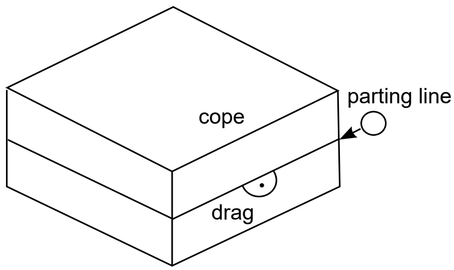
Alloy wheels

Railway wheels

The images in the above lines are some of the examples of the casted products usually we see in a day today life. Then what is casting? we all know liquid takes the shape of the bowl to which it's poured. Similar principle is adopted in casting process "**the molten liquid takes the shape of the container**". So in the casting process, a material is first melted or heated to proper temperature, and sometimes treated to modify its chemical composition also. The molten material is then poured into a cavity known as mould that has the predetermined desired shape. Once the cavity is filled and allowed to solidify for certain duration the casting will be generated in an unfinished form. Many of the structural features that ultimately control product properties are set during solidification. The parts which are complicated and contains more intricate structures then casting process is economical to use.

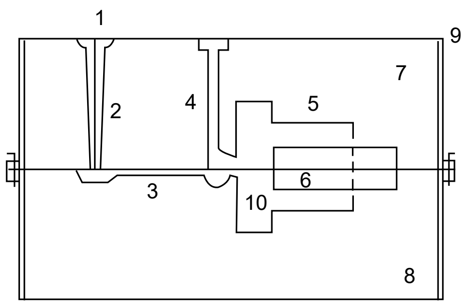
1.1.1 Casting Terminology

Various terms used in a casting are described with the following figure



Metal Casting

Fig. 1.1: Cope and Drag



1 - Pouring basin
2 - Sprue
2 - Runner
4 - Riser
5 - Draft
6 - Core
7 - Cope
8 - Drag
9 - Flask
10 -Mould Cavity

Fig. 1.2: Casting Terminology

- **Pattern:** It is an approximate replica of the final casting to be produced.
- **Flask:** The rigid metal / wood frame that holds the moulding aggregates.
- **Cope:** In a horizontally parted two-part mould, the upper half of the pattern.
- **Drag:** In a horizontally parted two-part mould, the bottom half of the pattern.
- **Core:** A core is a sand/Metal shape that is inserted into a mould to produce the internal features in casting, such as holes or passages.
- **Riser:** A riser is an additional pipe in the mould where in the molten metal rises once the cavity is filled. It acts as a reservoir for additional molten liquid that can flow into the mould cavity to compensate any shrinkage that occurs during solidification.
- **Gating System:** The network of inter connected channels used to deliver the molten metal to the mould cavity is known as the gating system.

- **Pouring cup:** The pouring cup / basin is the portion of the gating system that receives the molten metal from the pouring vessel and controls its delivery to the rest of the mould. The metal travels through a sprue then horizontal channels called runners, and finally through gates into the mould cavity.
- **Moulding sand:** Moulding sand is the refractory material used for making the mould. It is a mixture of silica, clay and moisture to get required properties.
- **Baking sand:** Baking sand consists of refractory material, and it is made of used sand or burnt sand.
- **Facing sand:** Facing sand is the carbonaceous material sprinkled on the inner surfaces of the moulding cavity for obtaining better surface finish.
- **Loam Sand:** Green or dry sand with at least 50% clay and dries hard is called loam sand. It also contains fire clay. It has 18 to 20% moisture and produces a good surface finish.
- **Parting sand:** For separating the moulds from adhering to each other by separating fine sharp dry sand called parting sand. It can be used to keep green sand away from sticking to the pattern. It is the clean clay free silica sand.

1.1.2 Advantages and Limitations of Casting Process

Advantages

- Complex shape can be easily produced.
- Practically any material can be casted.
- The properties of casting are same in all directions due to uniform cooling
- Any size of casting can be produced up to 200 tons.
- Casting is the often cheapest and most direct way of producing a shape with certain desired mechanical properties.
- Certain metals and alloys for special applications such as metal-based alloys for gas turbines cannot be worked mechanically and can be cast only.
- Casting is best suited for composite components requiring different properties in various directions.
- These are made by incorporating preferable inserts in a casting. For example, aluminium conductors into slots in iron armature for electric motors, wear resistant skins onto shock resistant components.

Limitations

- With normal sand casting process, the dimensional accuracies and surface finish is poor.
- Certain defects are unavoidable even after the due care in designing.
- Sand casting is labour intensive activity.

INTERESTING FACTS

The casting process dates back more than 5000 years. The oldest surviving casting is a copper frog from 3200 BC.

The sand casting process was first documented by Vannoccio Biringuccio ('the father of the foundry industry') in a book written around 1540.

Sand casting really took off in the early 20th Century with the rapid expansion of the automotive and machine building industries. In 1924, the Ford Motor Company produced one million cars and accounted for one third of the total sand casting production in the US.

Nowadays, more than 70% of all metal castings are produced via sand casting.

The most common casting metals are aluminium, iron, tin, steel, bronze and copper.

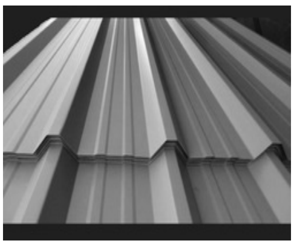
VIDEO RESOURCES

Metal Casting

Contineous Casting

Sand Casting

1.2 FORMING



Roofing Sheets

Bar Bending work

Smithy work

The above pictures are very common images of any body's life activity from rural to urban area. You might have come across or sometimes you might have used them knowingly or unknowingly in your life. The roof sheets are very common material in buildings, The bar bending work is a common activity to start the building construction, the smithy activity is common in rural area for making agricultural implements, lot of processes are involved in compound wall gate making.

1.2.1 Introduction

One of the most common manufacturing processes used in industry and others in day today life activity. The forming is an activity to change the size and shape of the finished/semi fished product with the help of force, pressure and heat. The various methods involved in forming is shown below

- Formiming Process
  - Hot Forming
    - Forging
    - Rolling
    - Extrusion
  - Cold Forming
    - Wire drawing
    - Swaging
    - Roll forming
    - Deep Drawing

All the materials have a special character known as Plasticity (Plasticity enables a solid under the action of external forces to undergo permanent deformation without rupture.) The forming process exploits this remarkable plasticity property of some engineering materials. Where the solids have the ability to flow as solids without deterioration of their properties. Because all processing is done in the solid state, there is no need to handle molten material or deal with the complexities of solidification in earlier casting process. Here the material is simply rearranged to acquire the shape, as opposed to the cutting away of unwanted regions; the amount of waste can be substantially reduced.

The forming process may be classified based on the type of load applied and the amount of heat provided to the input materials. One more classification is according to product formed and rate of forming etc.

1.2.2 Forming Process Classification

The classification is based on the type of tools used and the way the material is stressed for deformation.

Compression forming process

- Forging
- Rolling
- Extrusion
- Tension forming
- Stretch forming
- Pressure by hydraulic forming
- Combined Tension and Compression forming
- Wire drawing
- Tube drawing
- Deep drawing
- Bend forming
- Pipe bending
- Circular bending
- Shear forming
- Embossing
- Die shear forming

Let's study the major forming process in following paragraphs.

1.2.3 Forging

Forging is a manufacturing process where metal is pressed, pounded or squeezed under great pressure to produce high-strength parts. Most of the time compressive force is applied to perform the forging operation. The equipment may be in the form of hammers, presses, or special forging machines. This operation can be performed in all range of temperature from hot, cold, warm, and isothermal condition. Most commonly the forging is done with work pieces above their recrystallization temperature.

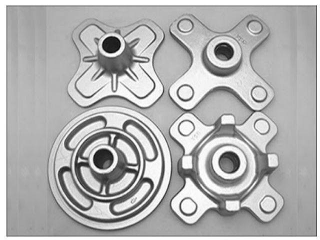
Forging is one of the oldest known metalworking processes. Traditionally, forging was performed by a smith using hammer and anvil (smithy is a forging operation with small hand-held tools to prepare the small jobs), though introducing water power to the production and working of iron in the 12th century allowed the use of large trip hammers or power hammers that increased the amount and size of iron that could be produced and forged. The smithy or forge has evolved over centuries to become a facility with engineered processes, production equipment, tooling, raw materials and products to meet the demands of modern industry.

In modern times, industrial forging is done either with presses or with hammers powered by compressed air, electricity, hydraulics or steam. These hammers may have reciprocating weights in the thousands of kilograms. Smaller power hammers, ranges 230 kg or less reciprocating weight, and hydraulic presses are common in art smithies as well.

The art of the forging techniques dates to at least 4000 BC and earlier. The hot forging of metals all began in the land of Mesopotamia. However, the very first recorded metal, forged by fire and employed by humans was Gold. To shape the metal, rock was used as a forging hammer. Later the metals are used for making the weapons. After the industrial revolution the hydraulic and pneumatic powers are used to forge the metals. The application of forging varies from simple components weighing from grams to metric tons. Following examples may give you an idea of application of the forging products with different methods.

Connecting rod

Coin



motor casing

The forging operation may be performed either drawn out-where the length is increased and the cross section is reduced, up-setting- where the reverse of drawn out the cross section is increased and length is reduced, squeezed in closed impression dies to produce multidirectional flow for desired patterns

1.2.4 Forging Process classification

The following are the most commonly used forging processes practiced in the industries.

- Drop-hammer forging.
- Impression-die drop-hammer forging.
- Press forging.
- Orbital forging.
- Upset forging.
- Automatic hot forging.
- Roll forging.
- Swaging.
- Net-shape forging.

The most commonly used forging method in an industry is the upsetting forging which is explained as below.

Upset forging involves increasing the diameter of a material by compressing its length. Because of its use with a multitude of fasteners, it is the most widely used of all forging processes when evaluated in terms of the number of pieces produced. The forging can be performed both in hot and cold condition. The forging motion may be horizontal or vertical based on the requirement. The operation is explained in the following figure 1.3,

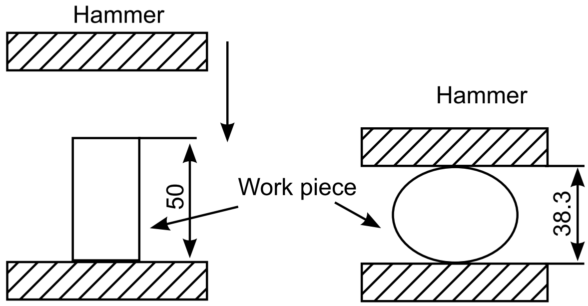


Fig. 1.3: Upsetting Forging Operation

The operation may be carried out either in open dies or closed dies, the hydraulic, pneumatic or mechanical sources are used for pressing the work piece, once the work piece gets the desired shape the hammers will retrieve back quickly for next operation. Upset-forging often used to form bolt heads and other kind of fasteners and also to shape valves, couplings, and many other automotive components.

1.2.5 Advantages and Limitations of Forging Process

Advantages

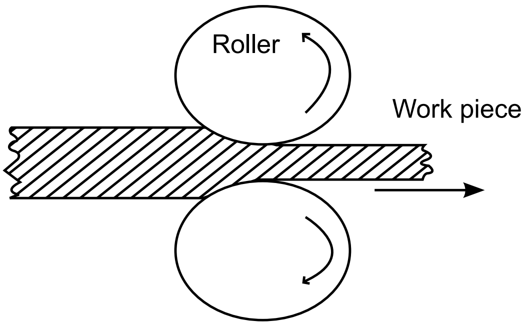
- Generally tougher than casting products
- Will handle impact better than castings
- The tight grain structure of forging makes it mechanically strong. There is less need for expensive alloys to attain high strength components.
- Offers great wear resistance
- Low cost operation.
- This process does not requires special skilled operator.
- Variety of shapes can be formed by this process.

Limitations

- High initial cost for big forging presses.
- Secondary finishing process required in hot forging.
- It cannot produce complex shapes.
- Size is limited due to size of press.
- Brittle metal cannot be forged.

1.2.6 Rolling operation

Rolling operation is used to minimize the thickness or change the cross section of a material through compressive forces exerted by rolls or by set of rolls. As shown in Figure 1.4, the work piece in the cold or hot form is passed between two rollers that rotate in opposite directions. The gap between the rollers decides the thickness of the output material. The rollers gap may be adjustable in many industries. The thickness of entering material is usually higher than the roller gap. Surface velocity of the rollers exceeds the speed of the entering material in to the roller gap, the friction along the contact interface supports to propel the material forward. The material when passed between the rollers is squeezed and elongates to compensate for the decrease in cross-sectional area. Sometimes the cluster arrangements of rollers use backup rollers to support the smaller work rolls based on the roller design arrangements.



Rolling Process

Fig. 1.4: Rolling Operation

In the hot-rolling process the material is fed above its recrystallization temperature. The input material should be heated to a uniform elevated temperature before it enters into the squeezing operation. In Cold rolling the input material is fed directly between the rollers to get the output. Mostly it is used to produce sheet, strip, bar, and rod type of products with extremely smooth surfaces finish and accurate dimensions.

The aluminium, zinc and other type of sheet are produced by this method are used for building roofing's, pipes, different sections, slots, channels can be produced by this process. The hot rolling process finds its application in automotive frames, floor, rail tracks, guard rails, doors, building materials, cold rolling finds application in engine canopy, computer cabinets, refrigerators doors and casings, automotive brackets, door latches etc.

1.2.7 Advantages and Limitations

Advantages

- Uniform dimensions can be obtained.
- Process is easy to monitor
- Close tolerance is possible for the components in the rolling.
- High-speed production takes place in the rolling.

Limitations

- The initial cost of equipment is high.
- Suitable for large scale production only.
- Poor surface finish and thereby we need to secondary operations for finishing

1.2.8 Extrusion Process

Extrusion is one more commonly used forming operation where, metal is compressed and forced to flow through a suitably designed die to form a product with reduced but constant cross section. The following products shown in the Figure-1.5are commonly found in many business activities. The aluminium rails for windows, rails, grills, cabinets etc are commonly found in day today life. The making of food items like *jilebi* and *Chakkli* are also part of extrusion process

Fig. 1.5: Extrusion Products

The easiest way to understand the **extrusion process is like squeezing toothpaste out of a tube!** The extrusion may be performed either in hot or cold condition. The advantage of hot extrusion is reducing the forces required to push the metal and reduce directional properties.

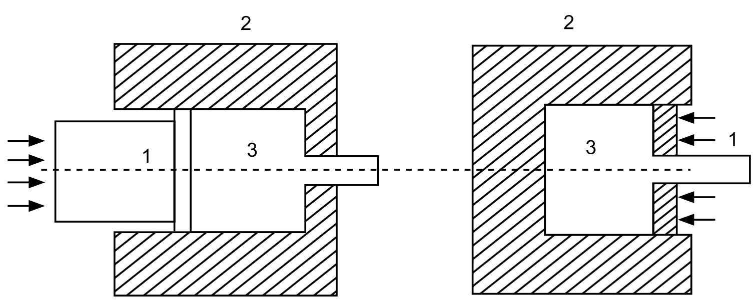
1.2.9 Methods of Extrusion Process

The various method of extrusion process is explained below

In the case of metals, a common arrangement is to have a heated billet placed inside a confining chamber. When a ram advances from one end, causing the billet to first upset and conforms to the confining chamber. As the ram continues to advance, the pressure builds until the material flows plastically through the die and extrudes to the desired shape and size.

Direct Extrusion

In this method, as shown in figure-1.6(a) a solid ram drives the entire billet to and through a stationary die, the output material has to be collected on the other side of the ram movement. At the same time the ram must be in a position to provide additional power to overcome the frictional resistance between the surface of the moving billet and the confining chamber.



(a) Direct Extrusion **(b) Indirect Extrusion**

1-Ram 2-Chamber 3-Extruded Rod

Fig. 1.6 (a & b): Direct and Indirect Extrusion

Indirect Extrusion

It is also known by reverse, backward, or inverted extrusion method, as shown in figure-1.6(b) a hollow ram pushes the die back through a stationary, confined billet. Because there is no relative motion between the surface of the moving billet and the confining chamber. So friction between the billet and the chamber is eliminated here. Hence the required force is lower, and longer billets can be used with no compromise on power and efficiency.

Hydrostatic Extrusion

In this process the high-pressure fluid surrounds the billet (work piece) and applies the force necessary to extrude it through the die.

Continuous Extrusion

Conventional extrusion is a discontinuous process, here with certain arrangements the billet is forced to give the continuous output.

1.2.10 Advantages and Disadvantages

Advantages

- Low cost per part production
- Flexibility of operation
- In hot extrusion, post execution alterations are easy because product will be in heated condition
- Continuous operation
- High production volumes
- Many types of raw materials can be used
- Good mixing
- Good surface finish
- Good mechanical properties obtained in cold extrusion

Disadvantages

- Variations in size of product
- Product limitations because of only one type of cross section can be obtained at a time
- High initial cost setup

1.2.11 Deep Drawing

We all know that the cylindrical or rectangular containers are formed with the help of sheet metal most commonly in all the industries. When the depth of the product is less than its diameter the process is considered to be shallow drawing. If the depth is greater than the diameter, it is known as deep drawing.

1.2.12 Pipe Bending

It is the process where the bending of the tubes or pipes will be done with the help of special tools. The hydraulic power or manual power is used with specially designed jigs and fixtures.

INTERESTING FACTS
The process of extrusion has been around since 1797 when Joseph Bramah patented the method.
It is also used in candle making
It was largely executed manually until the invention of the hydraulic press in 1820.
Plastic and polymers are used in extrusion for manufacturing advanced equipments.

VIDEO RESOURCES

Metal Forming

Forging

Extrusion

1.3 MACHINING PROCESS

Machining is the process of removing unwanted material from a work piece in the form of chips. If the work piece is metal, the process is often called metal cutting or metal removal. Now days most of the furniture's and wood works have been carried out with the help of wood lathes. The following images give an idea of turning operation products seen commonly in every day activity.

Wood carving products

turning operation-spark plug

Most of the machinery parts are manufactured by the machining operations! , Machining is the oldest manufacturing method still practiced in many industries even today for many operations. There are seven basic machining processes namely turning, milling, drilling, sawing, broaching, shaping and grinding. In this topic we will discuss some important operations in subsequent paragraphs.

1.3.1 Turning Operation

Turning is a machining process used to generate the cylindrical and conical surfaces by rotating the work piece between the two centres and traversing the single point cutting tool parallel to the work piece axis. The cylindrical diameter and figure 1.7 depicts the lathe machine usually found in the small industries and educational institutions.

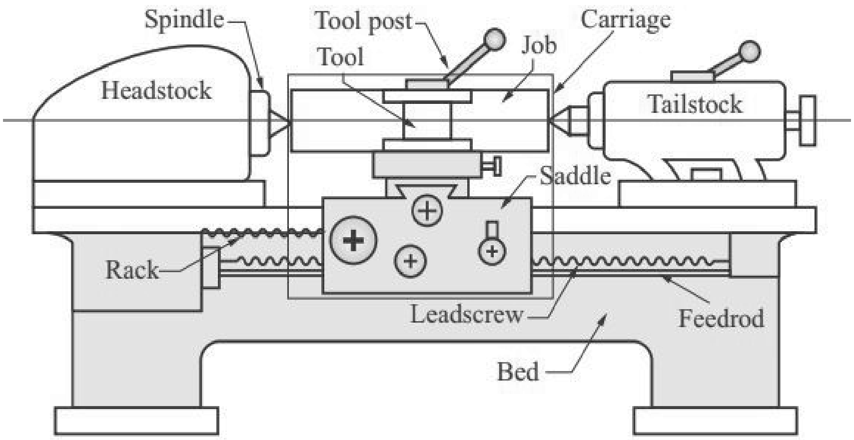
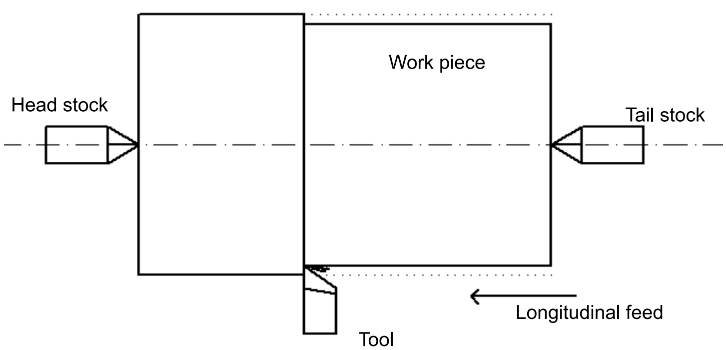


Fig. 1.7: Lathe Machine (source: rgpvonline.com)

The turning operation is usually performed on the lathe machine with the help of single point cutting tool. The cutting tool is fed against the rotating work piece. The principle of operation is shown in figure 1.8, the work piece held firmly between the two centres of the lathe machine known as head stock and tail stock. The tool is provided with the longitudinal and transverse movements while the work piece is rotated at suitable speeds. The material from the work piece is removed in the form of chips. Also, to cut the material properly, the tool material should be harder than the work piece material.



Turning Operation

Fig. 1.8: Turning Operation

Based on the movement of the tool the three different kinds of the surfaces can be obtained by turning operations

- **Cylindrical surface**- when the cutting tool moves parallel to the axis of the work piece then cylindrical surface can be obtained. This operation is termed as cylindrical or plain turning.
- **Taper surface**- when the cutting tool is moved at an angle to the axis of the work piece rotation then the tapered surface is obtained. The operation is called taper turning operation.

- **Flat surface**- when the cutting tool is moved perpendicular to the axis of the work piece the flat surface is obtained at the one end. This is to be done by fixing the work piece in only head stock. This operation is termed as facing operation.

1.3.2 Classification of Lathes

Lathes are designed in wide variety of types and sizes to suit different applications, it is difficult to classify them in to definite category, however based on the construction methods and functions, Lathes can be classified as follows.

- Engine/Centre lathe
- Speed lathe
- Bench Lathe
- Tool room lathe
- Production lathe
- Special purpose lathe
- Automatic lathe

1.3.3 Terminology of Turning Operations

- **Headstock:** It houses the power source, all the power transmission, gear box and the spindle. It is fixed at the left-hand side of the bed.
- **Tailstock:** It is situated towards the right-hand side of the bed and houses the tailstock spindle for the purpose of locating the long components by the use of centres.
- **Carriage:** It provides the necessary longitudinal motion to the cutting tool, to generate the surfaces.
- **Bed:** It provides a support for all the elements present in a machine tool. Beds are generally constructed using cast iron or alloy cast iron which consists of alloying elements such as nickel, chromium and molybdenum.
- **Columns:** The columns are those in which the bed is fixed.
- **Work-holding devices:** They are normally used for suitable location, effective clamping and support when required. ex. chuck, mandrel etc.
- **Lead screw:** The lead screw is used for thread cutting. It could be used for feeding the cutting tool in a direction parallel to the axis of rotation, many a times a separate feed rod is provided for this function.
- **Cutting speed:** it is a peripheral speed of work piece per unit time

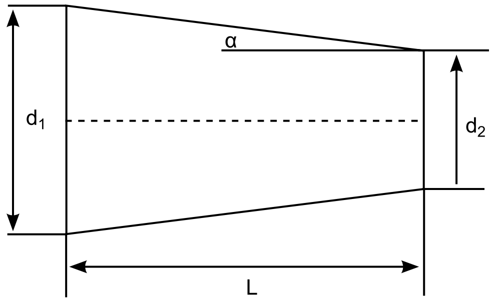
  $$V = \frac{\pi DN}{1000} \text{ mtr/min}$$

  Where D diameter of work piece, N speed of work piece in rpm
- **Feed:** It is the distance travelled by the tool during each revolution of the work piece measured in terms of mm/revolutions.
- **Depth of Cut:** It is the perpendicular distance measured from machined surface to the original surface

  $$t = \frac{(d_1 - d_2)}{2} \text{ mm}$$

Where d_1 –original diameter of the work piece, d_2 –final diameter of the work piece in millimeter

- **Conicity:** It is a term used in taper turning operation; it is the ratio of difference in diameter of taper to its length



Where d_1-larger diameter, d_2-smaller diameter, L- length of taper, α-semi taper angle
Conicity K

$$K = \frac{(d_1 - d_2)}{L}$$

Semi taper angle

$$\tan \alpha = \frac{(d_1 - d_2)}{2L} \text{ in degree}$$

The taper turning can be achieved by compound slide swivelling method or tail stock off set method

- **Knurling operation:** creating roughened surface like diamond and similar type of pattern over the surface of the cylinder by embossing on it with the help of a tool called knurling tool
- **Thread cutting operation:** creation of V-threads or square threads of desired pitch over the cylindrical surface.

INTERESTING FACTS

The modern lathe has origins dating back to Ancient Greece in the 13^{th} or 14^{th} century B.C. of course, this was a very rudimentary lathe, consisting of nothing more than a workbench with a rotating rod. Nonetheless, it paved the way for newer, more modern lathes, most of which still use this same basic design.

Throughout the Industrial Revolution, lathes were colloquially known as the “mother of machine tools” because they led to the creation of other machine tools. If it weren’t for lathes, perhaps other machine tools wouldn’t have been invented.

The lathe became an invaluable tool among manufacturing companies during the Industrial Revolution, however, giving these companies ideas to create other tools, hence why they were called the “mother of machine tools.”

VIDEO RESOURCES

Deformation of Metals

Metal Cutting

Tools Layout

1.3.4 Drilling Operation

Drilling is an operation used to create holes in a solid material using a drill also known as rotating cutter tool. There are various types of drilling machines available in the industry. In figure 1.9 bench drilling machine is shown.

To perform the drilling operation, the hole position is to be located on the work piece, which is mounted on the work table using suitable fixture. Suitable drill bit and coolant are selected. The drill is fitted in to the spindle. The tool head is brought over the work piece by swinging and moving the arm in the necessary position. The necessary feed and speed are set on the drill head drive mechanism. The machine is started and drilling may then perform on the work piece.

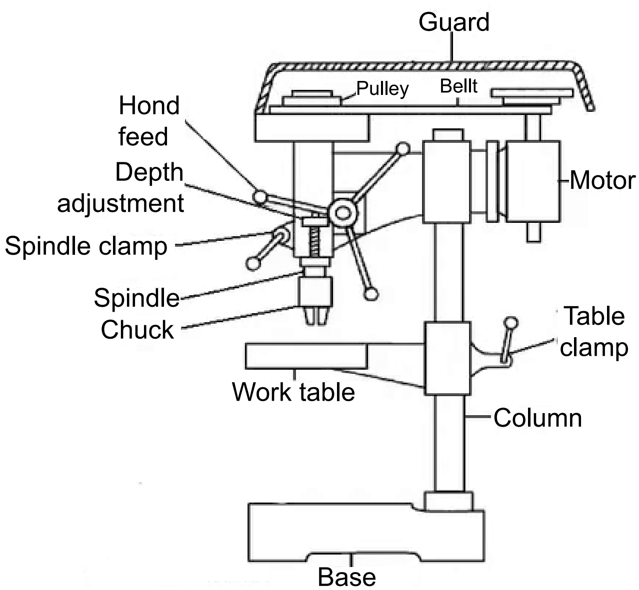


Fig. 1.9: Drilling Machine (Source: learnmechanical.com)

1.3.5 Milling Operation

It is a process by which the metal is removed from the work piece by using the tool called milling cutter. Most of the gear teeth and slots are made with this machine. The Figure 1.10 shows the one of the milling machine. Here the work piece is mounted on the machine table; the table can slide both horizontally and vertically. The milling cutter is mounted on the spindle. The spindle is powered by the motor through which the cutter rotates about the axis of the spindle. Based on the design the work piece is moved against the cutter, the multiple passes give the desired depth of cut. The coolant is supplied intermittently to cool the work piece and makes the operation effective.

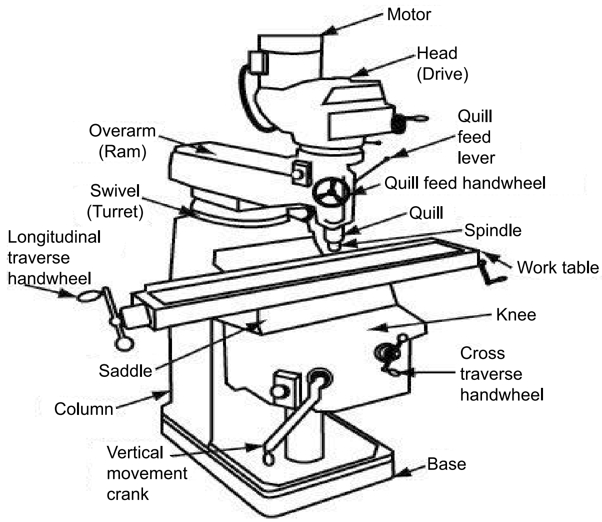


Fig. 1.10: Milling Machine (Source: in.pinterest.com)

INTERESTING FACTS

During the mid-1700 French inventor Jacques de Vaucanson filed a patent for a rotary file that mimicked the operation of modern-day milling machines. Just a few decades later, Samuel Rehe invented a functional milling machine. Since then, milling machines have emerged as one of the most commonly used types of machines in the manufacturing industry.

Although there are many types of milling machines, most of them can be classified as either horizontal or vertical depending on the alignment of their respective cutting tool. Vertical milling machines are characterized by a vertical alignment, whereas horizontal milling machines are characterized by a horizontal alignment. In a vertical milling machine, the cutting tool is mounted vertically. In a horizontal milling machine, the cutting tool is mounted horizontally.

VIDEO RESOURCES

Metal Cutting

Tools Construction

Mechanics of Machining

1.4 JOINING PROCESS

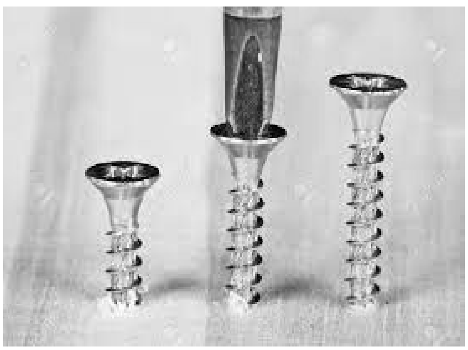
It is process where one or more components are assembled for a reason either permanently or temporarily. The following are the types of joints used in the industry. The joining process is important because most of the time the smaller pieces of product manufacturing become easy and economical. The joining/ assembling the smaller parts to make complex larger parts as well as joining different material parts requires the joining process. So, the assembly is an important integral part of the manufacturing process, by which a wide variety of consolidation processes have been developed to meet the various needs. Following are the basic joining processes practiced in industries.

I. **Temporary Joints:** these are the joints which are opened occasionally for repair or replacement Ex: nut & bolt joints, screwed joints, threaded joints, joints with latch and springs

II. **Permanent Joints:** These are never opened in life time of the product. Ex: riveted joints, welded joints, brazed joints, adhesive joints

1.4.1 Temporary Joints

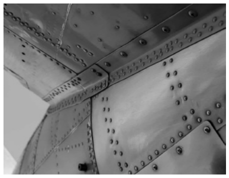
Most commonly these are called as mechanical joints. These are made with wide variety of techniques and fasteners designed to suit the individual or assembly requirements. These fasteners may be integral fasteners, threaded discrete fasteners which includes screws, bolts, studs, and inserts, non threaded discrete fasteners such as rivets, pins, retaining rings, nails, staples, and wire stitches. The following images shows some examples for temporary joints



Selection of the specific fastener or fastening method depends primarily on the materials to be joined, the function of the joint, strength and reliability requirements, weight limitations, dimensions of the components, and environmental conditions. Along with cost, accessibility, aesthetics etc. For easy assembly and disassembly threaded fasteners, snap fits, or other fasteners that can be removed quickly and easily should be specified. A mechanical joint acquires its strength through either mechanical interlocking or interference as a result of a clamping force. The various applications include the automobile, manufacturing, aerospace, marine and most of the equipment's have this kind of the joints at least in one of their parts.

1.4.2 Permanent Joints

These joints are permanent in nature and require the heating and cleaning of the surfaces. This category involves riveting, soldering, brazing, welding and adhesive bonding. Most commonly, welding is used to achieve permanent joints but, in some cases, where welding is not be the best choice and objectionable and when the materials possess poor weldability, welding is too expensive, or the joint involves thin or dissimilar materials. In such cases, low-temperature joining methods may be preferred. These include brazing, soldering, adhesive bonding. The following images describes the permanent joining process products. Let us discuss these in following paragraphs



Riveted joints in aerospace application

Welded joint

Soldering

It is a joining process having two or more pieces under heat with the help of solder and flux. The temperature range is usually below 450° centigrade. The flux is used to prevent the oxidation of metal at the soldering point. The commonly used flux materials are zinc chloride, ammonium chloride, hydrochloric acid, Borax etc the soldering operation is shown in figure 1.11 below.

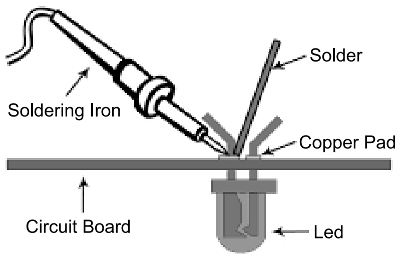


Fig. 1.11: Soldering

The soldering can be performed with following steps

- Clean the surface of the metal to be soldered
- The soldering gun is to be heated sufficiently
- Tip of the gun is to be dipped in flux and rubbed on the solder to tin tip.
- The molten solder is to be deposited on the joint
- The operation is performed

The soldering is economical, simple, due to low temperature operation the thermal distortions are less. The PCB in computer, TV and other electronic goods can be soldered.

Brazing

The brazing is also similar to soldering operation only the difference is the working temperature. It works above 450° centigrade temperature. The spelter and flux is used in the process. The spelter is a hard filler material may be in the form of borax, ash etc. The joints are stronger compare to soldering. This process finds application in tank, radiators joining process.

The brazing operation is to be performed with following steps

- Clean the surfaces of the brazing parts.
- Apply the flux on the surface
- Clamp the parts to be brazed
- The job is to be heated with blow torch
- The molten spelter has been allowed to flow in to the joints
- The jobs are allowed to cool slowly

Welding

It is a joining process used to join two similar or dissimilar metals with or without heat and pressure. It is important to note that not all joining processes are compatible with every engineering material. While weldability or joinability implies a reliable measure of a material's ability to be welded or joined, they are actually quite nebulous. One process might produce excellent results when applied to a given material, whereas another may produce a dismal failure. Within a given process, the quality of results may vary greatly with variations in the process parameters, such as electrode material, shielding gas, welding speed, and cooling rate. Based on the compatibility the process and materials are selected for particular joining process.

The welding can be classified as follows

a. Oxy fuel gas welding
   - Oxyacetylene welding (OAW)
   - Pressure gas welding (PGW)

b. Arc welding (AW)
   - Shielded metal arc welding (SMAW)
   - Gas metal arc welding (GMAW)
   - Pulsed arc (GMAW-P)
   - Gas tungsten arc welding (GTAW)
   - Flux-cored arc welding (FCAW)
   - Submerged arc welding (SAW)
   - Plasma arc welding (PAW)
   - Stud welding (SW)

c. Resistance welding (RW)
   - Resistance spot welding (RSW)
   - Resistance seam welding (RSW)
   - Projection welding (RPW)

d. Solid-state welding (SSW)
   - Forge welding (FOW)
   - Cold welding (CW)
   - Friction welding (FRW)
   - Ultrasonic welding (USW)
   - Explosion welding (EXW)
   - Roll welding (ROW)

e. Special purpose welding
   - Thermit welding (TW)
   - Laser-beam welding (LBW)
   - Electroslag welding (ESW)
   - Flash welding (FW)
   - Induction welding (IW)
   - Electron-beam welding (EBW)

As per the curriculum the Arc and gas welding process will be discussed in UNIT-5 to avoid the repetition of the content here.

Adhesive joining

Adhesive bonding is a process of joining materials in which an adhesive material is placed between the two surfaces to be joined generally called adherends. The ideal adhesive bonds to any material, needs no surface preparation, cures rapidly, and maintains a high bond strength under all operating conditions. Adhesive may be in the form of cement, glue, liquids from plants or chemical paste. Though natural adhesives both of organic and inorganic origins are available, synthetic organic polymers are usually employed to join the metals.

The development of adhesive took place from early applications like plywood joining operations to the use of structural adhesives joining. Adhesives find applications everywhere the fields like automotive, aerospace, construction, packaging, furniture, appliances, electronics, bookbinding, product assembly, and even medical and dental applications. Moreover, because adhesive bonding has the ability to bond such a wide variety of materials, its use has grown significantly with the ever expanding applications of plastics and composites.

INTERESTING FACTS

The screw first appeared in machinery during the time of the Ancient Greeks. Screws were first used in olive presses and grape presses. In the Middle Ages, this mechanism was adapted for use in the printing press and the paper press. The screw mechanism allows for tremendous force to be exerted on the object being pressed with minimal effort.

There is evidence that soldering was employed as early as 5,000 years ago in Mesopotamia. Soldering and brazing are thought to have originated very early in the history of metal-working, probably before 4000 BC. Sumerian swords from 3000 BC were assembled using hard soldering.

Ernst Sachs (Germany) claims to have developed the first electric soldering iron for industry and ERSA begins commercial production of a 200 watt electric soldering iron.

During the Iron Age the Egyptians and people in the eastern Mediterranean area learned to weld pieces of iron together. Many tools were found that were made in approximately 1000 B.C. During the Middle Ages, the art of blacksmithing was developed and many items of iron were produced that were welded by hammering

In 1881, French scientist Auguste De Meritens succeeded in fusing lead plates by using the heat generated from an arc. Later, Russian scientist Nikolai N. Benardos and his compatriot Stanislaus Olszewski developed.

VIDEO RESOURCES

Joining Technologies

Brazing

Soldering

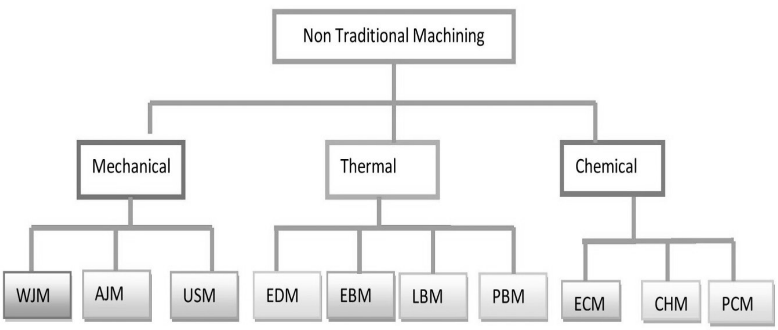
1.5 ADVANCED MANUFACTURING /NON-TRADITIONAL MACHINING

We all know that there are two kinds of the manufacturing processes one is traditional or conventional machining process which uses the lathe, drilling, milling, shaping and other machines. The second one is the Unconventional or Non-traditional manufacturing processes also known as advanced manufacturing process. It is defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tool as it needs to be used for traditional manufacturing processes.

These are employed where traditional machining processes are not feasible, satisfactory or economical due to special reasons.

Traditional machining is mostly based on removal of material using tools that are harder than the materials themselves. As the advancement in the industry activities, materials and machines, it has thrown new challenges to create newer materials and processes. New and novel materials because of their greatly improved chemical, mechanical and thermal properties are sometimes impossible to machine using traditional machining processes. The traditional machining methods are often ineffective in machining hard materials like ceramics and composites or machining under very tight tolerances as in micro machined components. The non-traditional machining has become ray of hope for newer and harder materials. The classification is made under three headings as mechanical, thermal and chemical process.

The Mechanical machining has Water Jet Machining (WJM),Abrasive Jet Machining(AJM) and Ultrasonic machining (USM). The Thermal category contains Electron Discharge machining (EDM), Electron Beam Machining (EBM), Laser Beam Machining (LBM), Plasma Beam Machining (PBM). In chemical category Electro Chemical Machining (ECM), Chemical machining (CHM)



From each category one process is explained in below sub topics

1.5.1 Abrasive Jet Machining

Abrasive water jet cutting is an extended version of water jet machining; here along with the water jet contains abrasive particles such as silicon carbide or aluminium oxide in order to increase the material removal rate compare to that of water jet machining. Wide range of materials from hardest brittle materials like glass, ceramics to extremely soft materials such as foam and rubbers can be cut by abrasive water jet cutting. The narrow cutting stream and computer controlled movement enables this process to produce parts accurately and efficiently. This machining process is especially ideal for cutting materials that cannot be cut by laser or thermal cut. Metallic, non-metallic and advanced composite materials of various thicknesses can be cut by this process. This process is particularly suitable for heat sensitive materials that cannot be machined by processes that produce heat while machining. The schematic of abrasive water jet cutting is shown in Figure 1.12

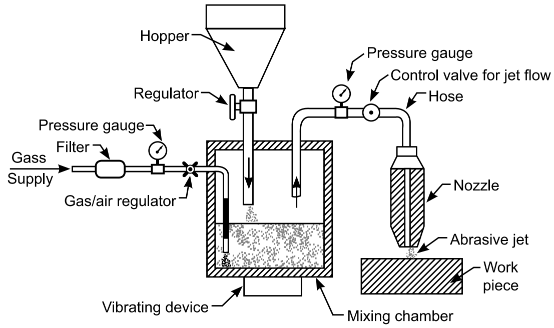


Fig. 1.12: Abrasive Jet Machining

Abrasive Jet Machining (AJM)

The chamber contains the water and abrasive slurry; at controlled pressure and pre-determined height the abrasive slurry particles will hit the work piece intermittently to remove the surface particles on the work piece.

Abrasive jet machining finds application in aerospace, automotive and electronics industries. In aerospace industries, titanium bodies for military aircrafts, engine components aluminium body parts and interior cabin parts are made using abrasive water jet machining. In automotive industries interior trim and fiber glass body components and bumpers are made. Similarly, in electronics industries, circuit boards and cable stripping are made by abrasive jet machining.

1.5.2 Laser Beam Machining

Laser-beam machining (LBM) is one of the thermal material-removal processes, where the high-energy, coherent light beam is used to melt and vaporize particles on the surface of metallic and non-metallic work pieces. Most of the time the Lasers are used for cutting, drilling, welding and marking purpose. The LBM more suitable for making accurately placed holes on the sheets.

The figure 1.13 shows the schematic laser beam production; here the laser discharge tube is mounted between the flash lamps. When the power is supplied to the flash lamps the beams start emitting from the laser discharge tube. The discharge tube is fitted with 100% reflective mirror at the top, which reflects all the beams to come down and pass through the partially reflecting mirror at the bottom. This high energy rays are made to pass through the lens, which is fixed near the work piece. The adjustment of the focal length gives the intensity of the required light. The high frequency of monochromatic light will fall on a superficial level at that point heating, melting, and disintegrating of the material occur because of impinging of photons. When the rays are made to fall on the single point on the work piece it erodes the surface, and creates the hole. The operation is very instantaneous.

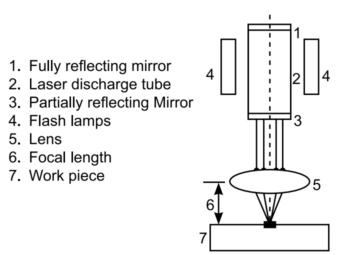


Fig. 1.13: Laser Beam Machining

Laser Beam Machining Process

LBM can make very accurate holes as small as 0.005 mm in refractory metals, ceramics, and composite material without warping the work pieces. This process is used widely for drilling and cutting of metallic and non-metallic materials. Laser beam machining is being used extensively in the electronic and automotive industries.

Advantages

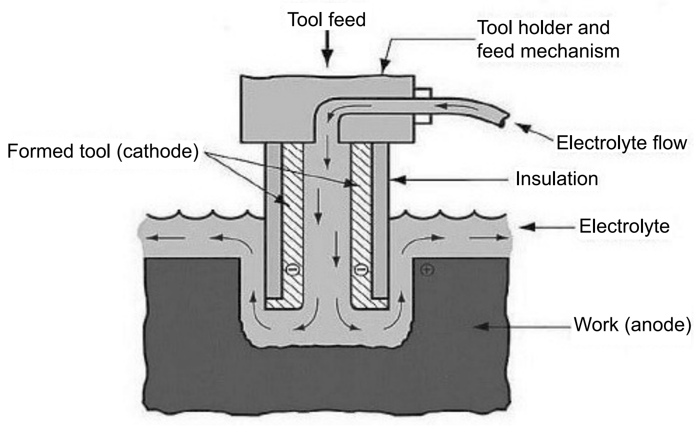
- The laser beam is used to cut all types of materials.
- Different types of lasers have different usages.
- It provides high precision.
- The maintenance cost of laser machines is comparatively low.

Disadvantages

- High initial cost.
- Requires high skilled workers to maintain laser beams.
- Not suitable for mass metal processes.
- More energy consumption.

1.5.3 Electro Chemical Machining

It is one of the Chemical machining processes, Electrochemical machining (ECM) is a metal-removal process based on the principle of reverse electroplating. In this process, particles travel from the anodic material (work piece) toward the cathodic material (machining tool). A current of electrolyte fluid carries away the depleted material before it has a chance to reach the machining tool. The figure 1.14 shows the schematic electro chemical machining operation.



Electro-chemical Machine (ECM)

Fig. 1.14: Electro Chemical Machining (source: machinemfg.com)

The electrolyte is supplied to the system using the pump. In between the pump and the system, a filter is placed which is used to filter the electrolyte before reaching the system. After passing through the filter and flow regulator, the electrolyte reaches the space between the work piece and the tool. As the electrolyte reaches the gap between anode and cathode, electrical contact is established between the anode and the cathode. After the electrical contact is established, the positive ions start flowing from the work piece towards the tool and negative ions start flowing from the tool towards the work piece. When the positive ions flow from the work piece towards the tool, the electrolyte carries away the positive ions with it and stops it from reaching the tool. So the materials start removing from the work piece as positive ions from the work piece are dissolving and carried away by electrolyte and material is removed due to the striking power of the negative ions coming from the tool. This material removal process from the work piece is continued until a cavity is created in the work piece which is a replica of the tool used in this process.

Advantages

- The components are not subject to either thermal or mechanical stress.
- No tool wear during ECM process.
- Fragile parts can be machined easily as there is no stress involved.
- High surface finish up to 25 μm can be achieved by ECM process.
- Complex geometrical shapes in high-strength materials particularly in the aerospace

Industry for the mass production of turbine blades, jet-engine parts and nozzles can be machined repeatedly and accurately.

Limitations

- ECM is not suitable to produce sharp square corners or flat bottoms because of the tendency for the electrolyte to erode away sharp profiles.
- ECM can be for very specialized applications

INTERESTING FACTS

There are many disadvantages and limitations of conventional machining like tool wear, complex surfaces, lower surface finish etc. Conventional machining processes are limited due to hardness of work piece. For machining hard surface harder tool material is required in conventional machining. This is sometime uneconomical and sometimes unavailable also. These limitations of traditional machining can be eliminated by non-traditional machining process. In these machining processes some other unconventional energy sources are used like laser, chemical, electron, hydraulic energy etc.

The introduction of water, steam, and later electricity as useful sources of energy led to the production of power-driven machine tools which rapidly replaced manually driven tools in many applications. Based on these advances and together with the metallurgical development of alloy steels as cutting tool materials, a new machine tool industry began to arise in the eighteenth and nineteenth centuries. A major original contribution to this new industry came from John Wilkinson in 1774.

The industrial revolution and advancement in the newer materials has posed new challenges to the engineers to think on newer machining process to meet the space, aerospace, defence and automotive sector.

VIDEO RESOURCES

Non-traditonal Abrasive Machining

Electr-Chemical Machining

Laser Beam Machining

UNIT SUMMARY

- Casting is one of the commonly used manufacturing process in which a liquid material is poured into a pre designed mould, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process.
- Most of the complex parts are usually manufactured with casting process.
- Forming or metal forming is the manufacturing process in which metals are given the required shape through mechanical deformation. The physical shape of a material is permanently deformed at the same time the work piece is reshaped without adding or removing material and its mass remains unchanged.
- Machining is a process in which a material is cut into a desired shape and size by a controlled material-removal process. The processes that remove the material in controlled manner collectively known as subtractive manufacturing in contrast to additive manufacturing.
- Joining processes are characterized by their ability to fuse or join two or more components for the purpose of creating a desired product, may be ready-to-sell consumer product. Most materials can be joined with many processes mainly fastening, soldering, brazing or welding and process can be used.
- Advanced manufacturing is the use of innovative technology to improve products or processes, with the relevant technology being described as advanced, innovative or cutting edge. Advanced manufacturing industries increasingly integrate new innovative technologies in both products and processes to meet the customer and societal needs.

EXERCISES

Subjective Questions

S. No	Question	CO	BL	PO	PI Code
1.	What is casting, why casting is one of the important methods discuss.	1	L1	1	1.4.1
2.	Comment on applications of castings.	1	L1	1	1.4.1
3.	Discuss the advantages and limitations of casting operation	1	L1	1	1.4.1
4.	What is forming and classify the forming process	1	L1	1	1.4.1
5.	When to choose the hot forming process over cold forming process	1	L1	1	1.4.1
6.	Enlist the different forming processes used in food preparation industries with examples	1	L1	1	1.4.1
7.	When to choose the machining operations, comment on it.	1	L1	1	1.4.1
8.	What are the different processes used for carving the ancient temple building materials?	1	L1	1	1.4.1

S. No	Question	CO	BL	PO	PI Code
9.	Discuss the turning operation with respect to taper turning operation	1	L1	1	1.4.1
10.	What are the different joining processes commonly used?	1	L1	1	1.4.1
11.	Comment on the need of non-traditional machining over traditional machining	1	L1	1	1.4.1
12.	Discuss the abrasive jet machining and applications	1	L1	1	1.4.1

Multiple Choice Questions

S. No	Question	Ans.	CO	BL	PO	PI Code*
1.	Which one of the following properties is the most essential for the metals in the process of casting, welding, brazing and soldering? (a) Fusibility (b) Malleability (c) Tenacity (d) Plasticity	a	1	L1	1	1.4.1
2.	Lathe bed is made of (a) High speed steel (b) High carbon steel (c) Mild steel (d) Cast iron	d	1	L1	1	1.4.1
3.	Which casting method gives quality dimensional tolerances (a) Centrifugal casting (b) Investment casting (c) Shell casting (d) Die casting	d	1	L1	1	1.4.1
4.	The permanent joints are made by (a) nut & bolt (b) rivets (c) lock nuts (d) screw	b	1	L1	1	1.4.1
5.	Non-Traditional machining can also be called as (a) Contact Machining (b) Non-contact machining (c) Partial contact machining (d) Half contact machining	b	1	L1	1	1.4.1

*The Performance Indicator code is referred from the AICTE exam reform document

KNOW MORE

- Teachers must know about the various casting processes used other than manufacturing industries like food industry, jewellery making etc
- The Various forming tools and their usages, calculations in forming operations.
- Tool geometry and feed, depth of cut, taper turning calculations
- Study of all the non-traditional machining processes and their relevance

Major Power Tools Catalogue

BOSCH | HiKOKI | BLACK+DECKER | DeWALT | CUMI | FERM

REFERENCES & SUGGESTED READINGS

- J. T. Black and Ronald A. Kohser, DeGarmo's *Materials and Processes in Manufacturing,* Eleventh Edition, John Wiley & Sons, Inc.
- B. L. Juneja, *Workshop/Manufacturing process,* Cengage Publications 2020.
- NPTEL course on *"Fundamentals of Manufacturing Processes"* by Dr. D. K. Dwivedi, Department of Mechanical & Industrial Engineering, Indian Institute of Technology, Roorkee.

2 CNC Machining Additive Manufacturing Fitting Operations and Power Tools

UNIT SPECIFICS

This unit elaborately discusses the following topics:

- CNC Machines
- Working of CNC Machine
- Additive Manufacturing Processes
- Fitting tools and operations
- Joining Process
- Advanced Manufacturing

The practical applications of the processes are discussed for making aware of the industrial applications. Generating further curiosity and creativity the video links and QR codes are generated at relevant intervals.

RATIONALE

As the advancements takes place in the life style of human beings, the need of newer and complex material requirement raised over the time. The increased demand with the limited time frame to reach the customer need of quality product, high precision, economically viable, more sophisticated, effective and efficient product and many more such requirements have made to invent the advanced machines. The Computer Numerical Control (CNC) machine is one of that kind. CNC machines evolved over time into the automated powerhouses, they began as simple devices controlled with a punch tape method into the software-powered machines. Modern CNC machines rely on software input and are much faster and more dynamic than their original NC counterparts. The modern industries working with medium and large scale operations are heavily dependent on CNC machines. The machining is a deductive process where the waste is removed from the work piece to get the required shape and size, on the contrary where new technique to get the finished product by adding the material layer by layer known as additive manufacturing. The basic assembly operations can be learnt through making prototype parts by using the available resources in the work shop. The fitting operations provide a chance to learn to make the different size and shape products and assembling them to get the desired shapes by hand held tools and power tools. These topics in this module help the learners to understand and demonstrate the different manufacturing and assembly operations.

PRE-REQUISITES

- Drawing
- General safety measures
- Hand tools
- Information about materials-Steel, Wood, Plastic and Glass

UNIT OUTCOMES

The students will be able to:

U2-O1: Identify different motions in CNC machines

U2-O2: Differentiate the coordinate systems.

U2-O3: Categorize the additive manufacturing process

U2-O4: Demonstrate the fitting operations

U2-O5: Recognise the different power tools.

Mapping of the Unit Outcomes with the Course Outcomes.

Unit-2 Outcomes	Expected Mapping with Course Outcomes *(1 – Weak Correlation; 2 – Medium Correlation; 3 – Strong Correlation)*				
	CO-1	**CO-2**	**CO-3**	**CO-4**	**CO-5**
U2-O1		1			
U2-O2		1			
U2-O3		1			
U2-O4		2			
U2-O5		1			

2.1 CNC MACHINING

Introduction

The history of numerical control (NC) began when the automation of machine tools initiated. The inception started with incorporating the concepts of abstractly programmable logic controls, and it continues today with the ongoing evolution of computer numerical control (CNC) technology. We know that the first NC machines were built during the 1940's and 1950's, based on existing tools that were modified with motors that moved the controls to follow points fed into the system on punched tape. These early servomechanisms were rapidly augmented with analog and digital computers, creating the modern CNC machine tools that have revolutionized the machining processes.

The advent of computers early 1970's lead to new industry revolution, the usage of computers in many industries and business giving the better results. The scientists and engineers started using the computers for production activities, the components with high precision and close tolerances and complex geometries were efficiently produced either in 2 or 3 dimensions. Otherwise it was difficult or uneconomical or even may be impossible with conventional machines. Thus CNC has made a big impact on the industries. The CNC Machines are the derivatives of NC machines, which are familiar during 1950 to 1970. They use the card readers, tapes for input provision. The CNC machine works on the coded instructions in the form of letter, number, symbols etc. Based on the instructions the tool changer will change the tool and make the next operation ready immediately.

2.1.1 CNC Machining Principle

The CNC machine consists of three components.The figure 2.1shows the CNC machine block diagram. The parts are Computer input device,Machine Control Unit(MCU) and Machine Tool.

- **Input Devices:** These are used to input the part program to the CNC machine. The part program is a set of instructions composed of letters, numbers and symbols that are required for the movement of the machine tool. The part program may be prepared by human being or by computer aided part program. The person is known as a programmer, who is expert in preparing these coded instructions. Commonly used input devices are punch tape reader, magnetic tape reader and computer via RS-232-C communication.

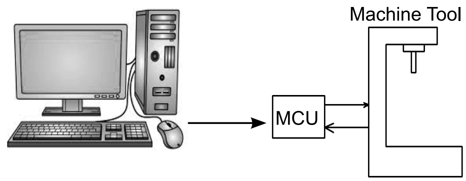


Fig. 2.1: CNC Machine Block Diagram

- **Machine Control Unit (MCU):** It is the heart of the CNC machine. It performs all the controlling actions of the CNC machine, the various functions performed by the MCU are
    - It reads the coded instructions fed into it.
    - It decodes the coded instruction.
    - It implements interpolation (linear, circular and helical) to generate axis motion commands.
    - It feeds the axis motion commands to the amplifier circuits for driving the axis mechanisms.
    - It receives the feedback signals of position and speed for each drive axis.
    - It implements the auxiliary control functions such as coolant or spindle on/off and tool change.
- **Machine Tool:** the CNC machine tool may be in the form of lathe, drilling, milling machine. CNC machine tool always has a slide table and a spindle to control the position and speed. The machine table is controlled in X and Y axis direction and the spindle is controlled in the Z axis direction.
- **Driving System:** The driving system of a CNC machine consists of amplifier circuits, drive motors and ball lead screw. The MCU feeds the signals like position and speed of each axis to the amplifier circuits. The control signals are then adjusted to actuate the drive motors. And the actuated drive motors rotate the ball lead screw to position the machine table.
- **Feedback System:** This system consists of transducers that act as sensors. It is also called a measuring system. It contains position and speed transducers that continuously monitor the position and speed of the cutting tool located at any instant. The MCU receives the signals from these transducers and it uses the difference between the reference signals and feedback signals to generate the control signals for correcting the position and speed errors.
- **Display Unit:** A monitor is used to display the programs, commands and other useful data of CNC machine. It is placed at appropriate place for visualization.

2.1.2 Axis of Rotation

The number of axes on a CNC machine determines the type of work it can perform, the level of detail it can cut, and the work piece locations it can manipulate. The machines having displacements in any two directions are known as 2-axis machines (lathe machine with X and Z axis), if the machines having all three axis rotation are known as 3-axis machines (milling machine with X, Y, Z axis). The demand in modern manufacturing has come up with 5-axis CNC machines where three linear motions like X, Y, Z and two rotary motions where the work table swivel and tool spindle swivel. The following figure 2.2 will give clear idea of the axis of rotation. The X-axis movement is the work piece/work table movement direction, Z-axis is the spindle movement and Y-axis denotes the saddle table movement. The movement of the tool either follows absolute coordinate system or incremental coordinator system. This will be explained in next sub heading.

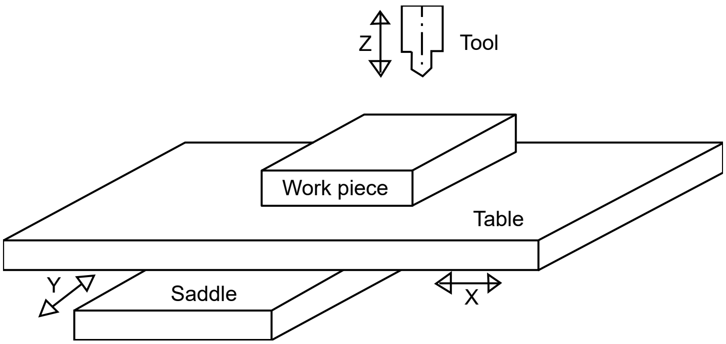


Fig. 2.2: Axis of Rotation

2.1.3 Coordinate System for Tool Movement

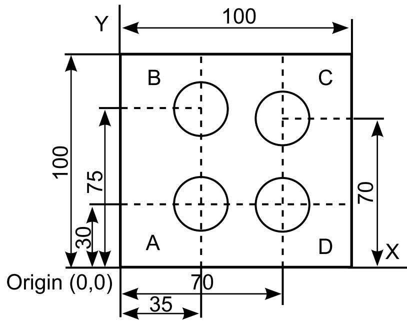
The Cartesian coordinate system is the fundamental system used to describe the motion of the tool and work piece within a three-dimensional space. CNC machines use numbers to locate a particular point along the X, Y, and Z-axis. They perform a series of instructions, one after another, to machine the work piece.CNC machines use either incremental or absolute coordinates to move from one location to the next. With incremental coordinates, the current position acts as the origin for the next position. With absolute coordinates, the origin stays in a fixed location, and each new location is calculated from that fixed position. Most CNC machines can move along multiple axes at once to perform contour operations.

Absolute Coordinate System

In this coordinate system all the measurements are started from the fixed origin i.e. X=Y=Z=0. Again this method is classified as fixed origin method and floating origin method.

- **Fixed origin method**

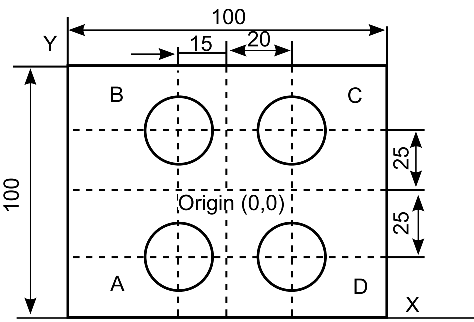
  In this absolute coordinate method the fixed origin is selected at the bottom left corner of the work table. Usually represented by (0, 0). All the measurements are referred from this point only. With the following example it can be understood properly. The four holes are drilled on a given work piece. The example of a drilled hole in a plate is explained in the figure 2.3.



Hole Name	Coordinator	
	X	Y
A	35	30
B	35	75
C	70	70
D	70	30

Fig. 2.3: Fixed Origin Method

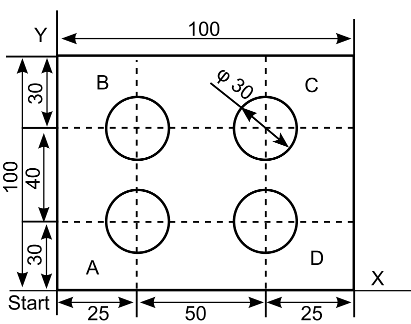
- **Floating Origin System**
  In this method the origin is located at the symmetric point of the given plate; the movement of the tool will take place from the centre of the plate. The distances for drilling holes are measured as positive and negative based on the quadrant where the hole is located. The system can be understood with the following example given in the figure 2.4



Hole Name	Coordinator	
	X	Y
A	–15	–25
B	–15	25
C	20	25
D	20	–25

Fig. 2.4: Floating Origin System

- **Incremental Coordinate System**
  In this method the next position is calculated from the current position. Thus the last stop becomes the origin for the next operation. The motion upward and forward are treated as positive, the down ward and back ward is treated as negative in calculations. The figure 2.5 gives an example for this coordinate system in machining operation.



Hole Name	Coordinator	
	X	Y
A	25	30
B	0	40
C	50	0
D	0	–40

Fig. 2.5: Incremental Coordinate System

2.1.4 Working of CNC Machine

The following are the procedural steps in CNC machine working.

- First, the part program is installed into the MCU of the CNC.
- In MCU, all the data process takes place according to the program prepared; it prepares all the motion commands and sends it to the driving system.
- The drive system works as per the motion commands sent by MCU. The drive system controls the motion and velocity of the machine tool.
- The feedback system records the position and velocity measurement of the machine tool and sends a feedback signal to the MCU.
- In MCU, the feedback signals are compared with the reference signals and if there is error, it corrects and sends new signals to the machine tool for the right operation to happen.
- A display unit is used to see all the commands, programs and other important data. It acts as the monitoring eye of the machine.

2.1.5 Advantages and Disadvantages of CNC Machines

Advantages

- The accuracy of Machining is high
- The time for machining is comparatively very less than manual machining
- Safe to operate for both operator and machine
- Operators are required only to create the program and thus less human intervention.
- No possibility of human error
- System is very Reliable
- Very complex designs can be made
- Low maintenance required as the machines are versatile/robust
- Uniformity and close tolerances can be achieved

Disadvantages

- Initial cost is very high
- Trained operator is required to operate the machine
- In case of breakdown a highly skilled professional is required to solve the problem

INTERESTING FACTS

CNC machining uses a machining technique that was developed in the 18*th* Century. However, it was not until the Cold War that the development of automation was addressed. At that time, the company person's work was commissioned by the U.S. Navy to increase the productivity of its production line for helicopter blades.

The first Numerical Control concept wasn't developed until 1949. John T. Parsons, an early computing pioneer, developed it as part of an Air Force research project carried out at the Massachusetts Institute of Technology (MIT). An experimental milling machine was built at the institute's Servomechanisms Laboratory, with the goal of using motorized axes to produce helicopter blades and stiffer skins for aircraft.

The idea was further developed and, in 1952, Richard Kegg (in collaboration with MIT) introduced the Cincinnati Hydro-Tel, a 28-inch vertical-spindle contour milling machine. Its commercial introduction came with a patent for a "Motor Controlled Apparatus with Positioning Machine Tool." The initial prototype, although it was operated using eight-column paper tape, a tape reader, and a vacuum-tube electronic control system, became a focus for future developments.

VIDEO RESOURCES

CNC Machines

CNC Machining Process

CNC Programming

2.2 ADDITIVE MANUFACTURING

Introduction

We are witnessing the transformation in all the fields, Most of the technological advancements are transformed from analog to digital processes. In recent decades, communications, imaging, architecture and engineering all had undergone their own digital transformations. Now, Additive Manufacturing can bring digital flexibility and efficiency to manufacturing operations also.

Till now we have studied how to create the final product by deduction method, where we removed the unwanted material from the surface of the work piece by suitable machining methods. On the contrary the final products not only done by deduction but also the final products can be made by adding the materials at suitable quantity and technique. This new field of manufacturing is called Additive Manufacturing. Additive manufacturing uses data from Computer-Aided-Design (CAD) software from the system or 3D object may be scanned by scanners and directed the hardware to deposit material layer by layer in precise desired geometric shapes. As its name implies, additive manufacturing adds material to create the final object. Few of the following images may help you to understand the varieties of product possibilities by additive manufacturing. The products range from toys to medical / engineering components.

Fan blade

Face Mask

Toy (Hulk)

Most of the times the terms "3D printing" and "rapid prototyping" are commonly used while discussing additive manufacturing, these two are actually a subset of additive manufacturing. While additive manufacturing seems new to many, it has started way back in the year 1981. Additive manufacturing delivers a wide variety of perfect products, complex geometries and simplified fabrication can be achieved. As a result opportunities abound for those who actively embrace additive manufacturing.

2.2.1 Additive Manufacturing Processes

The process of 3D printing begins by making a graphic model of the object to be printed. These are usually designed using Computer-Aided Design (CAD) software packages, and this is the most labor-intensive part of the process. Programs used for this include Tinker CAD, Fusion 360, and Sketchup. The process is shown schematically in figure 2.6

There are many makes and models for Additive manufacturing; even then the overall printing procedure is same. It is explained in following points

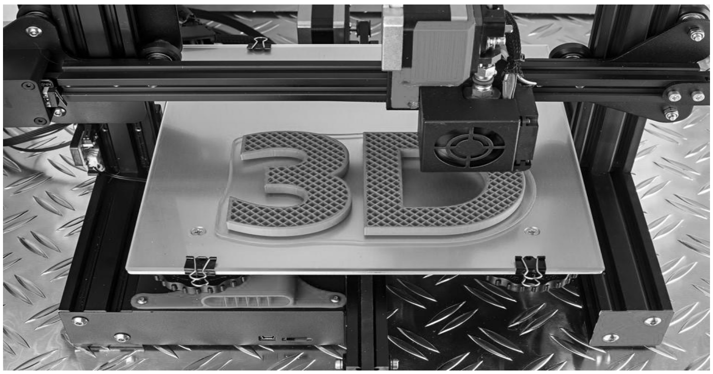


Fig. 2.6: 3D Printing Mechanism (source: line.17qq.com)

Step 1: Create a 3D model using CAD software in the computer.

Step 2: Once a model is created, it's time to slice it. Slicing software takes scans of each layer of a model and will tell the printer how to move in order to recreate that layer. The created CAD drawing is to be converted in to the standard tessellation language (STL) format. Most 3D printers use STL files in addition to other file types such as ZPR and ObjDF.

Step 3: The STL file is transferred to the computer controller for designating the size and orientation, which intern connects the 3D printer.

Step 4: The material is loaded for printing that may be polymers, binders and other consumables.

Step 5: Start the machine and wait for the model to complete.

Step 6: The printed object is removed from the machine.

Step 7: Post-processing like brushing off, water removing or may be curing is carried out.

2.2.2 Applications

- Aerospace
- Automotive
- Health care
- Toys
- Product development
- Tooling

INTERESTING FACTS

The kick-start of AM began much earlier than some might think, almost 40 years ago in 1981, when Hideo Kodama of the Nagoya Municipal Industrial Research Institute, published information regarding the manufacturing of a solid printed model. A few years later, Stereolithography (SLA) was patented by Charles Hull, creating models by curing a liquid photopolymer resin using UV lasers. Hull later commercialized the first rapid prototyping system, greatly reducing the time for designers and engineers to create 3D concepts and prototypes.

It wasn't until 1999 that scientists at the Wake Forest Institute were able to utilize 3D printing technology for medical applications – printing the synthetic scaffolds needed to grow a human bladder.

VIDEO RESOURCES

Additive Manufacturing

Rapid Prototyping

Additive Manufacturing Business

2.3 FITTING OPERATIONS

The fitting is basically/commonly refereed as join/assemble the finished products without using the permanent or temporary joining process! Most of the time products are made with the hand held tools in the workshop and they use very minimal power tools for the operations.

In day today life we are finding lot of fitted components. Even the dress what we purchase/ stitch should fit to our body!, The door when it's closed it should fit to the frame, the computer/ mobile cabinets should fit properly, electrical switches, water pipe joints, mobile charger pin and socket, electrical sockets etc are the real time examples for fitting components. The following images may help you to imagine the fitting operation. The fitting operation is helpful while translating idea in to product. The prototypes can be very easily done by fitting operation.

The fitting operation can be done on any kind of the material, in mechanical workshop the metal parts are finished with different tools and operations to make the final desired fit.

The different tools used in Fitting workshop may be categorised under following headings.

- Holding Tools
- Marking Tools and Measuring Tools
- Cutting Tools

- Finishing Tools
- Striking Tools

2.3.1 Holding Tools

The various work holding tools may be listed as Bench vice, hand vice, leg vice, pipe vice, c-clamp, v-block and hand press.

Bench Vice

The bench vice is commonly used for holding the work pieces. The typical bench vice is shown in the figure 2.7. It has two jaws; one is fixed and other one is moving. When the vice handle is turned in a clockwise direction the moving jaw forces the work against the fixed jaw. The body of the vice is made of castiron and is bolted to the working table.

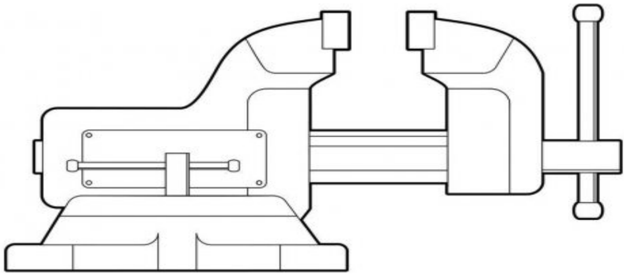


Fig. 2.7: Bench Vice

C-Clamp

This is used to hold the work piece against the v-block or an angle plate. The holding device looks similar to an English alphabet C, that's how the name is. The C-Clamp is shown in figure 2.8

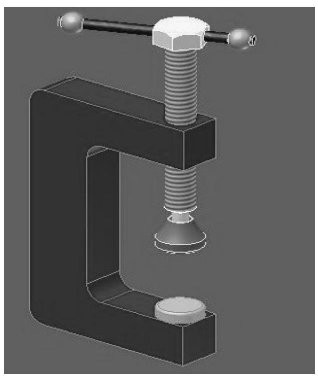


Fig. 2.8: C-clamp

V-Block

The v-block is used to hold measure and cut the circular pipes using the v- block. It is shown in the figure 2.9. The pipe is placed between the blocks. The upper block is moved downwards with the help of rotating handle fixed at the top of the body.

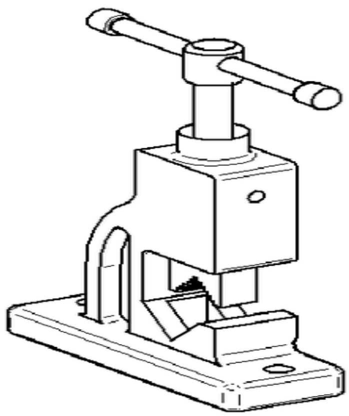


Fig. 2.9: V-block

Hand Press

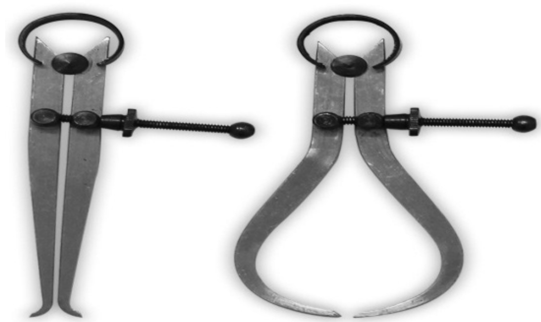
Whenever there is a need of light pressure or push required to assemble products the hand press is commonly used. The fitting of journal bearing, bearing bush, pipe insertion, sealing etc can be performed with hand press. This operates either with the assist of mechanical threads or hydraulic power.

2.3.2 Measuring and Marking Tools

The measuring and marking tool comprises the scale, calliper, micrometer, feeler gauges, scriber, divider, dot punch, try-square, angle plate, surface plate and marking table. The surface to be marked is applied with the chalk paste, so that better visibility can be achieved for marked lines. The marking tools are used to mark the necessary dimensions on the work piece, there are some equipments used to support the marking activity. The marking tools are explained in detail in following lines.

Callipers

These are used to measure and transfer the measurements of outside and inside diameters by respective callipers. The figure 2.10



Fitting Shop tools

Fig. 2.10: Different Types of Callipers

Scriber

Scriber is a slender steel rod used to scribe or mark lines on metal work pieces. It has a sharp needle like structure at the ends. It has one straight end and on other side it has bent end which helps to mark even the interior parts. The centre part is made with the knurling operation for holding purpose, which gives the grip to hold. It is shown in figure 2.11.

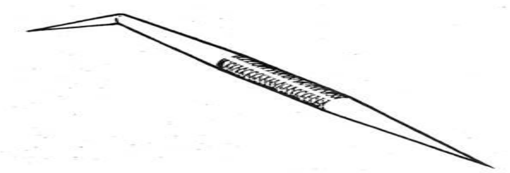


Fig. 2.11: Scriber

Divider

The divider is used to mark circles, arcs, semicircular arc, bisecting lines, etc on the metal work piece. This is similar to one you have in your school compass box. The divider is also used to transfer the equi- distances on the surfaces from the drawings.

Dot Punch

Punches are used to make the outlines of the marking and to locate the centre points. The punched line will become the guideline for the cutter during cutting operation. There are variety of punches available. The commonly used punches are centre punch and prick punch. Both the punches look similar only difference is the obtuse angle, for centre punch is 60^0 and for prick punch angle is 40°. The length and diameters vary from 90-150mm and 8-13 mm respectively. They are shown in figure 2.12. Even there are number punch and letter punch available to mark the letters/numbers for identification of parts.

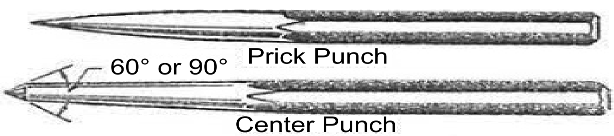


Fig. 2.12: Dot Punch

Try-Square

Try-square is used for inspecting the squareness and straightness of work piece. This is used intermittently to check the squareness and straightness during filing operation. The operation is shown in figure 2.13.

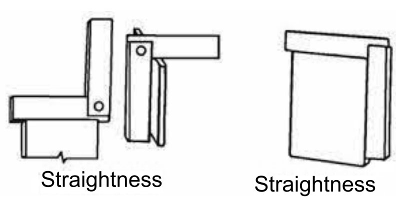


Fig. 2.13: Try-square

Angle plate

The angle plate is made of cast iron. It has two surfaces machined at right angles to each other. The work piece which is to be marked will be held against the face of angle plate to facilitate the marking or inspection. The work piece is to be placed against the wall of the angle plate. With the help of height gauge the desired dimensions are to be marked on the work piece. Even the slots are provided on the angle plate to clamp the work piece for desired operations. Figure 2.14 shows the Angle plate.

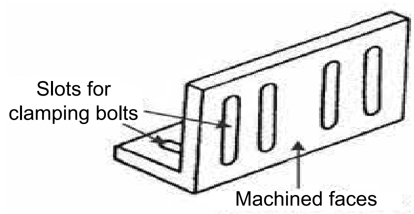


Fig. 2.14: Angle Plate

Surface Plate

The surface plate is used for testing the flatness of the work piece and other inspection purposes. It is used for marking on the work piece. It is more precise in flatness than the marking table. Surface plates are made of C.I. or hardened steel, ground and scraped to the required precision. Now-a-days surface plates made of special granite stone are manufactured in wide range of precision grades, colours and sizes. The figure 2.15 shows the surface plate.

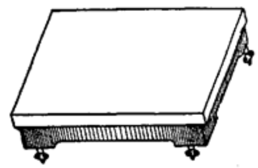


Fig. 2.15: Surface Plate

2.3.3 Cutting Tools

The various cutting tools include hack saw, chisels, cutting flier. The cutting operation can be performed either manually or with power operated hacksaw.

Hack Saw

The hacksaw is used for cutting metal by manually. It consists of a frame which holds a thin blade, firmly in position. The adjustment can be done with the help of wing nut. The hack saw blade is an additional part to be joined to perform the cutting operation. The blade has number of cutting teeth. The blade is fixed in the forward direction, so the cutting operation becomes easy for forward stroke. The figure 2.16 shows the hack saw.

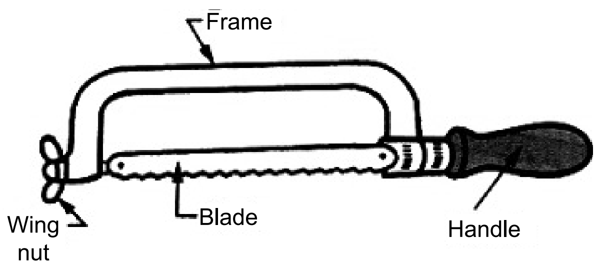


Fig. 2.16: Hacksaw

Chisel

Most of the time the Chisels are used for chipping the extra metal, the flat chisels are used for cutting thin sheets. The different types of chisels are shown in figure 2.17. The diamond point chisel as the name suggests, it has a diamond shaped tip and is commonly used to create grooves in the form of “V” shape. The **diamond point chisels** may be better suited to use on brickwork to create the grooves for electric/water piping. The flat chisel is basically a cold chisel type, most of the time used for cutting variety of metals. **Flat chisels** used to break off the unwanted things like rivet heads, nuts and metal rods. The **half-round chisel** is also called as round nose chisel. This has half round and remaining half as flat surface. Commonly used to create grooves or channels with rounded bottom surfaces. One such example is grooves in the bearings act as oil ways. A **cape chisel or cross cut chisel** is a narrow shaped tool. It is used for the chipping grooves and keyways. The design of the tool is such that the handle is thinner than the cutting edge, which narrows on two sides until it reaches a point. This chisel is designed not to get stuck where a flat chisel might. Chisels are annealed, hardened and tempered to produce a tough shank and a hard cutting edge.

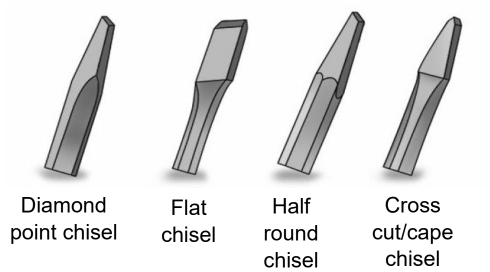


Fig. 2.17: Types of Chisels

Cutting Pliers

Cutting Pliers are hand tools used to hold objects firmly. They consist of a pair of metal levers joined at a fulcrum positioned closer to one end of the levers. Creating short jaws on one side of the fulcrum, and longer handles on the other side. They are also useful for holding, bending and compressing a wide range of materials. Generally, this arrangement creates a mechanical advantage.

2.3.4 Finishing Tools

The finishing tools used in the workshop comprise various types of files and scrappers. This operation is done at the end of the major cutting operation, to attain the required dimensional tolerance.

Files

These are most commonly used tools in all workshops; basically the file is made with high grade hardened steel. The file has few important parts, shown in figure 2.18. The nomenclature is explained here.

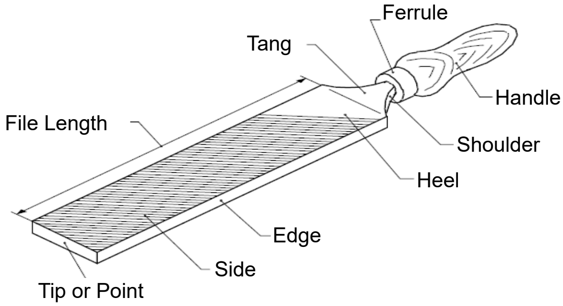


Fig. 2.18: File Nomenclature

- **Tip or End Point:** This is last end of the file which is opposite to tang
- **Face or side:** The biggest part of the file with teeth cut on its surface in various pattern.
- **Edge:** The height of the file or thickness of the file,
- **Heel:** The area of the file without teethes cut on it. It lies towards the handle
- **Shoulder:** the curved part of the file separating tang from the body. It tapers towards the end.
- **Tang:** The narrow thin part of a file which fits into the handle.
- **Handle:** The holding part of the file, usually made with wood or plastic. The tang is inserted into the handle.
- **Ferrule:** A protective metal ring at the beginning of the handle helps in preventing loosening or cracking of the handle.

Classification of files

The files can be classified on the basis of

(a) Cut of teeth
- Single cut files
- Double cut files
- Rasp cut

(b) Roughness
- Rough
- Smooth
- Bastard
- Dead smooth
- Super smooth
- Second cut

(c) Shape or cross section
- **Flat file**

  It is rectangular in section and tapered for 1/3 length in width and thickness towards the tip. The faces carry double cut teeth and the edges carry single cut teeth. It is a general purpose file. Shown in figure 2.19

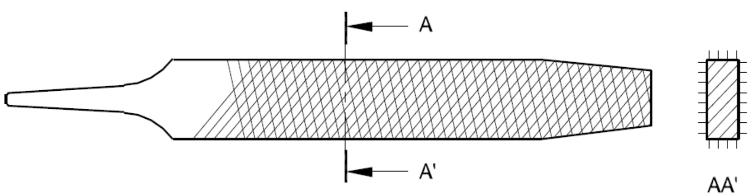


Fig. 2.19: Flat File

- **Square file**

  It has square in its cross section, used for filing the square holes, internal square corners, rectangular openings, keyways and spines etc. Shown in figure 2.20

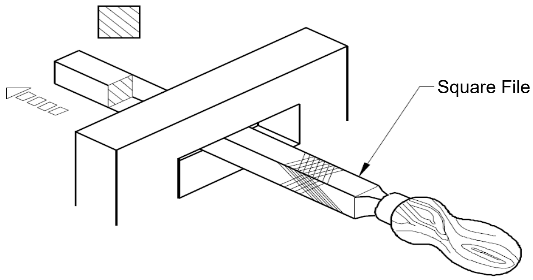


Fig. 2.20: Square File

- **Triangular file**
  It has triangular cross section, used for filing corners and angles, channels and v-shape grooves etc. Shown in figure 2.21

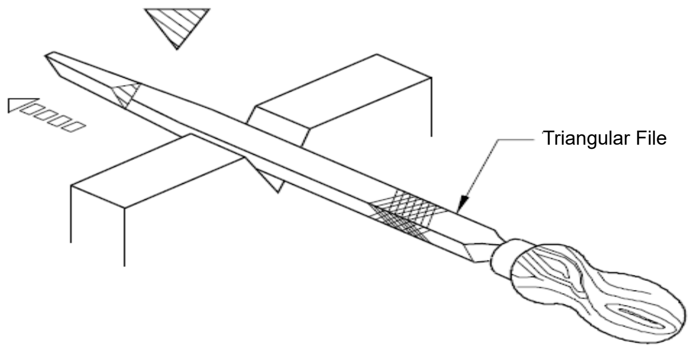


Fig. 2.21: Triangular File

- **Round file**
  It has circular cross section, used for enlarging the circular holes and most of the profiles with fillets and corners are filed with this round file. Shown in figure 2.22

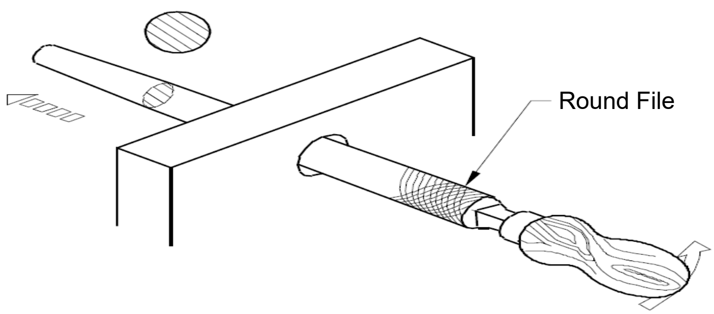


Fig. 2.22: Round file

- **Half round file**

  A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces. Shown in figure 2.23

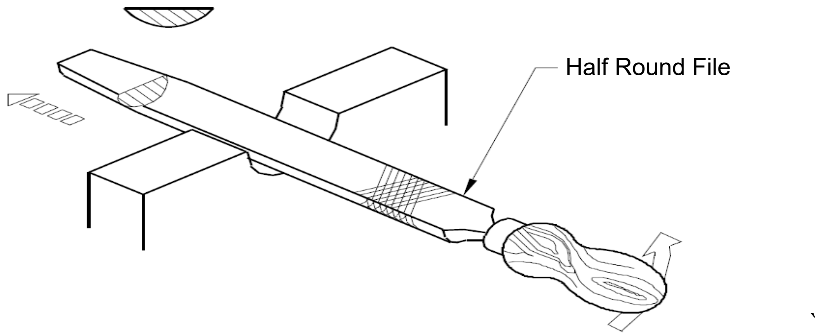


Fig. 2.23: Half Round File

- **Scrappers**

  These are sharp edged tools usually used to remove uneven spots on the surfaces. They are of different shapes like flat, triangular and half round etc.

2.3.5 Striking Tools

The striking tools are used to strike on the work pieces during different operation. Like punching, chipping, straightening etc. The different striking tools are explained below.

Hammer

Most commonly used striking tool is the hammer. Hammers are named based on their shape and material used. The various types are ball peen hammer, straight peen hammer, cross peen hammer. They are shown in figure 2.24. A ball peen hammer has a flat face which is used for general work and the ball end particularly used for revetting.

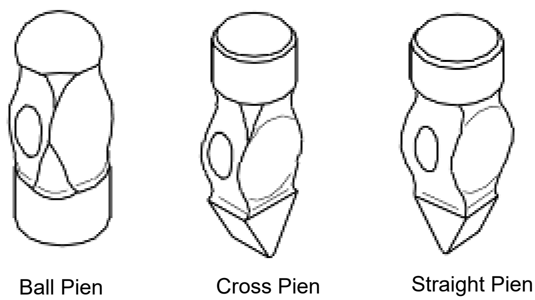


Fig. 2.24: Types of Hammers

The hammer consists of a hardened and tempered steel head firmly fixed on a tough wooden handle. The flat striking surface is known as the face, and the opposite end is called the peen.

Soft hammer/ Mallet

These are usually made with hard rubber or wood. Used to blow for smaller forces to minimise the damages on the work piece otherwise. Shown in figure 2.25

Fig. 2.25: Mallet

2.4 POWER TOOLS

A power tools are actuated by an additional power source and mechanism other than the manual labour. The common type of power tools uses electricity, chemical, fuel, hydraulic or pneumatic power sources. Power tools are classified as either stationary or portable and movable. Portable power tools have obvious advantages in mobility; often have advantages in speed and precision compared to movable power tools. Portable power tools can be easily carried from one location to another, and are usually light enough to be used while being held in a person's hands.

The list may include the following classification of power tools

(a) Electric operated power tools
- driller
- sawing
- polisher

(b) Chemical operated power tools(Battery operated)
- Impact driver
- Nail gun
- Rivet gun
- Cordless drill
- Power screw driver

(c) Fuel operated power tools
- Chain saw
- Grass cutter

(d) Hydraulic/Pneumatic operated power tools
- Impact wrench
- Air gun
- Lifters
- Vacuum pump

Driller

The power tool with a cutting or driving tool attachment (a drill or driver bit), that operates with an electric motor and spins the attachment at a rapid pace for quick, efficient drills and drives. The attachment is held by a chuck and pressed against the target. The varying drill bit can be used to make different size holes. As the driller is portable and movable as well as handy in nature, it can be taken to even remote places. Some drillers are operated with battery power. The driller is shown in figure 2.26

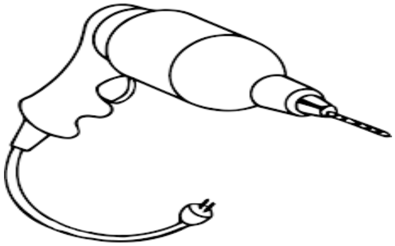


Fig. 2.26: Power Driller

Power operated screw driver

The power operated/ battery operated screw driver is shown in figure 2.27. Basically it is similar to the manual screw driver, comprises the power driven unit in the form of battery. The manual effort required to put/remove the rivets is completely done effectively and efficiently within no time with this machine.

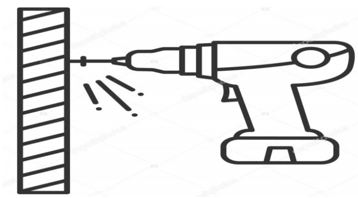


Fig. 2.27: Power Screw Driver

Chain Saw

The chain saw is used to cut the wood log and to cut/ trim the trees. It is operated by the small petrol engine. This saw is handy and can be taken to any remote area. The operation is efficient and quick. We have seen the usage of this machine during the rainy season; the labours will clear the roads quickly by cutting uprooted trees. Shown in figure 2.28

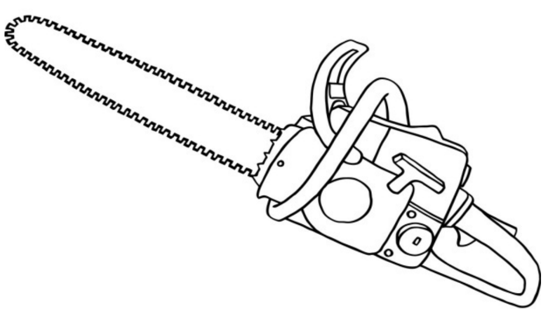


Fig. 2.28: Power Chain Saw

Impact wrench

The wrench used for tightening/loosening the nut and bolts, usually this kind of the tools uses the pneumatic power for its operation. The schematic figure is shown in figure 2.29.

Fig. 2.29: Pneumatic Impact Wrench

INTERESTING POINTS

Before the Industrial Revolution of the 18^{th} century, hand tools were used to cut and shape materials for the production of goods such as cooking utensils, wagons, ships, furniture, and other products.

After the advent of the steam engine, material goods were produced by power-driven machines that could only be manufactured by machine tools. Machine tools and jigs and fixtures were the indispensable innovations that made mass production and interchangeable parts realities in the 19^{th} century.

The revolutionary art that created the definitive ground and polished tools of Neolithic man was essentially a finishing operation that slicked a chipped tool by rubbing it on or with an abrasive rock to remove the scars of the chipping process that had produced the rough tool.

VIDEO RESOURCES

Limits

Measuring Tools

Industrial Safety

UNIT SUMMARY

- CNC machining is fabrication method where written alpha-numeric codes control the machinery and its accessories in the manufacturing process. These codes determine everything from the movement of the cutting tool, its spindle speed, feed depth of cut axis of rotation etc. CNC machining is a subtractive fabrication method.
- The advanced and more complex parts can be machined effectively and efficiently.

- Additive manufacturing is also referred as rapid prototyping or 3D printing is technology that works on the basis of successive layers of material is used to create 3D imensional objects.
- Additive manufacturing application has no boundaries. In the beginning the Rapid Prototyping focused and limited to preproduction visualization models. More recently, it has been used to fabricate end-user products in aircraft, dental restorations, medical implants, automobiles, and even fashion design products.
- Working on small components with hand held tools and instruments, usually on work benches in workshop are generally referred as Fitting work.
- The hand operations in fitting shop include marking, filing, sawing, scraping, drilling, tapping, grinding, etc., using hand tools or power operated portable tools.
- Power operated tools are time saving and efficient devices invented to complete jobs otherwise the traditional tools were taking significantly longer time to finish.

EXERCISES

Subjective Questions

S .No	Question	CO	BL	PO	PI Code*
1.	Why CNC machines are called high precision machines	2	L1	1	1.4.1
2.	Discuss the advantages of CNC Machines over the conventional machines	2	L1	1	1.4.1
3.	Rapid prototyping is the new technology for survival, discuss?	2	L1	1	1.4.1
4.	Enlist the possible application areas for additive manufacturing	2	L1	1	1.4.1
5.	Make a list of products you will see in day today life made from fitting operation.	2	L1	1	1.4.1
6.	Discuss the sequential steps involved in making the metal fitting models	2	L1	1	1.4.1
7.	Discuss the different power sources used in power tool equipments.	2	L1	1	1.4.1

Multiple Choice Questions

S. No	Question	Ans.	CO	BL	PO	PI Code*
1.	CNC machining centers do not include operations like __ (a) milling (b) boring (c) welding (d) tapping	c	2	L1	1	1.4.1
2.	For CNC machining skilled part programmers are needed. (a) True (b) False	a	2	L1	1	1.4.1

S. No	Question	Ans.	CO	BL	PO	PI Code*
3.	Which of the following is a step of the Rapid Prototyping process? (a) Create a CAD model of the design (b) Convert the CAD model to STL format (c) Slice the STL file into thin cross-sectional layers (d) All of the mentioned above	d	2	L1	1	1.4.1
4.	In extrusion-based 3D Printing RP system, raw material form used is ________ (a) wax (b) powder (c) rubber (d) wire	d	2	L1	1	1.4.1
5.	You should always wear eye protection when using grinders. (a) True (b) False	a	2	L1	1	1.4.1

*The Performance Indicator code is referred from the AICTE exam reform document

KNOW MORE

- The part program generation, use of the G and M codes for programming
- The calculations and numeric's involved in machining operations.
- ASTM standards in rapid prototyping/additive manufacturing.
- Additive manufacturing demonstration with available resources.
- Utilization of the fitting tools and sequencing of operations to derive the given model drawings.
- The creation of power tools for automation of academic instruments.

REFERENCES AND SUGGESTED READING

- Prof. Dr. Ing. Andreas Gebhardt, "Understanding Additive Manufacturing", 2011, Hanser Publications, Cincinnati, USA.
- "Work Shop Manual", 2020, JSS Science and Technology University, Mysore.
- Mikell P. Groover, "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", John Wiley & Sons. Inc. Publication, 4th ed. 2014.
- Fundamentals of CNC Machining, A Practical Guide for Beginners by Auto Desk.
- Rapid Manufacturing Course on NPTEL by IIT, Kanpur.

3 Electrical and Electronics

UNIT SPECIFICS

This unit elaborately discusses the following topics:

- Basic Terminology
- Resistance in Series and parallel
- Transformer
- Electric Motors
- Electric Drive
- Electronic Engineering

The unit has the topics for basic understanding of electrical and electronic engineering and the practical applications of the circuits are discussed with circuit diagrams.

RATIONALE

Electrical / Electronic engineering is one of the core professional engineering disciplines. It deals with the study and application of electricity, electronics and electromagnetism. The field first became an identifiable occupation in the late nineteenth century along with civil and mechanical engineering. The reason is commercialization of the electric telegraph and electrical power supply demand. The field now covers a range of sub-disciplines including those that deal with power, optoelectronics, digital electronics, robotics, automotive, analog electronics, mobile communication, computer science, artificial intelligence, control systems, electronics, signal processing and telecommunications, instrumentation and many more.

The term electrical engineering may or may not encompass electronic engineering. In simple electrical engineering deals with the power generation and distribution as well as the problems associated with large-scale electrical systems such as power transmission and motor control, whereas electronic engineering deals the utility of the generated electricity for different applications. The study may include small-scale electronic systems including computers and integrated circuits. The simplest way to make distinction is that electrical engineers are concerned with transmitting electrical energy, while electronics engineers are concerned with transmitting the information using electricity!

PRE-REQUISITES

- Types of conductors
- Electrical wiring
- Circuit Drawing
- General Safety Measures

UNIT OUTCOMES

The students will be able to:

U3-O1: Identify different elements of electrical system

U3-O2: Apply the laws of electrical & electronic engineering to simple circuits.

U3-O3: Comment on electrical/electronic circuits.

U3-O4: Differentiate the utility of electrical motors.

U3-O5: Get exposed to application of open loop and closed loop control system.

Mapping of the Unit Outcomes with the Course Outcomes:

Unit-3 Outcomes	Expected Mapping with Course Outcomes *(1 – Weak Correlation; 2 – Medium Correlation; 3 – Strong Correlation)*				
	CO-1	**CO-2**	**CO-3**	**CO-4**	**CO-5**
U3-O1			1		
U3-O2			1		
U3-O3			1		
U3-O4			1		
U3-O5			1		

3.1 INTRODUCTION

Electrical Engineering deals with electricity and its applications in every one's life. Even though we cannot see the flow of electricity with bear eyes but we can see it by operating the appliances. It supplies power to run most of the domestic and industrial appliances, heavy machinery, electric lights etc. Electricity also encompasses the communication devices such as the mobile, telephone, radio, computer, television and all other consumer electronic devices. And, of course, electronics is changing everything around us every day! Through such pervasive devices as hand-held calculators, computers and controllers that help to operate robots, automotives, aircrafts, satellites and many more.

The following images may give you an idea about the application of electrical and electronics engineering in our day today life activities. Shown in figure 3.1

Fig. 3.1: (a) Electric bulb (b) Computer CPU (c) Mobile phone Circuit

In this module we will be discussing the basic fundamentals and applications of electrical and electronic equipments. The flow of electrical charge in a conducting media is referred as electric current. There are two types of currents available namely, direct current (DC) and alternating current (AC). Direct Current flows in one direction with a constant voltage polarity while Alternating Current changes direction periodically along with its voltage polarity. Thomas Alva

Edison and Alessandro Volta were pioneers in DC current and wrote much of electricity's history. But as societies grew the use of DC over long transmission distances became more inefficient. Nikola Tesla changed all that with the invention of alternating current electrical systems. With AC it is possible to produce the high voltages needed for long transmissions. Therefore today, most portable devices use DC power while power plants produce AC. with this background let us start with the terminology.

3.2 BASIC TERMINOLOGY

An electric circuit is an interconnection of various elements such as voltage source, current source, resisters, inductors and capacitors. An electric circuit consists of two types of elements they are

- **Active Elements or Sources**: They possess energy of their own and can impart it to other elements of the circuit. There are two sources of (i) voltage source (ii) current source
- **Passive Elements or Sinks**: They do not possess energy of their own. They receive energy from source. The passive elements are resistance, inductance and capacitance.
- **Electric Current**: The rate at which the electric charge is transferred across a point in a conductor is known as electric current flowing through it. It is denoted by "I" and measured in terms of Ampere. One Ampere of current may be defined as the current flowing through a conductor, when a charge of one coulomb crosses a point in the conductor in one second.

$$I = \frac{q}{t}$$

- **Resistance:** It is the property of the conductor by virtue of which, it opposes or limits the flow of current through it. The unit of resistance is Ohm. It is denoted by symbol Ω. The resistance of a conductor is directly proportional to its length (*l*) and inversely proportional to its area (a)

$$R = \frac{l}{a} \qquad \text{or} \qquad R = \rho\frac{l}{a}$$

  Here ρ is specific resistance or resistivity of the conducting material.
- **Relay:** A relay is basically a switch that is used to open or close a circuit. It controls the flow of electricity to create a desired result.
- **Electric Potential:** It is the amount of work done to bring a unit positive charge from infinity to that point. The unit of measurement is volt (V).
- **Volt:** It is the potential difference across a resistance of one Ohm through which a current of one Ampere is flowing.
- **Electromotive force (EMF):** It is an electrical effort required to drift the free electrons in one particular direction in a conductor. It is measured in volts. The movement of electrons is always from negative to positive, while movement of current is always assumed from positive to negative.
- **Ohm's law:** The ratio of potential difference (V) between any two points of a conductor to the current (I) flowing between them is constant. Provided the temperature of the conductor is constant. Where R is resistance.

$$\text{Constant} = \frac{V}{I} \qquad \text{or} \qquad R = \frac{V}{I}$$

This law is applicable for both AC and DC current circuits.

- **Electrical Power (P):** It's defied as the rate at which electric work is done in an electric circuit.

$$P = \frac{W}{t} = \frac{VIt}{t} = VI$$

It's measured in Joules per second or in Watts.

According to Ohms law

V = IR i.e P = I^2 R

Now for easy understanding of the above equations we have consolidated them into a simple Ohm's Law pie chart for both AC and DC circuits. Shown in figure 3.2

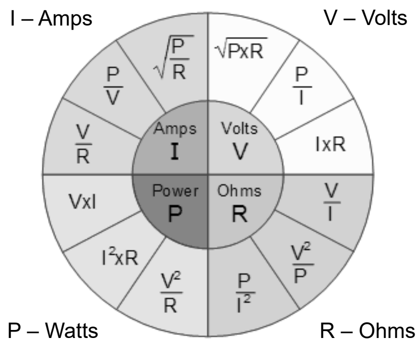


Fig. 3.2: Ohm's Law Pie Chart

- **Faraday's First Law of Electromagnetic Induction:** Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced. If the conductor circuit is closed, a current is induced is called induced current.
- **Faraday's Second Law of Electromagnetic Induction:** Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced; the induced e.m.f in a coil is equal to the rate of change of flux linkage.

3.3 RESISTANCE IN SERIES

The resistance can be connected either in parallel or series based on the application requirements. Let us know the effect of resistance on voltage due to this series connection. Consider the three resistances R1, R2, R3 are connected in series as shown in the figure 3.3. Let 'V' be the total voltage applied across the circuit and 'I' is the current flowing through the circuit.

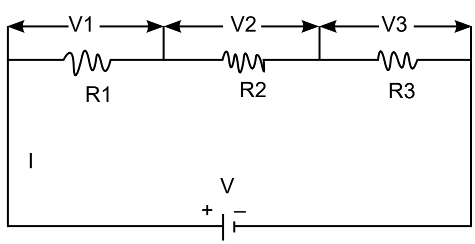


Fig. 3.3: Resistance in Series

V1, V2, V3 are the voltage drops across the R1, R2, R3 respectively

The V1+V2+V3 = V = IR1 + IR2 + IR3

Applying the Ohm's law V=I Req = I (R1+R2+R3)

Thus $$\boxed{R_{eq} = R1 + R2 + R3 + \; + \; + \; + \; + \; + \; + \; + \; + Rn}$$

Thus the total or equivalent resistance of the series circuit is arithmetic sum of the resistances connected in series.

3.4 RESISTANCES IN PARALLEL

Consider the three resistances R1, R2, R3 are connected in parallel across voltage V volts in a circuit. Then I is the total current is divided into I1, I2, I3 and flowing through R1, R2 and R3 resistances respectively. The figure 3.4 shows the circuit diagram for parallel connection.

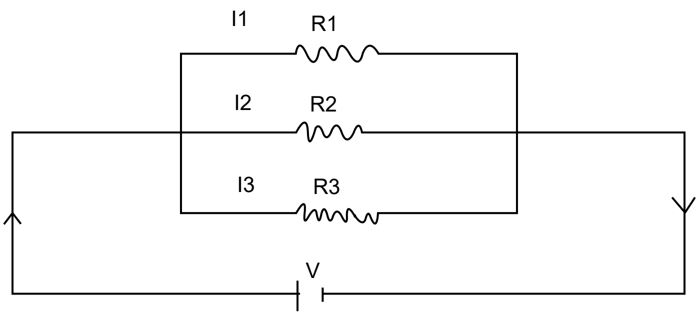


Fig. 3.4: Resistance in Parallel

Let $$I = I1 + I2 + I3 = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3}$$

$$I = V\left[\frac{1}{R1} + \frac{2}{R2} + \frac{3}{R3}\right]$$

$$I = V\left[\frac{1}{R_{eq}}\right]$$

Thus $$\boxed{\frac{1}{R_{eq}} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4} + \; + \; + \; + \; + \; + \; + \; + \; + \frac{1}{Rn}}$$

3.5 KIRCHHOFF'S LAW

The law can be studied in terms of current and voltage law,

3.5.1 Current Law

The algebraic sum of all the currents meeting at any junction of an electric circuit is zero.

$$\sum I = 0$$

With the help of the figure 3.5 consider a junction point "o" in a complex electric circuit at which four currents I1, I2, I3 and I4 will meet. All the current flowing towards the junction are taken as positive and all current flowing away are taken as negative.

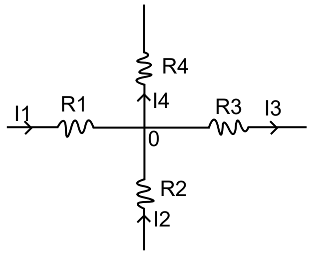


Fig. 3.5: Current Law Circuit

According to Kirchhoff's current law

$$\boxed{I1 + I2 - I3 - I4 = 0} \quad \text{or} \quad \boxed{I1 + I2 = I3 + I4}$$

With this we can state that "At any junction of an electric circuit, the sum of all the current entering the junction are equal to sum of all current leaving the junction".

3.5.2 Voltage Law

The algebraic sum of the product of current and resistance in each of the conductors in any closed mesh in a network and the algebraic sum of the electromagnetic force (e.m.f) in that path is zero. In other words, "In any closed electrical circuit, the algebraic sum of all the e.m.f's and the resistive drops is equal to zero".

$$\boxed{\sum IR + \sum e.m.f = 0}$$

Usually the rise in the voltage should be given positive (+) sign and fall in voltage as negative (–) sign. Keeping this in mind when we move from negative (–) terminal of battery to its positive (+) terminal, there is a rise in potential hence voltage should be given a positive sign. On the other hand from positive terminal to negative terminal there is a fall in potential, the voltage is represented by negative sign.

3.6 TRANSFORMER

The transformer is static piece of device by means of which the electric power is transformed from one alternating current circuit to another with the desired in voltage and current, without changing the frequency.

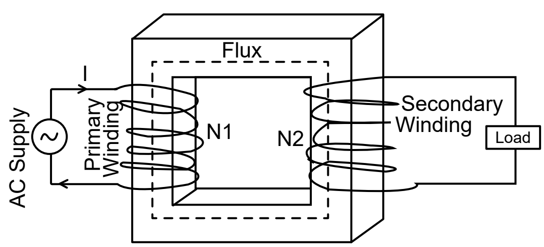


Fig. 3.6: Transformer

The basic principle of working will be understood with the help of figure 3.6. The principle of mutual induction states that when two coils are inductively coupled and current in one coil is changed uniformly then an e.m.f gets induced in other coil. This e.m.f can drive a current when closed path is provided to it. This is how the transformer works on similar grounds. The two inductive coils are connected by a common magnetic circuit but separated by electric connection. Both coils have high inductance. The coil in which electric energy is fed from AC source is called primary winding. It has N1 number of turns and the other from which energy is drawn is called secondary winding. It has N2 number of windings on it.

3.6.1 Application

- To step up and step down the voltage level in Electric transmission, distribution lines.
- The welding machine used in the welding shop.
- There are transformers (rectifiers) all over every house; they are inside the charger unit which you plug into recharging your cell phone / laptop or other devices.

3.7 ELECTRIC MOTORS

Electric motor is an electric machine which converts supplied electrical energy into mechanical energy. The electric motor operates through the interaction between these motor's magnetic field and electric current in a wire winding. This will going to generate a force called torque, applied on the motor's shaft.

Electric motors may be powered by direct current (DC) sources, such as batteries or rectifiers otherwise by alternating current (AC) sources such as inverters, electric generators and directly from power grid.

Electric motors are used in automobiles, trains, industrial power tools, fans, air conditioning equipments, household appliances, disk drives and even some electric watches use micro sized motors.

3.7.1 Classification of Motors

The detailed classification is shown in figure 3.7 as below.

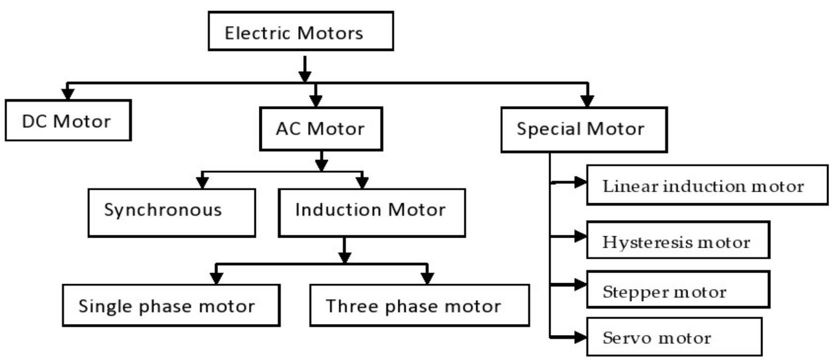


Fig. 3.7: Electric Motor Classification

Among the classifications of motors mentioned above, the DC motor is the only one that is driven by direct current. The rest all are AC electric motors and are driven by alternating current,

3.7.2 Three Phase Induction Motor

The three phase induction motor is an AC induction motor which operates on three phase supply of current as compared to the single phase induction motor where single phase supply is needed to operate it. The three phase supply current produces an electromagnetic field in the stator winding which leads to generate the torque in the rotor winding. The figure 3.8 shows the stator and rotor of 3-phase induction motor.

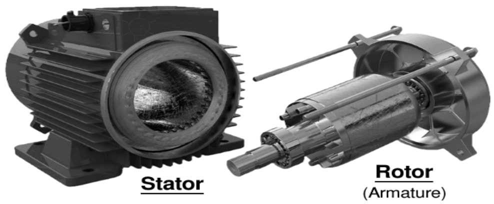


Fig. 3.8: Stator and Rotor

Induction motor works on the principle of electromagnetic induction. When three phase supply is given to the stator winding, a rotating magnetic field (R.M.F) of constant magnetic field is produced. The speed of rotating magnetic field is synchronous speed, NS rpm. This rotating field produces an effect of rotating poles around a rotor. Let us take the direction of this magnetic field is clockwise.

Now at this instant rotor is stationary and stator flux R.M.F. is rotating. So it's obvious that there exists a relative motion between the R.M.F. and rotor conductors. Now the R.M.F. gets cut by rotor conductors as R.M.F. sweeps over rotor conductors. Whenever a conductor cuts the flux, e.m.f. gets induced in it. So e.m.f. gets induced in the rotor conductors called rotor induced e.m.f. this is electro – magnetic induction. As rotor forms closed circuit, induced e.m.f. circulates current through rotor called rotor current. Any current carrying conductor produces its own flux. So rotor produces its flux called rotor flux. For assumed direction of rotor current, the direction of rotor flux is clockwise.

Now there are two fluxes, one R.M.F. and another rotor flux. Both the fluxes interact with each. On left of rotor conductor, two fluxes are in same direction hence added up to get high flux area. On right side of rotor conductor, two fluxes are in opposite direction hence they cancel each other to produce low flux area. So rotor conductor experiences a force from left to right, due to interaction of the two fluxes. As all rotor conductor experiences a force, overall rotor experiences a torque and starts rotating. So interaction of the two fluxes is very essential for a motoring action.

3.7.3 Application of 3-Phase Induction Motors

The induction motor is mostly used in industrial applications. The squirrel cage induction motors are used in residential as well as industrial applications especially where the speed control of motors is not needed such as:

- Pumps and submersible pumps.
- Pressing machine
- Lathe machine
- Grinding machine
- Conveyor
- Flour mills
- Compressor
- Steel mills
- Lift
- Crane Machine
- Hoist
- Line shafts

3.8 ELECTRIC LOAD

In day to day life we come across the term electric load frequently. It is a device which consumes the electric energy in the form of current and transforms it into other desired output forms. They may be heat, light, work, etc. They are classified as fallows.

3.8.1 Classification of Electric Load

The nature of the Electric load depends on the application for which it is applied. The load factor, demand factor, diversity factor, power factor, and utilisation factors are the deciding parameters. The different types of electric loads are explained in figure 3.9 as below.

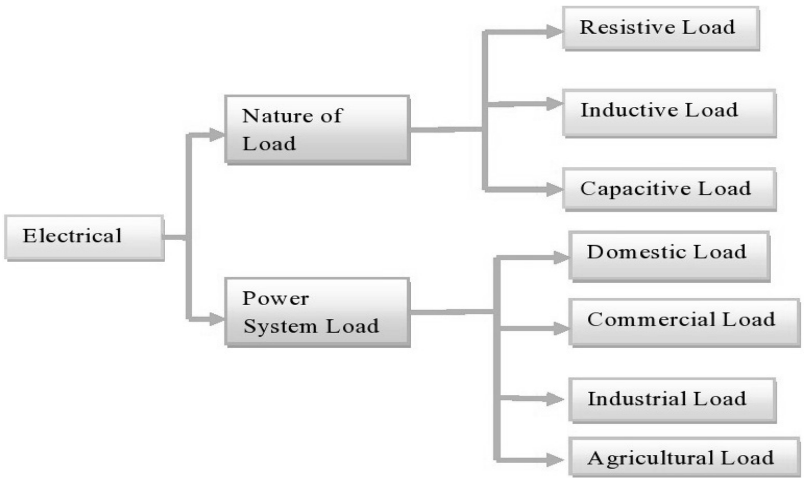


Fig. 3.9: Classification of electric loads

- **Resistive Load:** This load obstructs the flow of electrical energy in the circuit and converts it into thermal energy, due to which the energy dropout occurs in the circuit. The lamp and the heater are the examples of the resistive load. The resistive loads take power in such a way so that the current and the voltage wave remain in the same phase. Thus the power factor of the resistive load remains in unity.
- **Inductive Load:** The inductive loads use the magnetic field for doing the work. The transformers, generators, motor are the examples of this load. The inductive load has a coil which stores magnetic energy when the current pass through it.
- **Capacitive Load:** Here the voltage wave is leading the current wave. The examples of capacitive loads are capacitor bank, three phase induction motor starting circuit.
- **Domestic Load:** This load largely consists of lighting, cooling or heating. It is the total electrical energy consumed by the electrical appliances in the household work. It varies from house to house because it depends on the living standard, climatic condition, geographic location, type of residence and many more. The domestic loads mainly consist of lights, fan, water heater, refrigerator, air conditioners, mixer, grinder, room heater, ovens, water pump, etc.
- **Commercial Load:** This mainly consist of lightning of commercial spaces like shops, offices, advertisement hoardings, etc., Along with Fans, Heating, Air conditioning and

many other electrical appliances used in commercial establishments such as market, restaurants, offices, bank, school, college are considered as a commercial load.

- **Industrial Loads:** it includes small-scale industries, medium scale industries, large scale industries, heavy industries and cottage industries.
- **Agriculture Loads:** This includes mainly water pumps-sets for irrigation purposes. The agricultural implements.

3.9 ELECTRIC DRIVE

An electrical drive is an electromechanical device for converting electrical energy into mechanical energy to impart motion to different machines and mechanisms for various kinds of process control. An Electric Drive is a system, used to control the movement of an electrical machine. This drive employs a prime mover such as a petrol / diesel engine, steam / gas turbines, electrical / hydraulic motors like a main source of energy. These prime movers will supply the mechanical energy toward the drive for controlling motion. An electric drive can be built with an electric drive motor as well as a complicated control system to control the rotating motor shaft.

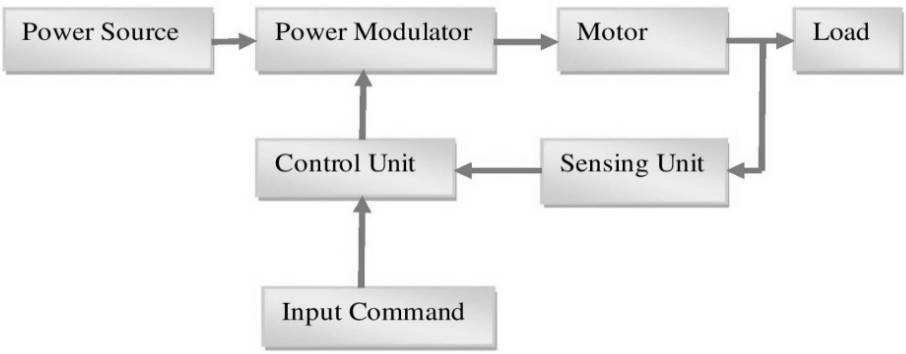


Fig. 3.10: Electric Drive block diagram

The power source offers the necessary energy for the system. The modulator is used to control the output power of the supply. The power controlling of the motor can be done in such a way that the electrical motor sends out the speed-torque feature which is necessary with the load. The power modulator can change the energy based on the motor requirement. And it also chooses the motor's mode of operation like braking or motoring. The control unit is used to control the power modulator. This unit produces the rules for the safety of the motor as well as power modulator. The sensing unit is used to sense the particular drive factor such as speed, motor current. This unit is mainly used for the operation protection.

3.9.1 Applications of Electrical Drives

- Traction systems- electric tractions mainly include electric trains, buses, trolleys, trams, and solar-powered vehicles inbuilt with battery.
- Lifts, cranes, electric car, etc.
- Extensively used in the huge number of domestic as well as industrial applications
- They are used in extreme operating conditions such as explosive and radioactive environments

3.10 ELECTRONIC ENGINEERING

Electronics and communication engineering is an extension of electrical engineering where the advanced systems are discussed. The devices what we use from mobile to space shuttle require the electronic parts. The advancement and advantages of electronics in industrial activities lead us to embrace the change. The new interdisciplinary has evolved known as Mechatronics. It is a way of combining the classical engineering disciplines for mechanical, electrical engineering and computer science. The objective is to build smart products and "intelligent" machines. The major objective of mechatronics is to design and implement the system in which mechanical, electrical and electronic subsystems are embedded into a single system.

The industrial automation demands the self control system to meet the highest accuracy, sensitivity, speed, quick response etc. This is possible by integrating the electronic devices such as diodes, transistors, sensors, semiconductors, integrated chips, resistors and many more with mechanical devices. The scope and application of electronics in engineering field is vast, but we will confine our scope to mechanical / manufacturing engineering here. We accepted the automated system over manual systems based on advantages and economics involved in it. One such system we will discuss here is control system.

3.10.1 Control System

A control system is a system of devices that manages, commands, directs, or regulates the behaviour of other devices or systems to achieve a desired result. A control system achieves this through control loops. As human civilization is being modernized day by day the demand for automation has increased alongside it. Automation requires control over systems of interacting devices.

In recent years, control systems have played a central role in the development and advancement of modern technology and civilization. Practically every aspect of our day-to-day life is affected more or less by some type of control system. Few examples of domestic and industrial applications are air conditioner, refrigerator, automatic iron. In industry the quality control of products, weapons, transportation systems, power systems, space technology, robotics, and many more.

There are two main types of control systems. They are Open-loop control systems and Closed-loop control systems.

- **Open-loop control system**

  It is also referred as non-feedback system; here the output has no influence or effect on the control action of the input signal. In other words, in an open-loop control system the output is neither measured nor "fed back" for comparison with the input. Therefore, an open-loop system is expected to faithfully follow its input command or set point regardless of the final result. The figure 3.11 shows the open loop system.

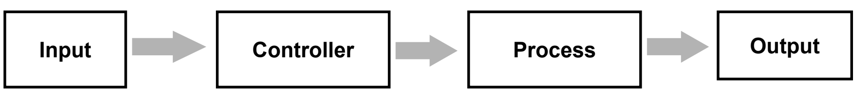


Fig. 3.11: Open loop control system

Some of the practical examples of open loop control system are listed below

- **Light Switch –** Lamps glow with full power irrespective of intensity requirement.
- **Volume on Music System / TV –** adjusted manually irrespective of audibility.

- **Electric Hand Drier** – Hot air comes out in wash rooms as long as you keep your hand under the machine, irrespective of how much your hand is dried.
- **Car Wind screen wiper** – Irrespective of quantity of rain drops it wipes the wind screen until it is stopped.
- **Washing Machine –** The normal washing machine runs according to the pre-set time irrespective of washing is completed or not.
- **Bread Toaster –** machine runs as per a time set irrespective of toasting is completed or not.
- **Automatic Tea / Coffee wending machine –** works for pre-adjusted time irrespective of size of cup.

- **Closed Loop control system**

  Here the output is controlled based on the input quality/quantity such that the input will adjust itself based on the signal received by the feedback system based on output requirement. The open-loop control system can be converted into a closed loop control system by introducing the feedback system in a loop. The figure 3.12 below shows the block diagram of the closed loop control system.

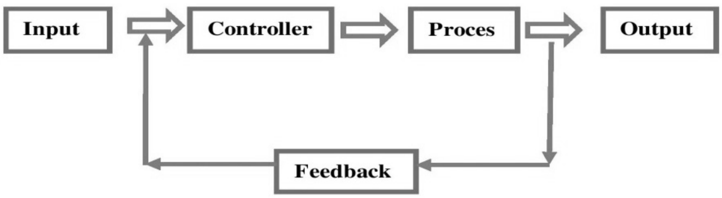


Fig. 3.12: Closed loop system.

The following are the few applications of closed loop system.

- **CNC Machine:** Receives the signal based on the machining requirements.
- **A Missile Launched Radar Auto Tracker:** The direction/position of the missile is controlled by comparing the target.
- **Water Level Controller:** The water level is controlled by the sensor in the water tank, when it reaches the desired level, automatically the water pump gets on / off.
- **Automatic Electric Iron:** Heating elements are controlled by the output temperature of the iron.
- **Servo Voltage Stabilizer:** Voltage controller operates depending upon the output voltage of the system.
- **Room Air Conditioner:** Air conditioner functions depending upon the temperature variation of the room.

INTERESTING FACTS

William Gilbert, an English scientist, characterized magnetism and static electricity around the year 1600, and Alexander Volta discovered that an electric current could be made to flow in1800. In the mid-1800s, a variety of European scientists had established the general rules governing electricity, and, ultimately, theories involving electricity and magnetism were joined under a concept called electromagnetism (James Clerk Maxwell's discovery). Thomas Edison developed many useful items such as the light bulb.

In the year 1821, British scientist Michael Faraday explained the conversion of electrical energy into mechanical energy by placing a current-carrying conductor in a magnetic field, which resulted in the conductor's rotation due to the torque produced by the mutual action of electrical current and field. Later in the year 1886, the first electrical motor was invented by scientist Frank Julian Sprague. That was capable of rotating at a constant speed under a varied load range and thus derived motoring action.

The first electric drive was invented in 1838 by B.S.Iakobi in Russia. He tested a DC motor which is supplied from a battery to push a boat. Although, the application of electric drive in industrial can happen after so many years like in 1870. At present, this can be observed almost everywhere. We know that the speed of an electrical machine (motor or generator) can be controlled by the source current's frequency as well as the applied voltage.

Printed circuit boards are almost always green because they are made from a glass-epoxy, which is naturally green.

A Siemens SMT line can place a component as small as 0.4 mm x 0.2 mm on a board. It is so tiny you would need a microscope to see it.

Only 10 percent of energy in a light bulb is used to create light. Ninety percent of its energy creates heat. Compact fluorescent light bulbs (CFLs) use about 80 percent less electricity than conventional bulbs and last up to 12 times longer.

VIDEO RESOURCES

Electric Circuits

Fundamentals of BEE

Basic Electronics

UNIT SUMMARY

- Alternating current reverses its direction many times but direct current flows in only one direction.
- The transformer is static piece of device by means of which the electric power is transformed from one alternating current circuit to another with the desired in voltage and current, without changing the frequency.
- Electric motor is an electric machine which converts supplied electrical energy into mechanical energy. The electric motor operates through the interaction between these motor's magnetic field and electric current in a wire winding.
- The three phase supply current produces an electromagnetic field in the stator winding which leads to generate the torque in the rotor winding.
- The nature of the Electric load depends on the application for which it is applied. The load factor, demand factor, diversity factor, power factor, and utilisation factors are the deciding parameters.

- An electrical drive is an electromechanical device for converting electrical energy into mechanical energy to impart motion to different machines and mechanisms for various kinds of process control.
- The open-loop control system can be converted into a closed loop control system by introducing the feedback system in a loop.

EXERCISES

Subjective Questions

S.No.	Question	CO	BL	PO	PI Code*
1.	Define the relation between voltage, current and resistance	3	L1	1	1.4.1
2.	Enlist the devices which uses the Alternating and Direct Current	3	L1	1	1.4.1
3.	With the help of block / circuit diagram discuss the power flow for a desktop computer system.	3	L1	1	1.4.1
4.	Discuss the transformer working with applications	3	L1	1	1.4.1
5.	Discuss the application areas of an electrical motor in engineering field	3	L1	1	1.4.1
6.	Discuss the classification of different electric loads	3	L1	1	1.4.1
7.	Comment on advantages of closed loop control system over the open loop control system	3	L1	1	1.4.1

Multiple Choice Questions

S. No.	Question	Ans.	CO	BL	PO	PI Code*
1.	For a coil having a magnetic circuit of constant reluctance, if the flux increases, what happens to the current? (a) Increases (b) Decreases (c) constant (d) Becomes zero	a	3	L1	1	1.4.1
2.	Kirchhoff's current law deals with the conservation of? (a) Momentum (b) Mass (c) Potential Energy (d) Charge	d	3	L1	1	1.4.1
3.	A source transformation is__________ (a) Unilateral (b) Bilateral (c) Unique (d) Cannot be determined	b	3	L1	1	1.4.1
4.	The Primary reason for D.C. motor Preferred over A.C. motor (a) Constant speed operation (b) High-speed operation (c) Variable speed operation (d) Low-speed operation	c	3	L1	1	1.4.1

S. No.	Question	Ans.	CO	BL	PO	PI Code*
5.	A closed loop system is distinguished from open loop system by which of the following? (a) Servomechanism (b) Feedback (c) Output (d) Input	b	3	L1	1	1.4.1

*The Performance Indicator code is referred from the AICTE exam reform document

KNOW MORE

- The application of Ohms', Kirchhoff's law to different circuits.
- The calculations and numeric's involved in power transmission.
- Construction and working of transformers for various applications.
- Understand the conversion of AC to DC and vice versa for requirements.
- Closed loop control systems for domestic and industrial applications.
- The creation / demonstration of simple electric circuits with various elements for academic purpose.

REFERENCES AND SUGGESTED READING

- John Bird, "Electrical Circuit theory and Technology", Elsevier Third Edition, 2003.
- Lj.Nagrath and M. Gopal, "Control System Engineering", New Age International Publishers, 2006.
- R.K. Rajput, Utilization of Electrical Power, Laxmi Publication (P) Ltd.
- NPTEL course on "Basic Electrical Technology", IIT Kharagapur

4 Carpentry Plastic Moulding Glass Cutting

UNIT SPECIFICS

This unit elaborately discusses the following topics:

- Wood working Tools
- Power Tools
- Plastic Moulding
- Glass Cutting

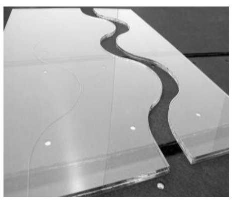
The content and the video resources relate the topics to the industrial and day today activities very closely.

RATIONALE

With the advancement of the science and technology the human beings are facing a challenge to develop newer materials to accommodate his sophisticated requirements. To meet such requirements, especially the construction of domestic, commercial and industrial premises / equipments becomes very challenging. The wood, plastic and glasses are used abundantly in the construction work, machineries, equipments and amenities. The better aesthetics, lighter weight, strength, etc has encouraged the innovations in carpentry, plastic moulding and glass cutting industries. The following images may give some input about the importance of this carpentry, plastic moulding and glass cutting activities in different industries.


Carpentry


Plastic Moulding


Glass Cutting

The **carpentry** work has applications in building construction, furniture, artistic equipments, idols, chariot, interior design of buildings, automotive body building (trucks),handles for metallic weapons / equipments (swords / hacksaw, axe etc). The **plastic molding** is process where powder or liquid polymer such as polyethylene or polypropylene is placed into a hollow mold so the polymer can take mould shape. Depending on the type of process used, the range of heat and pressure used to create an end product. The plastic moulding finds application in both domestic and industrial appliances. The helmet, automotive parts like plastic gears, electrical switches, consumer products, medical devices and toys etc. The **glass** is a mixture of silica and soda ash. The glass is most widely used material, finds its application for construction, automotive, medical, aerospace, toys, packaging, tableware, artistic elements, sun glass, lens, chemical containers etc.

PRE-REQUISITES

- Drawing
- General safety measures
- Hand tools
- Information about materials-Steel, Wood, Plastic and Glass

UNIT OUTCOMES

The students will be able to:

U4-O1: Identify the different carpentry tools

U4-O2: Prepare carpentry models for given drawings.

U4-O3: Identify the plastic moulding operations

U4-O4: Demonstrate the plastic moulding process

U4-O5: Get aware to the glass cutting operations.

Mapping of the Unit Outcomes with the Course Outcomes:

Unit-4 Outcomes	Expected Mapping with Course Outcomes *(1 – Weak Correlation; 2 – Medium Correlation; 3 – Strong Correlation)*				
	CO-1	CO-2	CO-3	CO-4	CO-5
U4-O1				1	
U4-O2				2	
U4-O3				1	
U4-O4				1	
U4-O5				1	

4.1 CARPENTRY

It is the oldest term used in the human civilization; Primitive carpentry developed in the forest regions during the latter part of the Stone Age, when early humans improved stone tools so they could be used to shape wood for shelter, animal traps, and dugout boats. In the Middle Ages, carpenters began a movement towards specializing as shipwrights, wheelwrights, turners, and millwrights. Now the Carpentry has become a **skilled trade and a craft.**

The carpentry work is primarily meant for cutting, shaping and installation of building materials in construction of buildings, ships, timber bridges, concrete formwork, etc. Carpenters traditionally worked with natural wood and did rougher work such as framing, but today many other materials are also used and sometimes the finer trades of cabinet making, interior decoration, idol making, furniture making, and acoustic buildings are also considered as part of carpentry work. Now the scope of carpentry is not only limited to wood and wood products but also it is expanded to synthetic building materials with the usage of power tools. Today's carpenters not only know about wood, but also about materials such as particle board, wall-board, suspended ceiling, tile, plastic, laminates. They must also know how to use many modern tools, fasteners, construction techniques, interior designs, space constraints, and how to follow safety procedures.

Throughout the ages, people are using the wood for a variety of purposes like fuel, building materials, weapons, cart making, automotive body building, burning the dead bodies etc. Most commonly we use wood for everything but it is important to distinguish wood from lumber.

Lumber refers to the board, timbers, etc., produced from sawmills, whereas wood refers to the materials itself, which comes from many species of trees. Based on the type of the finish obtained the carpentry is divided into two categories as rough and finish carpentry. The rough carpentry includes erecting frameworks, scaffolds, and wooden forms for concrete, as well as building docks, bridges, and supports for tunnel and sewers. Finish carpentry includes building stairs, installing doors, cabinets, wood paneling and moulding and putting up acoustical tiles. Along with wood the product of the wood known as plywood is also extensively used. Plywood is made of number of layers or plies of wood veneers. A layer may be 1/16 inch to 5/8 inch thick. The center layer is known as the core.

4.1.1 Advantages of Wood

- Wood is among the most versatile building materials in the world.
- Besides its inherent beauty, wood has a much higher ratio of strength to stiffness than iron, steel, or concrete.
- It is easily available as well as worked easily.
- It has great ability to absorb shocks from sudden loads.
- It is free from rust and corrosion, comparatively light in weight, and adaptable to a countless variety of purposes.

4.1.2 Applications of Wood

- **Constructional material:** roofs, pillars, doors and windows, shuttering materials for concrete work.
- **Agricultural implements:** Bullock cart, Hoe, Plough, Yoke, Leveller, Harrow, Spade, Axe. Scythe etc
- **Transportation industry:** for body building of Trucks, railway coaches, chariot, boat, ships.
- **Furniture:** table, chair, sofa set, kitchen wares etc.
- **Sports and entertainment:** cricket bat, hockey stick, baseball stick, walking stick, musical instrument like harmonium, piano, etc.
- **Toy industry:** wooden toys for kids play,
- **Artistic industry:** wood carvings, interior design, wardrobes, idols.
- **Weapon holder:** sword, knife, rifle gun etc.
- **Fuel:** for cooking in rural areas and for burning.

It is necessary for every professional to know how to make different products from the wood. Most of the prototypes can be created out of the wood and wood products. So it is necessary for all of us to understand the different types of tools required to work on the wood / lumber cutting and shaping operations.

4.1.3 Wood Working Tools

With the help of hand and tools one can create anything that comes to mind to form the wood. The carpentry tools can be categorized under following headings.

a. Marking and Measuring Tools
b. Cutting Tools
c. Planning Tools

d. Boring / Drilling Tools
e. Striking Tools
f. Holding Tools
g. Power Tools

Lets us discuss the above tools in detail in the following lines

4.1.4 Marking and Measuring Tools

Even though the wood work does not require the much precision measurements the following tools assures the required precision needed.

Folding Ruler

It is a wooden measuring instrument having four folding with each measure 15 cm in length. The ruler is able to measure up to 60 cm. shown in figure 4.1.

Fig. 4.1: Folding Ruler

- **Divider:** It is used to transfer the equal distance from measuring scale to the work piece.
- **Calliper:** Used to measure the inside and outside diameters of the work piece.

Try Square

It is used to check the perpedicularity of the surfaces. Also used to draw the perpendicular lines. It consists of a steel blade marked with the centimeter / inch on it. The Stock may be metallic or wooden, made to hold the measuring blades, Shown in Figure 4.2.

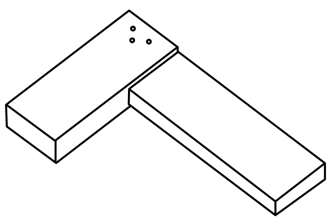


Fig. 4.2: Try Square

Bevel Square

It is used for setting, measuring, making parallel lines and angles on the work piece. It is made with the metallic or wooden stock fitted with the slotted measuring blade. The blade can be adjusted along the slot at any required angle by the screw. 0 -180° angles can be set using this instrument. Shown in Figure 4.3.

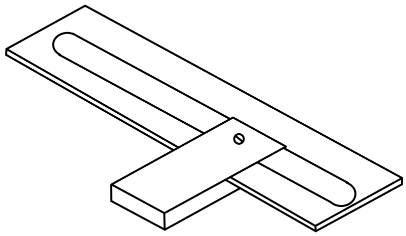


Fig. 4.3: Bevel Square

Marking Gauge

Marking gauge is commonly known as a scratch gauge. It is used for both wood working and metal working to mark out lines for outlining or cutting operations. The parallel lines can be easily drawn with reference to the edge or surface. It is made with four parts. A long wooden beam 20 cm to 30 cm, a fence, locking screw and a marking scribe / needle. The fence slides along the beam to adjust the desired distance for marking. The locking screw is used to lock the movement. The marking needle has sharp metal which will pierce through the wood. Shown in Figure 4.4.

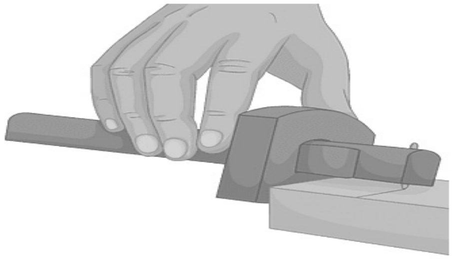


Fig. 4.4: Marking Gauge

Mitre Square

It is used for marking and checking angles other than 90° in woodwork and metalwork. Commonly mitre squares are used for marking and verifying 45° and supplementary 135° angle. It is shown in Figure 4.5.

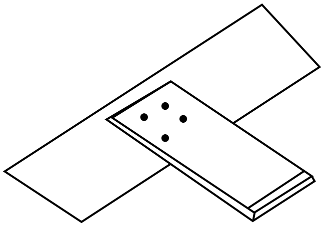


Fig. 4.5: Mitre Square

Mortise Gauge

A mortise gauge has two pins that can be adjusted relative to each other at the end of the beam. This gauge is used to scribe two lines simultaneously and is most commonly used to layout mortise in domestic construction. The main body commonly known as the stem. It is made by a solid piece of wood. Adjustable pin and locking screw for desired adjustments. The screw pulls a piece of wood within the stem to control the adjustable pin. The needle is made by sharp thin metallic element. It is shown in Figure 4.6.

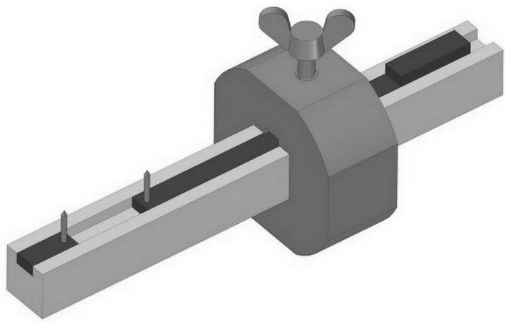


Fig. 4.6: Mortise Gauge

4.1.5 Cutting Tools

The cutting tools include the saw, chisel and gouges. These are basically used to cut the wood into desired size, shape and dimensions. Usually the finishing operation is done with the different kinds of chisels. Let's discuss them in following headings.

Rip Saw

It is an all purpose saw used by carpenter. A rip saw is also known as tooth saw. The rip-cut saw will taper down to some virtual point at its very end. The rip saw cuts during the forward or push stroke to craft a clean cut along the grain. This design enables it to move easily within the wood as you cut. Usually the Rip saw measures 700 mm long and 12 to 20 teeth per 100 mm length. It is shown in figure 4.1.5 (a). The rip saw has larger teeth and is used for cutting along the grain.

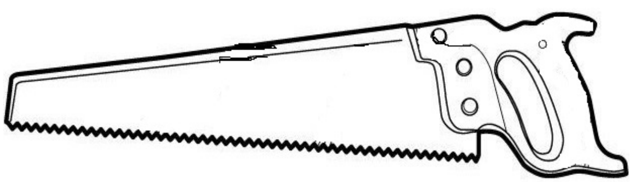


Fig. 4.7: Rip Saw

Cross Cut Saw

A crosscut saw is designed for cutting wood perpendicular to the wood grain. Crosscut saws may be smaller or larger in size, with small teeth close together for fine work like woodworking or large for coarse work like log bucking. The length usually ranges from 600 to 650 mm long, 39 to 40 teeth per 100 mm length. Shown in figure 4.8.

Fig 4.8: Cross Cut Saw

Coping Saw

Coping saw is used to make both external and internal cuts. It falls in the bow saw category. It has a thin narrow blade of 250 to 350 mm length. It is positioned and stretched between a steel frame and locks on both ends. This saw works on a pull stroke and comes with teeth that face downwards. The coping saw has ability to cut through a hole or even a cutout. This saw is used for cutting curves as the handle revolves in their sockets. The stiffness can be maintained by tightening the lock screw. It is shown in figure 4.9.

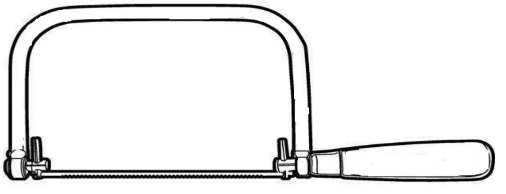


Fig. 4.9: Coping Saw

Tenon or Back Saw

A Tenon Saw is a large backsaw used for making deep, accurate cuts in furniture joinery. It should make straight, fast cuts without binding. The saw derives its name from its use in the cutting of tenons for mortise and tenon joinery. A thin blade is reinforced with steel back. Tenon blades are 250 to 400 mm in length, around 50 teeth per 100 mm length. The teeth look like equilateral triangle sometimes called as peg teeth. It is shown in figure 4.10.

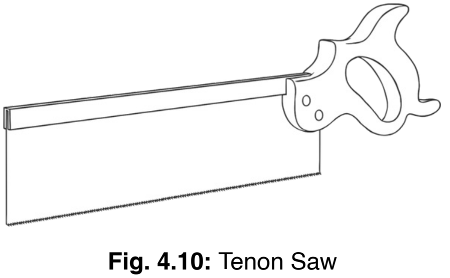


Fig. 4.10: Tenon Saw

Firmer Chisel

It is most commonly used general purpose tool; it can be operated by either hand pressure or mallet force. They are made by solid steel. They were used in heavy-duty woodwork and had a blade with a rectangular cross-section and hardwood handles. Firmer chisels are considered very distinctive and extraordinary as they are one of the oldest models of chisels. They are used to create very sharp and perpendicular corners. Shown in figure 4.11 (e).

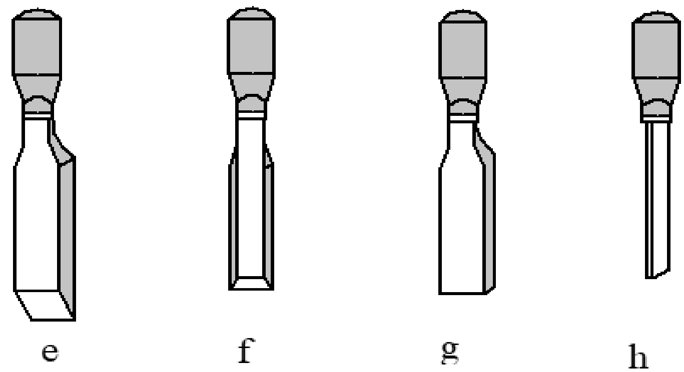


Fig. 4.11: (e) Firmer Chisel, (f) Beveled Edge Firmer, (g) Paring Chisel, (h) Mortise Chisel

Bevelled Edge Firmer Chisel

These are used for more delicate work activities, where the firmer chisel may not be useful. They are not too long or too short; most of the carpentry industries commonly use them. The name itself indicates that they have a bevelled side and straight edge, which allows them maximum access to dovetail joints. Shown in figure 4.11 (f).

Paring Chisel

It looks like the combination of firmer and beveled edge firmer chisel. They are long, thin, and flexible chisels with often beveled sides. The cutting edge of the blade is sharpened to 15 to 20 degrees to enable smooth cutting. Most of the time the Paring chisels are operated by hand and need not be hit with a mallet as they are delicate instruments designed for fine work. Shown in figure 4.11 (g).

Mortise Chisel

The mortise chisel is named so because it is primarily used to cut mortise joints. These chisels have heavy blade which is thicker than its width, ranges from 3 to 16 mm. It consists of huge forged bolsters and a hardwood handle. They are usually capped or have steel hoops on their handle that help them to withstand the blows of a mallet. The chisel is edged to an angle between 30 and 40 degrees. Shown in figure 4.11 (h).

Gouges

These are special purpose chisels which are made of curved blades at the tip. The curved shape may be inside or outside; sometimes it has spoon shape based on the requirement. The outside ground gouges are used to make hallows. The outside ground chisels are called as firmer gouges and inside ground gouges are called as scribing gouges. The shapes of gouges vary from soon shape to fish tail type. The size varies from 6 mm to 40 mm wide. Shown in figure 4.12.

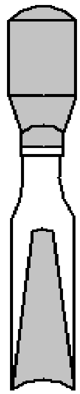


Fig 4.12: Gouge Chisel

4.1.6 Planing Tools

The planes are used to create the smooth leveled surfaces on the wood. The various planes used in the workshop are jack plane, trying plane, rebate plane, smoothing plane, plough plane and metal plane.

Wooden Jack Plane

Wooden jack plane is oldest form of general-purpose wood working bench plane. It is used for removing the upper layer of timber down to size in preparation. It consists of a wooden block known as body; the cutting blade is fixed with the support of wedge and cap iron or back iron. The back iron may not be involved in cutting operation but it supports the blade to prevent the chattering and break the shaving into curly pieces. The length may range from 350 to 450 mm and blade width may be 50 to 75 mm. Shown in figure 4.13.

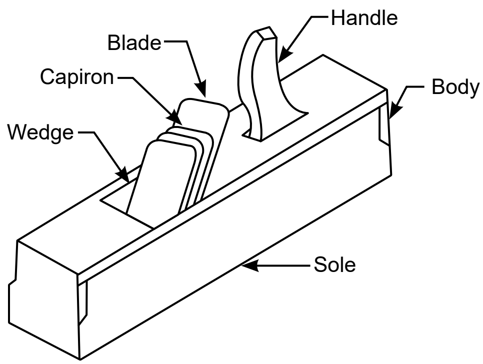


Fig. 4.13: Wooden Jack Plane

Metal Jack Plane

It serves the same purpose as that of wooden jack plane but facilitates better surface finish and faster operation. Here the body is made of grey cast iron. The sole and other parts have bright finish and bulky in nature. The thickness of layer removal can be adjusted with the help of adjustment screw. In place of wedge in wooden plane metal strips are used for adjustment and support. It is shown in figure 4.14.

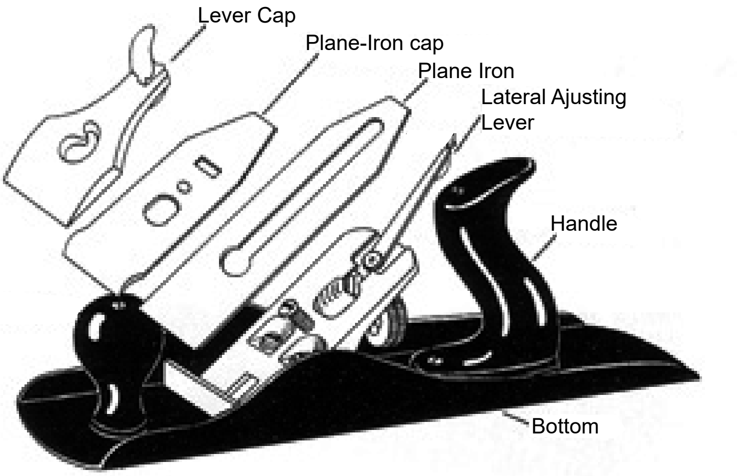


Fig. 4.14: Metal Jack Plane

Trying Plane

It is used for finishing operation. It is used to remove very thin layer of wood. The length of the plane usually varies from 550 to 650 mm; the width of the blade is 60 mm.

Smoothing Plane

It is the smallest of its kind and can be held by single hand to operate. As the name indicates it is used for finishing operation. It is used to cut very minute layer of wood, commonly used after the jack plane operation. It measures around 200 to 250 mm long and blade width about 70 mm. It is shown in figure 4.15.

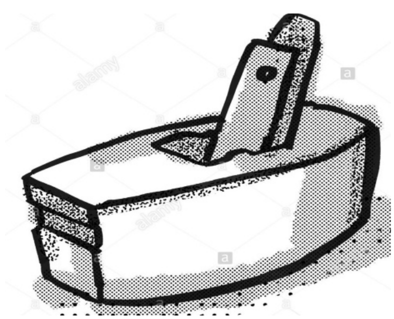


Fig. 4.15: Smoothing Plane

Rebate Plane

It is also known as rabbet plane. Its hand plane designed to make small recess along the edges to join. It is used to make grooves for rebate joints (also known as lap joints). This plane finds application in door fitting slots, window glass fitting slots. Usually width of the blade ranges from 10 to 50 mm. It is shown in figure 4.16.

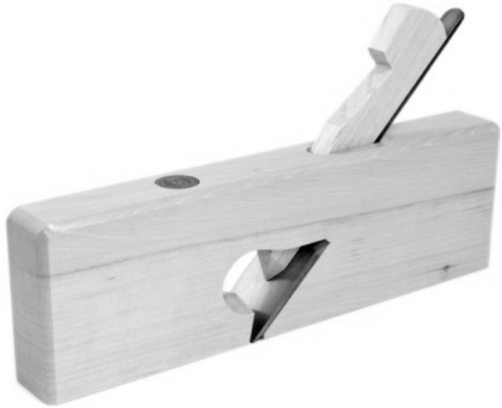


Fig. 4.16: Rebate Plane

4.1.7 Boring / Drilling Tools

The carpentry work also needs to make a drill / bore to accommodate the nails, rivets, stoppers etc. To perform the drill the various hand driven tools are used in the workshop. They are Gimlet, Bradawl and Brace boring tool. The various kinds of the drill bits are used in these boring equipment.

Bradawl Tool

It is very simple and handy tool; carpenters use this bradawl tool for boring small and medium shallow holes. These holes are used for seating the nails and screws of small to medium sizes. It is shown in figure 4.17.

Fig. 4.17: Bradawl Tool

Gimlet Tool

A gimlet is a handy tool used for drilling small holes in wood. It contains a tapered twisted steel bar. The twist is tapered and occupies about one third of its length. The bottom end has a sharper needle for easy penetration. The other end has a wooden handle for easy rotation. It is shown in figure 4.18.

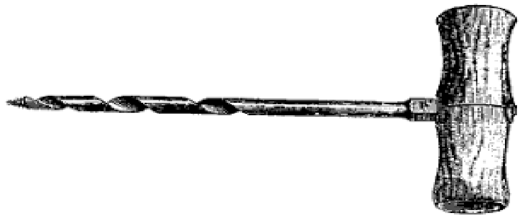


Fig. 4.18: Gimlet Tool

Brace Tool

Brace tool is a hand-operated tool for boring holes in wood; it consists of a crank-shaped turning device at the centre of the body with gripping element on it. The tail end has a provision to hold the twist drill bits. The operation takes place because of the ratchet and gear arrangement inside the unit. There are two types of the braces used in workshop; they are ratchet brace and wheel brace. In the wheel brace the handle wheel is fixed at the middle part of the equipment. The rotation of the wheel turns the drill bit at the tail end for drilling operation. Here the ratchet brace is shown in figure 4.19.

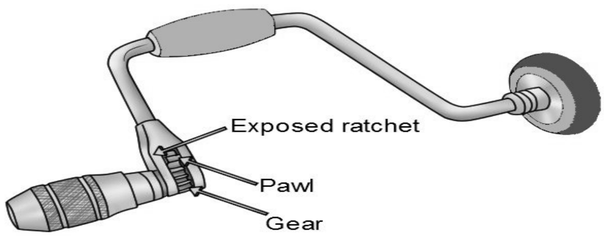


Fig. 4.19: Ratchet Brace

4.1.8 Striking Tools

The striking tools used in carpentry work are light in weight and used for lighter blows. Mallets and few cast iron hammers are generally used as striking tools in carpentry shop. A hammer is used for a sharp blow, at the same time it likely damages the chisel handle whereas the softer striking surface such as mallet made by rubber, wood, plastic will give better result. Some of important such tools are discussed as under.

Mallet

A mallet is a light weight hammer made of wood or sometimes rubber; it is smaller in size comparatively and relatively large head. In carpentry shop we find wooden or plastic mallets commonly. Mallets may have different material faces made of plastics, nylon and natural rubber. Even soft metals such as copper, aluminum, brass or lead used for special purpose applications. It is shown in figure 4.20 (a & b).

Fig. 4.20: (a) wooden mallet (b) nylon mallet

Steel hammers

Warrington, peen and claw hammers are generally used by carpenters. They are described as under. Warrington hammer shown in figure 4.21 is used for knocking in nails, assembling joints and setting wooden boards. The head is forged from tool steel and is obtainable in various weights. The face of hammer is hardened, tempered and ground slightly convex. The center part of the head is not hardened as a precaution against breakage in use through its being to brittle. The handle is made of wood and is oval in cross-section to have a comfortable grip. The end of the handle fits into a hole in the head and is held in position by wooden or metal wedges which open out the grain, thus securely locking the two parts together.

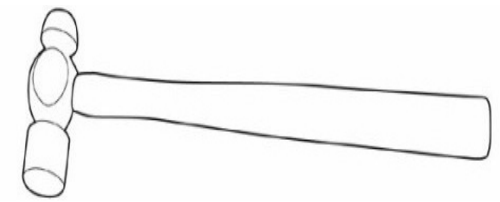


Fig. 4.21: Warrington Hammer

The claw hammer on one end it possesses curved claw which is used for pulling out nails. The other end is used for light striking work. In order to provide the extra strength needed for this levering action a strong handle on claw hammer is always necessary for carrying out this task. It is shown in figure 4.22.

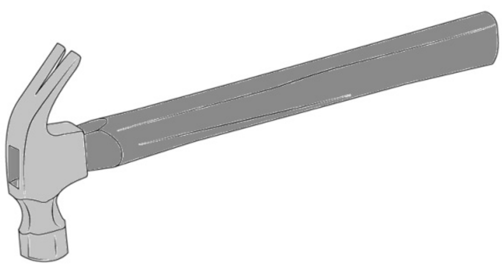


Fig. 4.22: Claw Hammer

4.1.9 Holding Tools

The wood working personnel need work piece holding devices for effective and efficient working. The work bench, carpenter vice, c-clamp are most commonly used holding tools in carpentry shop. The workbench consists of flat surface to keep the wooden plates for different operations like cutting, planning, chiseling, marking etc. It has different size stoppers to hold the wooden blocks firmly while planning operation is carried out. The carpenter vice is a metallic device having a movable and fixed jaw. By rotating the handle the jaw movement can be controlled, the movable jaw slides over the screw. The assembly and fitting of the wooden plates will be carried out by this device. It is shown in figure 4.23.

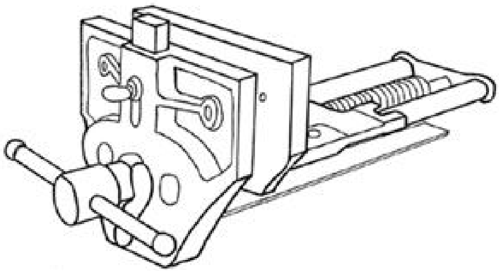


Fig. 4.23: Carpenter Vice

C-clamp or G-clamp or G-cramp is one more holding device used in the carpentry shop to hold the work piece. These clamps are called C clamps because of their C-shaped frame, or also often called C-clamps or G-clamps because including the screw part; they are shaped like English capital letter G. They are used along with the small padding plates to avoid the indentation of the clamp end. It is shown in figure 4.24.

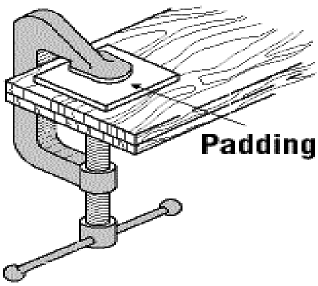


Fig. 4.24: C-clamp

4.1.10 Power Tools

As the automation embracing all the fields in science and technology, the carpentry shop is not excluded. The newer and advanced tools / devices finds place in carpenters tool kit. As we know that the efficiency, effectiveness, dimensional tolerances are the buzz words in industries of today, the only solution is usage of power tools. Most commonly used power tools in carpentry works are discussed below. The power tools require the power source in the form of fuel, electricity or stored energy (dry or wet battery).

Circular saw

Circular saw is one of the most commonly used for cutting operation; the various sizes of the wood can be cut quickly and effectively within no time. It uses toothed / abrasive disk or blade to cut using a rotary motion of the electric motor. It consists of the metallic frame surrounding the cutter and rotating motor parts for protection, sufficient space is provided at the bottom for rotation of the cutter. The straight line cutting operation takes place either by moving the tool or by moving the work piece against it. This cutter is used to cut the wood log, plates and plywood sheets. This will replace the different conventional saw used in the carpentry shop. The circular saw rotates at 4000 to 5200 rpm and requires around 5 to 7.5 HP or 1440 watt, the blade diameter may be 185 mm and above. The various capacity and size circular saws are available in the market. It is shown in figure 4.25.

Fig. 4.25: Circular Saw (Courtesy: Bosch Tools)

Power drill

The power drill with various capacity are available in the market, they are used to make a required size holes on the wooden blocks. The power drills may be operated by electricity or battery. The power drill may use regular drill, hammer drill, or impact driver drill based on the application. Power drills are available in portable and battery-powered versions, and sometimes they also come with a cord. Hammer drills offer more force, the bit reciprocates hence it will bore easily through other enduring materials like concrete with better ease. Impact driver power drills work on the same principle as hammer drills, but with lesser force. The tool kit comprises the various shapes and length drill bits in it. It is shown in figure 4.26.

Fig. 4.26: Power Drill (Courtesy: Bosch Tools)

Table saw

A table saw is a fixed power tool sometimes referred to as a bench saw or saw bench. The table saw consist of a circular blade mounted on an arbor that is driven by an electrical motor. A table saw allows the user to cut wood on a flat table. The desired dimension is to be marked on the wood log and fed against the cutter so the cutting takes place. As the cutter is open in nature lot of care / precaution must be taken to operate the machine. It is shown in figure 4.27. The table saw cut with perfectly straight edges, but also used for miters, bevels, and even dado groove cutting.

Fig. 4.27: Table Saw

Nail Gun

A nail gun is used to drive nails into wood and other materials. This tool is replacing the nails and hammers otherwise they are operated manually. It drives nails much faster and efficiently than its manual counterpart. This will save money and time during process. There are varieties of nail gun models with different power range of operation. It is our responsibility to select the right model according to requirement. It is shown in figure 4.28.

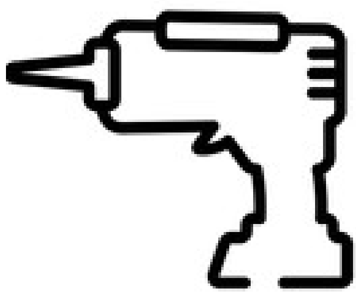


Fig. 4.28: Nail Gun

Jigsaw

It is commonly used to cut woods in rounded and circular patterns. It is more accurate and effective. Jigsaw tools are ideal for cutting curves and complex shapes on the wood plank. They are used to make crosscuts on a wooden board and finishing inside corners. But they are not good for making long, fast straight cuts where a circular saw works better. It is shown in figure 4.29.

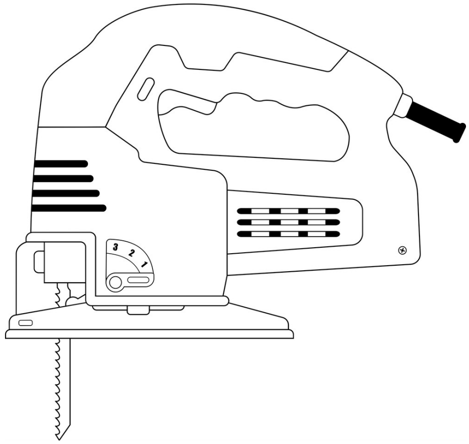


Fig. 29: Jig Saw

Sander

There are varieties of sanders are available, they are palm sander, Random orbital sander.

It uses hook and loop fastened sanding disks. A random orbital sander is a good tool for getting an incredibly smooth and scratch-free finish. It is a sander that moves the sanding media in a circular manner while at the same time moving the entire pad in a slightly oval orbit around the center of the sanders in z-axis. A random-orbit sander is a hand-held power tool popular with carpenters, cabinet makers and many other woodworking professions. A typical random-orbit sander consists of a mains or battery powered motor housed inside an ergonomic body to which a sanding pad can be attached. The motor drives the sanding disc and causes it to rotate at high speed, whilst simultaneously moving in an elliptical orbit so that no single spot on the disc travels the same path twice. It is shown in figure 4.30.

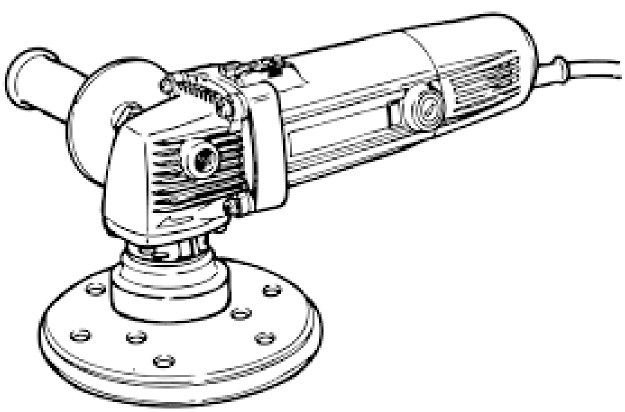


Fig. 4.30: Random Orbital Sander

Wood router

The wood router is the most versatile power tool in the wood worker's tool-range. It is a semi-portable tool that a worker can run manually. It is used to make the slots, counters, texts, slots etc on the wood surface. It is expected to prefer a router that has variable speed controls or they have ability to operate with slower speed. It is shown in figure 4.31.

Fig. 4.31: Wood Router

Wood Carving

INTERESTING FACTS

Carpentry in the United States is almost always done by men. With 98.5% of carpenters being male, it was the fourth most male-dominated occupation in the country in 1999, and there were about 1.5 million positions in 2006. Carpenters are usually the first tradesmen on a job and the last to leave.

Archaeologists believe crude forms of chisel have been around since prehistoric times. The ancient Egyptians used copper and bronze chisels to work wood and stone. In fact, ancient inscriptions made from chisels have been found in 7th-century BC Egyptian tombs. Greeks also used chisels to carve marbles in as early as the 6th century.

The Mahogany wood holds a regal stature worldwide. Dating all the way back to the 17th Century, Mahogany was used extensively in Great Britain. It is a fine wood, solid, glues perfectly and is aesthetically appealing. However, considering its huge demand and the sad fact that the mahogany tree sources were never replenished, there's a scarcity of this wood all over the world.

VIDEO RESOURCES

Building Materials

Construction Materials

Glass and Timber

4.2 PLASTIC MOULDING

Plastic is an organic material consists of synthetic or semi-synthetic compounds that are malleable in nature, therefore can be easily molded into solid objects. The term ''plastic'' is derived from the Greek word ''*plastikos*'', meaning *fit for moulding*. Whenever we talk about materials we use the term **plasticity**, it is general property of all materials that involves permanent deformation without breaking.

Today the world is full of plastics! Practically everything we see and use on a daily basis is entirely or partly made with plastic material. The television, computer, car, house, refrigerator, kitchenware, bank ATM card, stationery, clothes and many other essential products utilize plastic materials. However, all plastics are not made alike. Manufacturing industries use different plastic materials and compounds based on the requirements because each of them possesses unique properties.

The popular and commonly used plastics are Acrylic or Polymethyl Methacrylate (PMMA), Polycarbonate (PC), Polyethylene (PE), Polypropylene (PP), Polyethylene Terephthalate (PETE or PET), Polyvinyl Chloride (PVC), Acrylonitrile-Butadiene-Styrene (ABS)

4.2.1 Types of Plastics

Depending on physical properties, plastics are divided into following two types

- **Thermoplastics:** Plastics that can be deformed easily upon heating and can be bent easily. Linear polymers and a combination of linear and cross-linked polymers come under thermoplastics. Example: PVC, nylon, polythene, etc.
- **Thermo settings:** Plastics that cannot be softened again by heating once they are moulded. Heavily cross-linked polymers come under the category of thermosetting plastics. Example: Bakelite, melamine, etc. Bakelite is used for making electrical switches whereas melamine is used for floor tiles

4.2.2 Advantages of Plastics

- They are strong and ductile
- They have low melting temperature so can be moulded easily
- Poor conductors of heat and electricity
- No machining is required to get the final finishing.
- They have low density, hence lighter in weight.
- Available in different colours, the aesthetic appearance is pleasing.
- They are neutral in nature, may not react to acids and alkalise.
- They are corrosion resistant.

4.2.3 Applications of Plastics

Plastics find applications in almost all the areas of utility.

- Packaging
- Building and construction
- Mobility and Transportation
- Electrical and electronic devices
- Agricultural implements
- Medicine and Healthcare
- Sports and Leisure
- Energy and Power sector

4.2.4 Plastic Moulding Methods

Plastic moulding is the process of pouring liquid / semisolid / granular plastic into a certain container or mould to get the desired shape and size. There are five types of plastic moulding processes used in the industries. They are extrusion moulding, compression moulding, blow moulding, injection moulding and rotational moulding. Let us discuss them in following headings.

Extrusion Moulding

It is similar to the metal extrusion process here hot melted plastic is pressed through a pre designed die to create a lengthy shaped plastic part. It is most widely used for thermoplastics. This die is custom made for the particular outcome of the product that is desired. The other forms of plastic moulding methods also use extrusion so get the raw liquid into the moulds, the difference here is that other methods use the moulds to make the desired shape and here the extrusion die itself is making the shape.

The parts that can be extruded may include the straw, PVC pipes, plastic sheets, electric fitting strips, tubes etc. The process is shown in figure 4.32. The liquid / semi solid plastic billet is driven by the piston through the die; the desired output will be available at the other end.

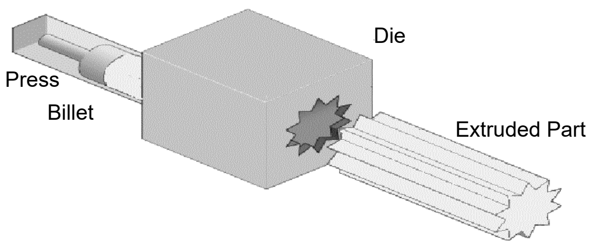


Fig. 4.32: Extrusion Moulding

Compression Moulding

In this method a preheated plastic billet is placed in an open, heated mold cavity. The mould is closed by moving the upper movable plunger over it. The moulds will get locked properly with the help of guiding screws provided on both the movable and fixed mould cavity. Once the upper movable plunger closes the mould, the plastic takes the shape of the pattern provided on the plunger. The process is finished off by cooling the mould so that the plastic keeps its form before being trimmed and removed from the mould. This process is used to make automotive components, toys, kitchenware, furniture etc. The process is shown in figure 4.33.

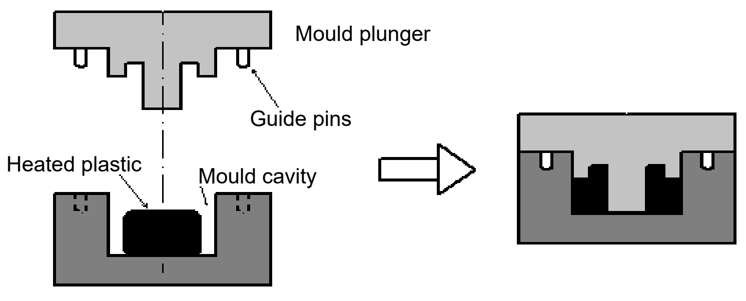
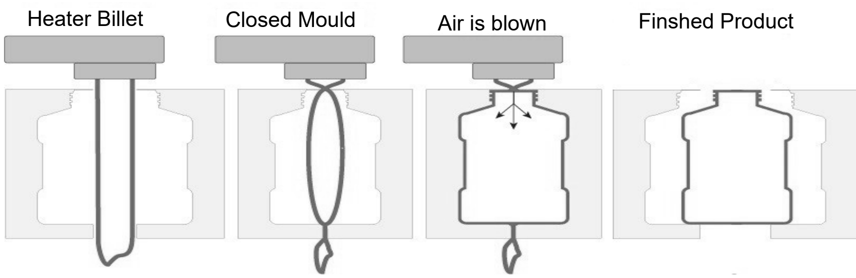


Fig. 4.33: Compression Moulding

Blow Moulding

With this method bottle and drums can be produced, Here the plastic is heated till it becomes to liquid state. The mould cavities are brought closer to this liquid plastic. Once the mould is closed the air is **blown** at the middle of the cavity so the liquid plastic moves towards the extreme walls of the cavity and sticks to the wall. The plastic gets its final shape because of the **air blow**, so the name is blow moulding. The excess material is passed through the recess provided at the bottom of the mould. After the certain time the mould gets cooled and the finished product is removed from the mould and trimming can be done to remove chipped plastic at the edges. The process is very fast and can be able to produce up to 1000 parts per hour based on the complexity of the job. This method is used to make plastic bottles, drums, cases, fuel tanks, toys, automotive components. It is shown in figure 4.34.



Designing of Plastic Products

Fig. 4.34: Blow Moulding

Injection Moulding

It is a most commonly used for high volume plastic component production. It consists of Cylinder with tapered ending towards the mould. The raw material in the form of granules or liquid plastic is poured in to the hopper. The raw material is pushed into cavity with the help of screw plunger. Near the taper end of the cylinder the heating coils are fixed to heat the raw material entering the cavity. The mould will be opened with the help of ejector pins once the mould gets cooled. Most of the complicated and intricate parts can be manufactured with the help of this process. The cost of the mould is high because it is made by aluminum or high strength steel. The injection moulding is used to produce construction equipments, kitchen wears, helmets, toys, electric switches, Health care equipments, toilet seats, furniture, scientific equipments etc. It is shown in figure 4.35.

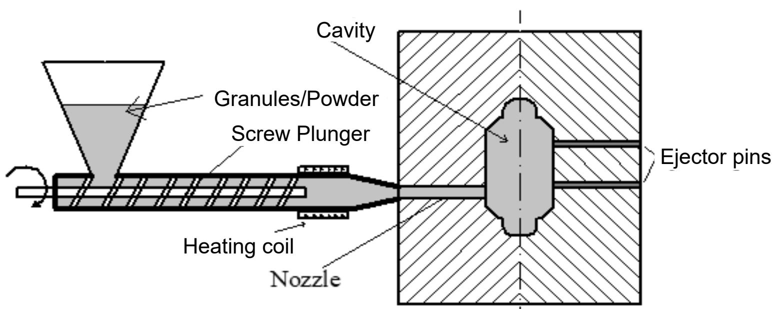


Fig. 4.35: Injection Moulding

Rotational Moulding

Rotational moulding is used for moulding the hollow products. Large size tanks, flower pots, footballs, road cones, fenders, luggage trays etc. The finished product takes place because of rotation and heating of the mould. The process takes place in four stages. It is shown in figure 4.36.

- **Filling of the raw material:** The mould cavity is opened to fill the powdered polyethylene or polypropylene and then mould is closed.
- **Rotation and heating:** Here it is heated to about 300°C. At the same time the mould is rotated such that the powder is forced against the wall of the mould.
- **Cooling:** Cool air is blown around the mould with the help of external fans, till the mould gets cooled, cooling continued slowly it raw material solidifies walls of the mould.
- **Demoulding:** The finished product is ejected from the mould and the mould is ready for the next repetition.

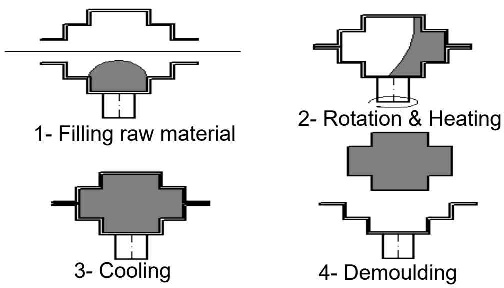


Fig 4.36: Rotational Moulding

INTERESTING FACTS

Plastic moulding began in the late 1800's to fill the need for plastic billiard balls as opposed to the commonly used ivory billiard balls of the time. In 1868, John Wesley Hyatt invented a way to make billiard balls by injecting celluloid into a mould. Four years later, Hyatt and his brother invented and patented a machine to automate the process. This was the first plastic injection moulding machine in existence and it used a basic plunger to inject plastic into a mould through a heated cylinder.

In 1946, the screw injection moulding machine was invented by James Hendry, which replaced the plunger injection technique. This is the technique most commonly used today.

Modern rotational moulding also has a rich history beginning in 1855 when rotation and heat were used to produce metal artillery shells in Britain.

Plastics were introduced into the process in the early 1950's, when rotational moulding was first used to manufacture doll heads. And then in the 1960's the modern process of rotational moulding that allows us to create large hallow containers with low-density polyethylene was developed. In recent history, process improvements, better equipment, and plastic powder developments have sped up the process of creating finished products which has caused rotational moulding to grow rapidly in popularity.

Plastic was discovered by famous German chemist Christian Schonbein in 1846. Plastics were actually discovered accidentally. Christian was experimenting in his kitchen and by accident; he spilt a mixture of nitric acid and sulphuric acid. To mop that solution (a mixture of nitric and sulphuric acid) he took a cloth and after moping he kept it over the stove. After some time, the cloth disappeared and from their plastic got its name.

VIDEO RESOURCES

Injection Moulding

Transfer Moulding

Moulding Terminology

4.3 GLASS CUTTING

You are looking handsome / beautiful because of glass! Yes, it's because of mirror.

Believe it or not we need glass in every walk of the life. Glass is most popular material we use at our home and workplace. Because of its advantageous properties it is used in many applications.

Glass is an inorganic solid material, transparent or translucent, hard, brittle, and impermeable to liquids and gases, it's inexpensive to make, easy to shape when it's molten, reasonably resistant to heat when it's set, chemically inert. Such kind of the properties, make it suitable for many applications like storage of food and beverages, chemicals, glassware, automotive parts, electronic gadget covers, toys, ornaments, aesthetic article, construction material for doors and windows.

The glass is made by heating ordinary sand containing silicon dioxide until it melts and turns into a liquid. This sand melts at high temperature of 1700°C.

It is a difficult task to select a glass for a specific application. It mainly depends on the environment to which the glass will be exposed to as well as the performance specifications required. After knowing the desired performance specifications the selection of the glass on optical, thermal, chemical, and mechanical properties will determine the best and economic type of the glass.

4.3.1 Types of Glass

The glass may be classified as natural and artificial glass. There are several glasses are available in the market based on the chemical composition and commercial brand. The following table gives the brief details.

Table 4.1: Glass composition and applications

Product	Composition in %	Application
Soda lime glass	SiO_2 - 71, Na_2O – 14 CaO – 13, Al_2O_3 - 02	Glazing doors, windows, ordinary glass wares
Lead glass or Flint glass	SiO_2 - 46, Na_2O – 03 K_2O – 06, Pb O - 45	Electric bulbs, optical glass
Boro-silicate glass	SiO_2 -71 B_2O_3-13, Na_2O or K_2O-8, Al_2O_3 - 08	Laboratory equipment, kitchenware
Sheet Glass	SiO_2 - 64, Mg O – 10 , Al_2O_3 - 26	Show cases
Window glass	SiO_2 - 72, Na_2O – 15 CaO-08, Al_2O_3 – 01, MgO-04	Construction windows

Product	Composition in %	Application
Container glass	SiO_2 - 72, Na_2O – 13 CaO – 10 , Al_2O_3 - 02 K_2O – 06, MgO-04	Containers for chemical, liquids
Light bulb glass	SiO_2 - 73, Na_2O – 17 CaO – 05, Al_2O_3 - 01 MgO-04	Electric bulbs, thin glasses
E-glass (fibers)	SiO_2 - 54, Na_2O – 01 CaO – 17, Al_2O_3 - 15 MgO-04,B_2O_3 -09	Automotive, electronic goods

4.3.2 Glass Manufacturing

The glass manufacturing can be categorised as Continuous Process and Batch Process.

Continuous Process

Here a glass pipe making operation is explained as an example for continuous process. In this process the molten glass is poured continuously from the feeder, the mandrel pushes the molten material into the oven and the compressed air is passed regularly to maintain the required hollow space for it. The required length and size will be monitored at the other end. The process is shown in figure 4.37. It is suitable for mass production of similar products.

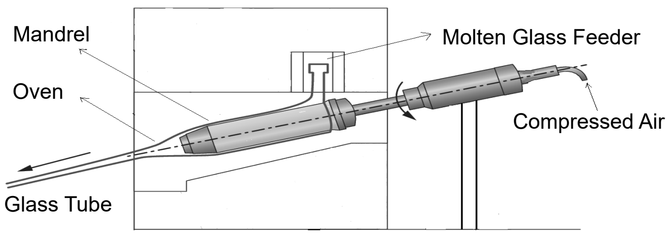
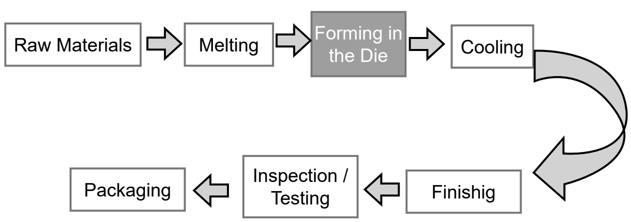


Fig. 4.37: Continuous Process

Batch Process

In this process all activities like continuous process are similar only change is the forming die is to be changed after each batch of production. The flow chart for any glass product can be explained with the figure 4.38. The raw material is to be heated then passed to the required size and shape die, immediately it fallows the cooling, finishing, inspection and packaging will be carried out. In one batch the similar kind of the products will be made. For changing the design and product the die is to be replaced with the desired one in the flow line. This process is useful to make different size and colour glass products.



Glass Workshop

Fig 4.38: Batch Process

4.3.3 Glass Cutting

Glass cutting is a very specialized kind of the work where the operator has to use the skill and common sense. The glass cutting technique started way back 17*th* century, later from year 1900 the more developments and challenges were seen in the glass cutting industries. From year 1930 as automobile industries began using glass and the automobile designers demanded windows in shapes other than rectangles, manually operated shape cutting machines were developed. The development now reached automatic computer controlled glass cutting machines. Let us see the classification of glass cutting in following figure 4.39.

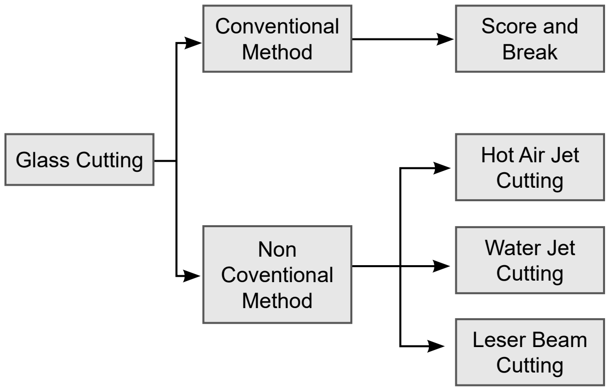


Fig. 4.39: Glass Cutting Classification

Conventional Glass Cutting Method

This is the good old method used for cutting the glass. Here glass cutting takes place with the help of a wheel cutter or diamond point. In this method, the glass is laid on the flat regular surface of the table. Sometimes the underneath surface may be covered with cloth or rubber sheet to provide the cushioning effect. The glass surface is first marked and scribed using a diamond point tool. The cutting tool has a provision to store the lubricating oil to support the cutting operation. The straight cutting can be done with the help of wooden or metallic scale. Some time to avoid the human error the tool is attached to a straight line moving attachment as shown in figure 4.40. There are some readymade templates for circular, elliptical and other curvature cutting. With extreme skill or close control an external force (usually tapping with tool / hand) is applied to break the glass along the scribing path. The position of the cutting face of the diamond tool with respect to the glass surface is significantly important because if not maintained to an optimum angle, the median crack can deviate from the vertical direction and the glass fracture will not coincide with cutting line.

Fig. 4.40: Conventional Glass Cutting Method

Non-Conventional Glass Cutting Method

With the advancement of glass technology in recent times, glass has become one of the most important engineering materials in architectural, medical, automotive, flat panel display, and electronics applications. With the increase in the difficulty level in contours and shapes it is desirable to have accurate and precise cutting technique. The Non-conventional glass cutting technique may give solution to such challenges. Most commonly the Laser technology is used in modern industries to achieve good quality, surface finish, and high speed of operation. The laser beam glass cutting method is explained here with the help of figure 4.41. The glass is placed on the table and the drawing is fed to the computer; the controller gives the signal to the laser head to take the position. The desired shape will be cut by the laser beam. The water jet and hot air jet cutting is also used based on the precision and economic considerations.

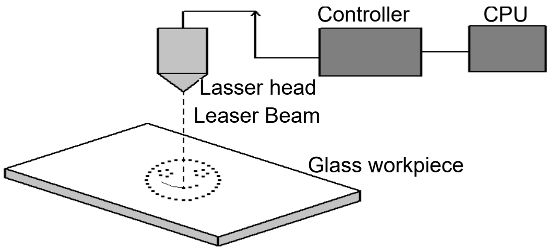


Fig. 4.41: Non-Conventional Glass Cutting Method

INTERESTING FACTS

Late in the 17^{th} century Bohemia became an important glass-producing area, and it remained important until early in the 20^{th} century. By the 17^{th} century England was making glass in the Venetian tradition that was notable for its simplicity.

The glassmaker George Ravenscroft discovered about 1675 that the addition of lead oxide to Venetian-type glass produced a solid, heavier glass. Lead crystal, as it was known, thereafter became a favourite type of glass for fine tableware.

The Romans and Egyptians probably used sand mixed with ground seashells as raw materials for silica and lime and hardwood ash as the source of soda.

Even though glass is solid (or liquid) in physical form, it can break easily. But do you know the speed at which glass shatters? Interestingly, the cracks of glass move at an incredible speed of about 3000 miles/hour or 4828 kilometers/hour. Compared to that speed of sound in dry air is about just 767 miles/hour.

Glass requires around 1 million years to decompose completely. As a result, glass is actually not that eco-friendly compared to other materials.

VIDEO RESOURCES

Glass

Glass Processing

Glass Processing

UNIT SUMMARY

- The carpentry work is primarily meant for cutting, shaping and installation of building materials in construction of buildings, ships, timber bridges, concrete formwork, etc. Most of the complex parts are usually manufactured with casting process.
- A carpenter's work may also extend to interior jobs, requiring some of the skills of a joiner. These jobs include making door frames, cabinets, countertops, and assorted moulding and trim.
- The cutting tools include the saw, chisel and gouges. These are basically used to cut the wood into desired size, shape and dimensions. Usually the finishing operation is done with the different kinds of chisels.
- The striking tools used in carpentry work are light in weight and used for lighter blows. Mallets and few cast iron hammers are generally used as striking tools in carpentry shop.
- Power tools increases the efficiency and close tolerances and accuracies can be achieved.
- The term ''plastic'' is derived from the Greek word ''plastikos'', meaning fit for moulding. Whenever we talk about materials we use the term plasticity, it is general property of all materials that involves permanent deformation without breaking.

EXERCISES

Subjective Questions

S. No.	Question	CO	BL	PO	PI Code
1.	Discuss the need of Carpentry in professional education	4	L1	1	1.4.1
2.	Enlist the application of wood in different fields.	4	L1	1	1.4.1
3.	Describe the different cutting tools	4	L1	1	1.4.1
4.	Discuss the need of power tools in wood industries.	4	L1	1	1.4.1
5.	Describe the drilling tools in carpentry work.	4	L1	1	1.4.1
6.	Explain the types of plastics with suitable examples	4	L1	1	1.4.1
7.	Enlist the application areas of plastics	4	L1	1	1.4.1
8.	Describe the injection moulding method with suitable sketch.	4	L1	1	1.4.1
9.	Discuss the rotational moulding process with neat sketch	4	L1	1	1.4.1
10.	Discuss why you need glass	4	L1	1	1.4.1
11.	Describe the continuous glass making method	4	L1	1	1.4.1
12.	Discuss the any one non conventional glass cutting operation	4	L1	1	1.4.1

Multiple Choice Questions

S. No.	Question	Ans.	CO	BL	PO	PI Code*
1.	Which of the following tool is used to make the surface plain? (a) Metal jack plane (b) Mallet (c) Try square (d) Chisel	a	4	L1	1	1.4.1
2.	Which of the following is not a cutting tool? (a) Chisel (b) rip saw (c) file (d) try square	d	4	L1	1	1.4.1
3.	The long plastic rods and tubes are produced by (a) Compression moulding (b) Extrusion (c) Injection moulding (d) Blow moulding	b	4	L1	1	1.4.1
4.	Which of the following is an example of thermoplastic material? (a) Camera bodies (b) Automobile parts (c) Electric plugs (d) Electric insulation	d	4	L1	1	1.4.1
5.	Which forming method is used for the production of hollow glasses? (a) Blowing (b) Pressing (c) Drawing (d) Casting	a	4	L1	1	1.4.1

*The Performance Indicator code is referred from the AICTE exam reform document

KNOW MORE

- Teachers must know about the various power tools used in carpentry work, the jigs and fixtures for holding the work material during carpentry work.
- The Various forms of wood and allied materials for construction and engineering work.
- The applications of plastic moulding for engineering products. Small activities on shaping the plastics.
- The formation of glass for aesthetic and architectural applications,

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5 Metal Casting Welding Brazing

UNIT SPECIFICS

This unit elaborately discusses the following topics:

- Classification of Metal Casting
- Permanent mould casting
- Design Considerations of Casting
- Arc Welding and Gas Welding
- Brazing operation

The industrial and general applications of the topics are discussed here to generate curiosity and creativity in readers.

RATIONALE

We are living in the world where everyone is depending upon castings, without castings there would be no Automotives, Aerospace, Wind energy turbines, Irrigation pumps, Agriculture equipments, Ornaments, Idols, Household equipments, Medical Devices and many more. By this way the casting has touched everyone's life. Metal casting is a modern process with ancient roots. In the metal casting process, metal shapes are formed by pouring molten metal into a mould cavity, where it is cooled and later extracted from the mould. Metal casting is arguably the earliest and most influential industrial process in history. It's used to make many of the metal objects used in our daily lives. At the same time metal casting foundries rely on metal recycling as a cost-efficient source of raw material, significantly reducing wasted scrap metal that might end up in landfills otherwise

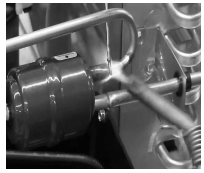
Welding is a permanent joint between two or more similar or dissimilar materials by heating them to a certain temperature with or without the application of pressure or by the pressure alone and with / without adding filler materials. The welding is extensively used in all engineering field of applications. The brazing is also one of the permanent joining processes takes at higher temperature. This process provides an opportunity to join different base materials permanently. The brazing process finds applications from domestic to industrial applications.

The following images will help you to understand the applications of casting, welding and brazing to human beings. The wheel drums of tractors and trucks are made by casting operation, the welding is not only done by human operator but the robots are also used in automated industries.

The brazing is used to join the different materials at high temperature, the refrigerator compressor is brazed by brazing operation.

Wheel Drum Casting

Robotic Welding



Compressor-Brazing

PRE-REQUISITES

- Drawing
- General safety measures
- Hand tools
- Information about materials-Steel, Wood, Plastic and Glass

UNIT OUTCOMES

The students will be able to:
U5-O1: Identify the different casting processes.
U5-O2: Understand the casting design considerations.
U5-O3: Understand the need of welding operations.
U5-O4: Prepare welding models for given drawings.
U5-O5: Get exposure to brazing operation.
Mapping of the Unit Outcomes with the Course Outcomes:

Unit-5 Outcomes	Expected Mapping with Course Outcomes *(1 – Weak Correlation; 2 – Medium Correlation; 3 – Strong Correlation)*				
	CO-1	CO-2	CO-3	CO-4	CO-5
U5-O1					1
U5-O2					1
U5-O3					1
U5-O4					2
U5-O5					1

5.1 CASTING

The process in which pouring of molten metal into a mould containing a hollow cavity of the desired size and shape, later it is allowed to solidify. The solidified part as well as this process is called as casting. The final product is ejected or broken out of the mould to get the final product.

Casting process enables engineers to make part in single piece often eliminates preliminary cutting, surface preparation, machining, assembly and fabrication and many more steps. The casting process suits for simple parts to very high complicated intricate design parts. The process is economical comparatively with other manufacturing processes. In UNIT-1 we understood the basic terminology in the casting process. In continuation to that now let's study the other aspects of the castings.

5.1.1 Casting Phenomena

The various types of casting processes are used in the industries based on the convenience, requirement and economical conditions. Here a generalized casting process is discussed in the following lines.

When the molten metal is poured on the designed cavity through the poring basin, the molten metal enters the system through sprue then gating channels, finally reaches the core and accumulates the cavity. Casting is basically a solidification process where the molten material is poured into a mould and allowed to freeze into the designed final shape. The additional molten metal rose through the riser and is helping the core by compensating the shrinkages. When the core is filled completely the solidification starts. Most of the structural features that ultimately control product properties are set during solidification process. At the same time many casting defects such as gas porosity and solidification shrinkages can be minimised or eliminated by monitoring the solidification process.

Solidification takes place in two stages namely nucleation and growth, controlling of both of these stages is very much desirable to get the sound castings. Nucleation initiates from within the molten liquid. When a material is at a temperature below its melting point, the solid state has a lower energy than the liquid. As solidification occurs, internal energy is released. At the same time, however, interface surfaces must be created between the new solid and the parent liquid. You can visualize how the **ice cubes are formed in a tray in refrigerator**, the initial solid forms on the walls of the container. The same phenomena can be expected with metals and other engineering materials.

After the certain duration the castings can be removed from the core and based on the type of casting the mould may be reused or collapsed. The unfinished casting may be sent for final finishing operation by machining or any suitable operations based on the applications.

5.1.2 Classification of Metal Casting

There are different criteria to classify the metal casting process; it may be on gravity, pressure, mould design etc. The following classification tree in figure 5.1 is one among them which focuses on major areas of castings.

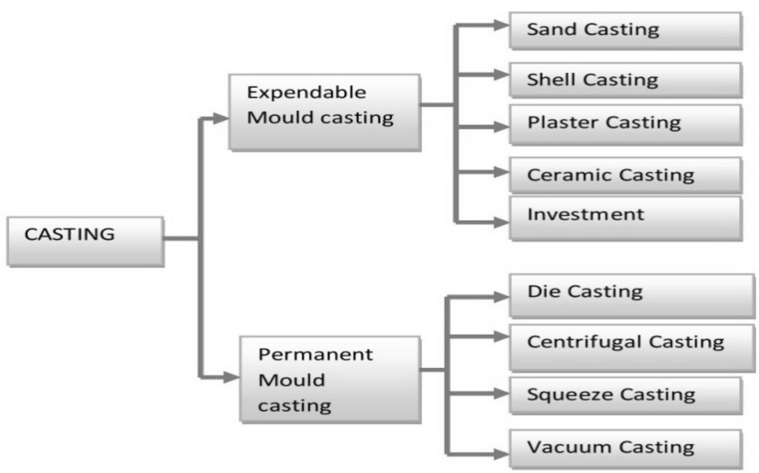


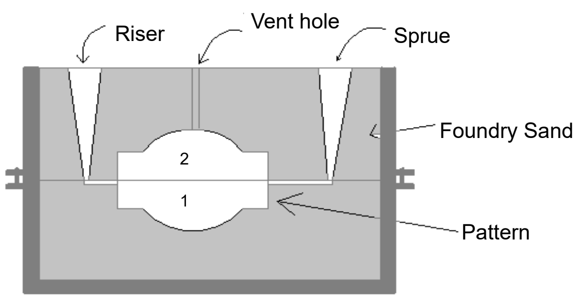
Fig 5.1: Classification of Casting

5.1.3 Expendable Mould / Temporary Mould Casting

Expendable mould casting is a temporary or single-use mould casting method. Here the casting will be removed by breaking or demolishing the mould. So the next product requires new mould for the operation. The most common forms of expendable mould castings are sand casting, shell casting plaster casting, investment (lost wax) casting and ceramic casting.

Sand Casting

It is one of the expendable types of moulding method where in making of mould is required for every casting. Here the moulding sand is filled in the drag part of the mould and the ramming is done continuously. Near the parting line the half portion of the pattern (split pattern) is placed, in figure 5.2 it is shown with number 1. The evenness of the top surface is achieved by leveling the foundry sand by leveler. Once the drag is ready the pattern will be removed slowly without affecting the surface to make the cavity. The other half pattern mentioned here as 2 is placed in cope and the same procedure is followed as of the drag. At appropriate place the sprue is placed for pouring the molten metal. The riser is provided at the appropriate place to maintain the level of the molten metal in the cavity to compensate the shrinkage. The air vent holes are provided to give way for the gases to escape from the mould. The unit will be kept for sufficient time to see that the molten metal gets solidified completely. After that the mould is broken to take out the casting. Most of the time the mould sand is reclaimed and reconditioned for further usage.



Brass Metal Casting

Fig. 5.2: Sand Casting

The sand casting finds applications in statue making, automotive engine parts, pump parts etc.

Shell Casting

The process uses the resin coated sand to form a shell. The process is explained in five steps as below.

Step 1: The sand is filled in the mould and the pattern is kept on the top of the mould box. The desired shape is made on the pattern and to see that the shape of the pattern should fit inside the mould box size.

Step 2: The mould is now rotated and kept above the heating coil so that the pattern is to be get heated. When it is kept upside down the sand will fall on the pattern. When slowly the heating is done with help of heating coil around 250°C, the sand starts accumulating on the pattern contours known as sand shell. The sand takes almost the pattern shape at this moment.

Step 3: The mould box is now brought back to original position, Now the extra sand will fall back in the mould box and certain amount of sand layer will stick on the pattern contours.

Step 4: Here in this step the pattern is removed from the mould box carefully and kept for some time to get cooled. The sand shell is slowly removed from the pattern and kept aside. Similar shape of sand shell is created by one more trail.

Step 5: The formed sand shells are used as core for the pouring of the molten metal. Here the shells are kept in the mould box and the shells are surrounded by the green sand. The molten metal will be poured in the shell cavity to get the desired shape.

The total process is shown in figure 5.3. The process offers excellent dimensional accuracy. Shell-mould sand is typically finer than ordinary foundry sand and, in combination with the plastic resin, enables fine detail and a very smooth casting surface. Cleaning, machining, and other finishing costs can be significantly reduced, and the mould process offers an excellent level of product consistency.

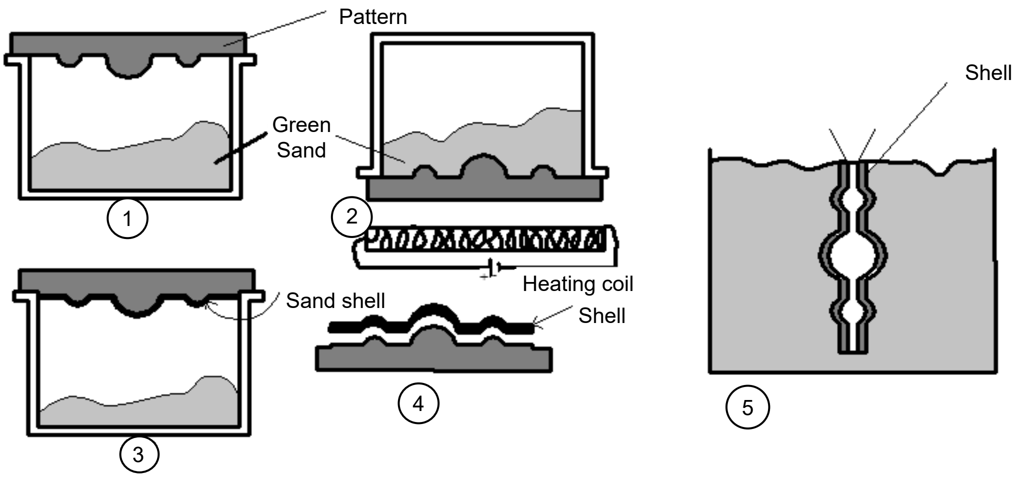


Fig. 5.3: Shell Casting

Plaster Casting

Plaster mould casting is similar to sand casting except the moulding material is plaster of Paris instead of sand here. The mould will be made with plaster of Paris and the molten metal is poured in the cavity to get the desired shape. Extensively this process is used for non- ferrous materials. The artistic idols and in medical applications like fracture healing treatment the plaster of Paris is used. The figure 5.4 shows the plaster moulding applications.

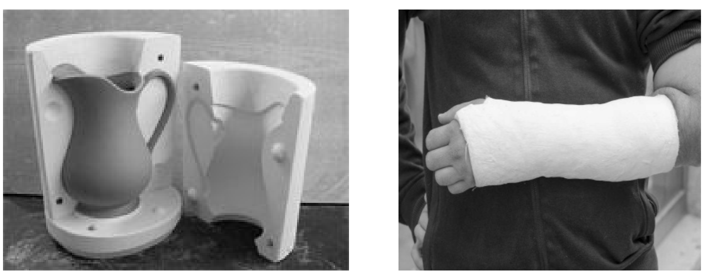


Fig. 5.4: Plaster Casting (Source: in.pinterest.com, collinsdictionary.com)

Ceramic Casting

This casting process uses ceramic as the mould material. It is a combination of plaster mould casting and investment casting.

Investment Casting / lost-wax casting

Investment casting is most commonly used for making complex-shaped components at the same time they demand closer tolerances, thinner walls and better surface finish. This casting is very special because of its distinguishing feature with which the mould is created. Here the pattern of the part is made with the wax. The wax may be honey bee wax or nowadays the chemical wax is used. The patterns are connected to a wax tree which is then dipped into fine ceramic slurry that contains colloidal silica and alumina. The dipped tree is then dried and heated around 1000°C inside an oven to melt out the wax. The wax is collected back and reused for next cycle. The tree is sintered with sand and now it is ready for pouring the molten metal. After the mould get cooled the vibration or water jet is used to remove the coating and clean the castings. This casting is used extensively for precisions parts. The Aerospace, Defense, Medical, Automotive, Oil and Gas and other fields finds application of this process. The wax tree is shown in figure 5.5.

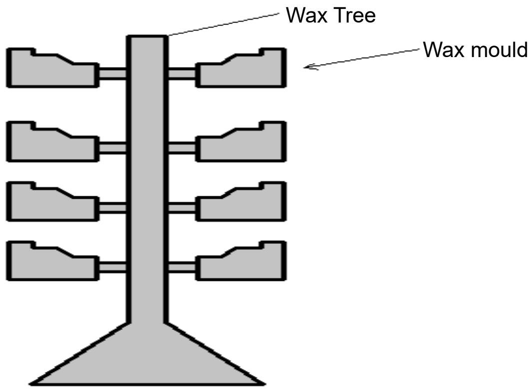


Fig 5.5: Investment Casting

5.1.4 Permanent Mould Casting

Permanent mould casting is used for producing a large number of castings using a single reusable mould. Usually the mould is made by steel elements. This casting process involves pouring molten metal into a mould cavity later it cools and gets solidified. After sometime the mould will be opened to remove the casting. As the mould is permanent it is reused for next cycle. The various types of Permanent Moulds are used in a number of casting processes like Gravity Die Casting (GDC), Low Pressure Die Casting (LPDC), High Pressure Die Casting (HPDC), Centrifugal Casting (CFC), Squeeze Casting (SC) and Continuous Casting (CC).

Die Casting

In this process the permanent metallic/steel die is made for reuse. The various forms of die castings are gravity die casting, High pressure die casting, low pressure die casting. The process is shown in figure 5.6. It almost resembles the injection moulding machine. The molten metal is pushed into the cavity for proper accumulation in pressure die casting. The pressure may range from 10 to 210 MPa. In case of gravity die casting the molten metal is poured into the cavity by the gravity force. After certain duration the solidification takes place in the cavity. The mould is pushed back with help of ejector pin. The finished casting is removed and the mould will be ready for next cycle operation. The die casting is used in automotive, electrical and other domestic / industrial appliences.

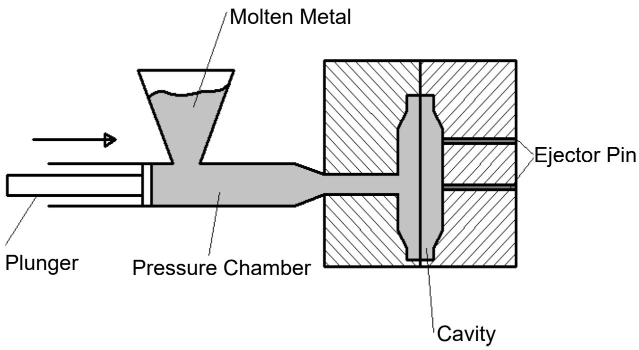


Fig. 5.6: Die Casting

Centrifugal Casting

This method is suitable for making tubular pipes and small diameter pipes. The mould will be rotated with the help of electric motor either in horizontal or vertical direction and the molten metal is poured with the help of ladle. The process begins with pouring the molten metal into a preheated, spinning die. The centrifugal force acts here to distribute the molten metal in the mould at pressures approaching approximately more than 100 times of gravity force. Because of this applied pressure and the controlled solidification process it produces superior quality components. Once the casting has solidified, the part is removed from the die. This process finds application in pipe and small diameter cylinder production. The process is shown in figure 5.7.

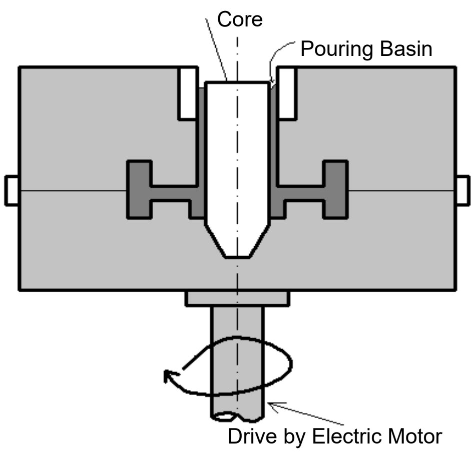


Fig. 5.7: Centrifugal Casting

Squeeze Casting

Squeeze casting the name itself says that the casting is made by squeezing the molten metal. It is also known as liquid forging. In other words, it is a hybrid metal forming process that combines permanent mould casting with die forging. The specific amount of molten metal alloy is poured into a preheated and lubricated bottom die and subsequently the upper die is forced on the bottom die. The required shape is made on both the upper and lower die. After the solidification the squeezed casting will be removed from the bottom die. It is shown in figure 5.8.

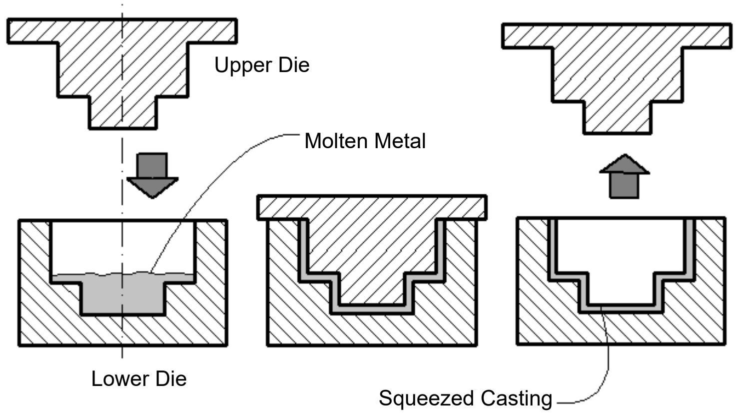


Fig. 5.8: Squeeze Casting

Vacuum Casting

The vacuum forming process involves the heating of plastic sheet then kept on the mould for forming it into desired shape casting. The vacuum is applied from the bottom of the mould so it sets on the mould cavity. Next step is to cool the plastic sheet until it sets hard. Then remove the finished part from the mould. The process is also known as thermoforming process because the plastic sheets are preheated before they get on to mould. The process is shown in figure 5.9. The vacuum casting process finds applications in Aerospace, Automotive parts, Medical devices, Consumer goods, Prosthetics. Decorative objects, Ornaments, Showpieces and Wall plaques

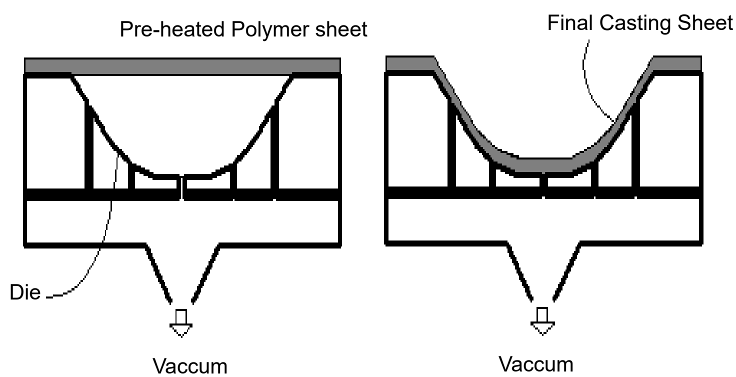


Fig 5.9: Vacuum Casting

5.1.5 Design Considerations of Casting

To create the sound castings the following design considerations to be fallowed.

- **Provision of Fillet Radius:** The sharp corners to be rounded off so it increases the endurance limit of the component and reduce the formation of brittle chilled edges during casting. Otherwise this sharp corner acts as a stress concentrator. It is shown in figure 5.10

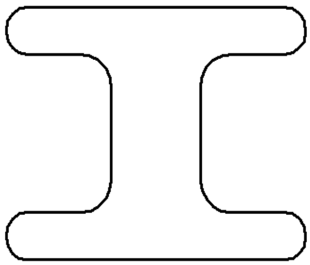


Fig. 5.10: I-Section

- **Avoid abrupt changes in the cross-section:** The sudden changes or abrupt changes in the cross-section of a casting are to be avoided as it results in high stress concentration. The thickness can be varied gradually if it is required. It is shown in Figure 5.11. It is recommended that as for as possible the thickness should be held uniform throughout the length.

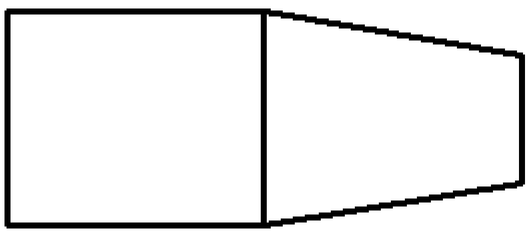


Fig 5.11: Taper Section

- **Design of component in compression than in tension:** The wide base is to be designed for the castings than the top face so that the total body experiences the compression than the tension.
- **Employ full cores:** It is always better to have full cores instead of jointed half cores. The cost can be reduced and greater dimensional accuracy can be achieved.
- **The gates, runners and risers design:** These are required to be attached with the pattern for pouring the molten metal, they should be properly placed and the sudden variation in dimensions should be avoided.
- **Surface Finish:** The surface finish of the casting depends totally on the surface finish of the pattern so it is desirable that the pattern should have a good surface finish.
- **Uniform Thickness:** The thickness and section of the pattern should be kept as uniform as possible

5.1.6 Casting Defects

The following defects may be found due to bad design of the pattern, mould, gating design, poring method and many more.

- **Pinholes:** these are the hole like structures appears at the borders of the castings.
- **Blowhole:** appears inside the casting may not be visible until machining.
- **Scar and Blister:** Due to improper venting a shallow blow may be produced is identified as scar. A blister is a shallow blow like a scar with thin layer of metal covering on it.
- **Scab:** This defect occurs when a portion of the face of a mould lifts or breaks down.
- **Drop:** Drop or crush in a mould is an irregularly shaped projection on the cope surface of a casting.
- **Hot tears:** Hot tears are hot cracks which appear in the form of irregular crevices with a dark oxidized fracture surface.
- **Swell:** A swell is a slight, smooth bulge usually found on vertical faces of castings
- **Rat tails:** appear as an irregular line or crack on the casting, when the surface of the molding sand buckles up.
- **Cold shut:** occurs when two wave fronts of two metal streams meet, but does not fuse.
- **Mis run:** occurs when the liquid metal does not completely fill the mould cavity, leaving an unfilled portion.

INTERESTING FACTS

Sand casting really took off in the early 20th Century with the rapid expansion of the automotive and machine building industries. In 1924, the Ford Motor Company produced one million cars and accounted for one third of the total sand casting production in the US. This demand led to new mechanisation and automation methods for casting.

According to the Crescent Foundry Blog (2017), iron castings can last up to 100 years, meaning cast components are extremely durable and cost-effective. The casting process is also extremely flexible. If a material can be melted, it can be turned into a casting. By adding other elements, you can create a variety of mixtures with different properties. They can be used to cast a wide variety of components in an infinite variety of complex shapes that can withstand many different environments.

The earliest examples of die casting by pressure injection - as opposed to casting by gravity pressure - occurred in the mid-1800s. A patent was awarded to Sturges in 1849 for the first manually operated machine for casting printing type. The process was limited to printer's type for the next 20 years, but development of other shapes began to increase toward the end of the century. By 1892, commercial applications included parts for phonographs and cash registers, and mass production of many types of parts began in the early 1900s.

VIDEO RESOURCES

Metal Casting

Casting and Joining

Casting

5.2 WELDING TECHNOLOGY

Welding is a permanent joining process used to join metals or thermoplastics together. In this process the work piece to be joined is melted at the joining interface and a filler material is added to form a pool of molten material later that solidifies to become a strong joint. The regular definition of the welding in many references is quoted as "The process of joining the metals by the application of heat with or without pressure and filler material". To apply the heat for melting the metals we need heat to be applied locally. The heat may be generated by different sources like fuel, chemical, electrical etc. The classification of the welding process is enlisted in the UNIT-1 of this book in joining methods topic. In this topic we will study the two major welding techniques; they are arc welding and gas welding. The following images will make you to visualize the different applications of welding. Now the welding is not only carried out by manually even the robots are assisting in welding technology.


Automotive welding


Robotic welding


ship welding

5.2.1 Arc Welding

Arc welding is one of the methods used for metal welding process. It uses an electrical power source to create an arc between the base metal and the electrode stick or wire. This electric phenomenon is called as arc discharge.

Arc welding is one of the most prominent types of welding. Arc processes involve using the concentrated heat of an electric arc to join metal materials together. These processes fall broadly into two categories: consumable electrode methods and non-consumable electrode methods. This distinction dictates whether the process involves the electrode melting and becoming part of the welded joint or not melting and only acting as an arc conductor.

The arc welding techniques can be again subdivided as

Flux-Cored Arc Welding (FCAW)

This is the most commonly used arc welding technique in the industry. The current is supplied through the transformer in the form of Alternating Current (AC) or Direct Current (DC). Commonly the AC is supplied by the transformer. When the voltage applied between these two spatially separated electrodes and gradually increased until the air insulation breaks and current flows between the electrodes. The function of an electrode is more than acting simply as a conductor for the electric-arc current it also acts as a filler rod. This type of arc welding uses tubular electrodes filled with flux. While emissive flux shields the arc from air, non emissive fluxes may need shielding gases. When the electrode strikes the base material, resulting in emittance of sharp light spark and high heat at the same time. This generated arc-shaped light is called an electric arc. The core wire melts in the arc and tiny globules of molten metal transferred explosively across the arc into the molten weld pool during welding. These tiny globules of molten metal quickly stick to the base material. They are not transferred by the force of gravity otherwise overhead welding would not be possible but are explosively transferred across the arc to form the arc stream.

In arc welding, positive voltage is applied to the electrode and negative voltage is applied to the base material. This makes an arc occur from the base material to the electrode. The arc is struck once you turn on the welding machine, adjust the settings, get safety gear in place, and scratch or tap the electrode against the base metal. The temperature of the arc is about 5,000°C to 20,000°C. The hot arc melts the metals where they should be joined. The molten material often with filler can then be crafted into a weld. It is shown in figure 5.12 and the detailed view is shown in figure 5.13

SMAW Welding

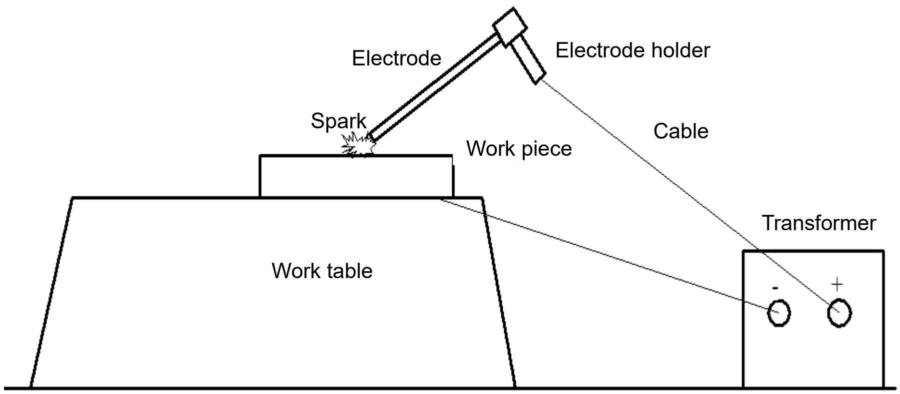


Fig. 5.12: Flux-cored Arc Welding

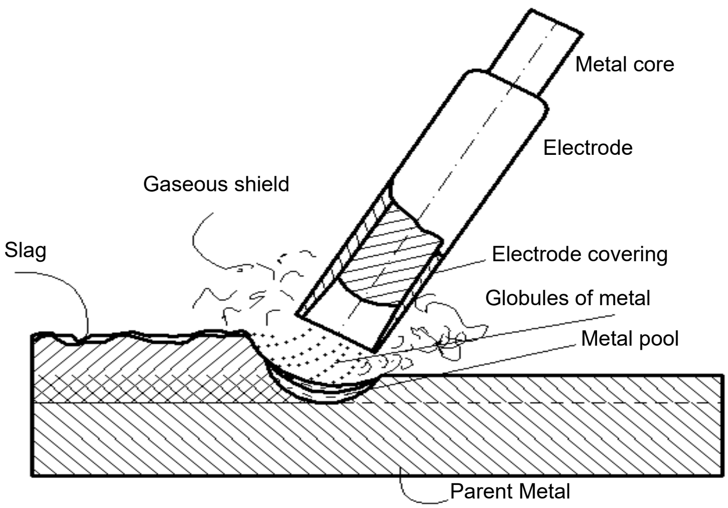


Fig. 5.13: Detailed View of Flux-cored Arc Welding

Gas Metal Arc Welding (GMAW) / Metal Inert Gas (MIG)

It is a specialized technique used for thin and thick sheet welding. It is commonly known as metal inert gas (MIG) welding. The process is shown in figure 5.14. It is similar to any other welding process with little bit difference. Here an arc is struck between the end of a wire electrode and the work piece. Melting both of them to form a weld pool. The wire is fed through a copper contact tube which conducts welding current into the wire. The wire serves as both heat source and filler metal for the welding joint. The weld pool is protected from the surrounding atmosphere by a shielding gas fed through a nozzle surrounding the wire. Shielding gas may be helium or organ gas it depends on the material being welded based on the application. The process offers high productivity, as the wire is continuously fed. This method has several benefits: simple, versatile, economical, low temperatures, and easily automated.

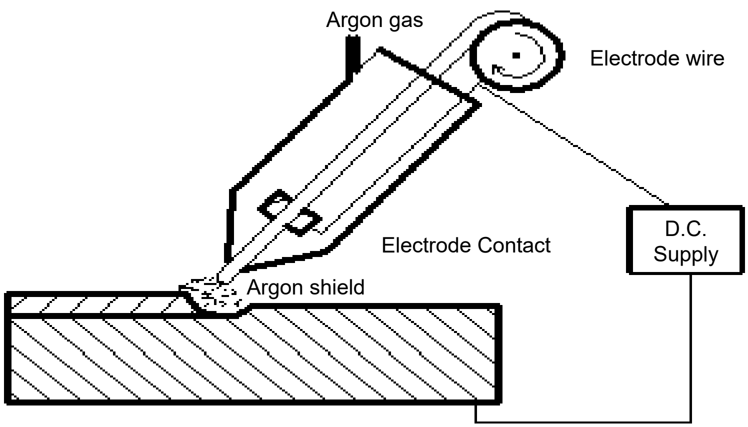


Fig. 5.14: Metal Inert Gas welding

Gas Tungsten Arc Welding (GTAW) / Tungsten Inert Gas welding (TIG)

GTAW or TIG welding is often considered as critical welding process. Gas Tungsten Arc Welding requires a non-consumable tungsten electrode, a constant current power source, and an inert shielding gas to create a plasma arc. The electrode is made of Tungsten to create the arc. Inert gases like argon or helium or a mix of the two is used to protect the shield during welding. In this method the slag formation is nil hence you will get cleaner welding surface. As this method is cleaner in operation hence suitable for welding stainless steel and non-ferrous metal jobs, where appearance matters prime importance.

Plasma Arc Welding (PAW)

Plasma arc welding (PAW) is an arc welding process very similar to TIG welding as the arc is formed between a pointed tungsten electrode and the work piece. This arc welding technique uses ionized gases and electrodes that create hot plasma jets aimed at the welding area. In this type of winding, there are three types of gas supplies being utilized namely plasma gas, shielding gas, and a back-purge gas. Plasma gas supplies throughout the nozzle turn into ionized. The shielding gas supplies throughout the external nozzle & protects the join from the environment. Back-Purge gas is mainly used when particular materials are being used. The temperature of the plasma is in excess of 20 000°C and the velocity can approach the speed of sound.

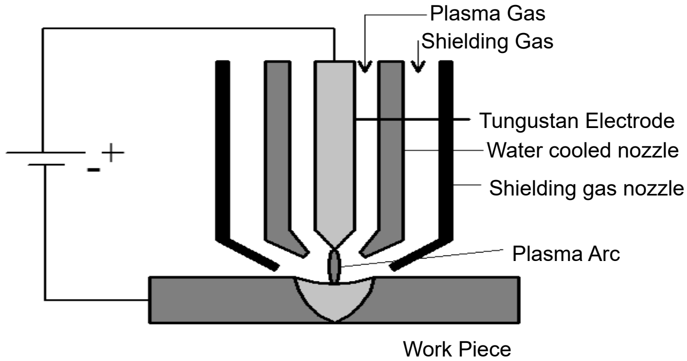


Fig. 5.15: Plasma Arc Welding

Shielded Metal Arc Welding (SMAW)

SMAW is one of the simplest, oldest, and most adaptable arc welding methods, making it very popular. The arc is generated when the coated electrode tip touches the welding area and is then withdrawn to maintain the arc. The heat melts the tip, coating, and metal, so that the weld is formed once that alloy solidifies. This technique is typically used in pipeline work, shipbuilding, and construction.

Submerged Arc Welding (SAW)

It is one more special kind of welding; the name may confuse you by seeing at first time. It is so named because the weld and arc zone are submerged beneath a blanket of flux. A blanket of powdered flux generates a protective gas shield and a slag. The flux material becomes conductive when it is molten, creating a path for the current to pass between the electrode and the work piece. The flux used in this welding is a granular insulative material that is made up of numerous small particles. This method enables deeper heat penetration because it acts like a thermal insulator. SAW is sued for high-speed sheet or plate steel welding.

Submerged Arc Welding

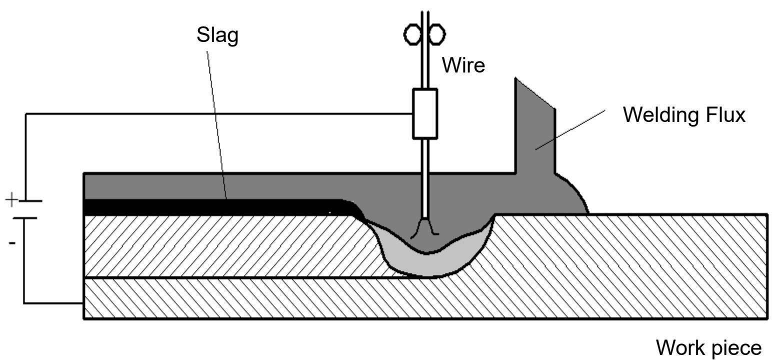


Fig. 5.16: Submerged Arc Welding

5.2.2 Gas Welding

Gas welding is one more type of welding process where in burning of fuel gases with the help of oxygen to form a concentrated flame of high temperature. This flame directly strikes the weld area and melts the weld surface and filler material. There are five types of gas welding process used in the industry. They are

- Oxy-acetylene gas welding
- Oxy-gasoline gas welding
- Methyl acetylene-propadiene-petroleum (MAPP) gas welding
- Butane or propane welding
- Hydrogen gas welding

Oxy-acetylene gas welding is the most commonly used gas welding technique. This gas mixture also provides the highest flame temperature of available fuel gases; however acetylene is generally the most expensive of all fuel gases. Acetylene is an unstable gas and requires specific handling and storage procedures.

Oxy-acetylene Gas Welding

In this type of welding, oxy-acetylene welding applies a mixture of acetylene gas and oxygen gas to supply welding torches. An oxy-fuel gas flame provides the heat required at a high enough temperature to melt most engineering materials in common use. The reactions are shown in the following equation.

$$2\,C_2H_2 + 5\,O_2 \rightarrow 4\,CO_2 + 2\,H_2O + \text{Heat Energy}$$

Acetylene is the most economical gas to use in conjunction with commercially pure oxygen supplied from high-pressure cylinders to give a flame with a maximum temperature of 3200°C. The figure 5.17 shows how the gas mixing takes place in the welding unit before it creates the flame.

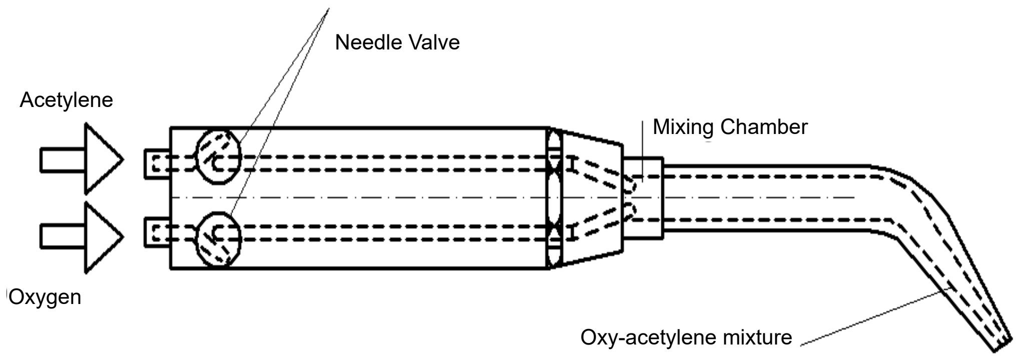


Fig 5.17: Oxy-Acetylene Gas Mixing Chamber

The oxygen is stored in a thick-walled solid drawn steel cylinder usually painted with black colour for identification. The gas is usually stored around 13660 kN /m^2 mild steel cylinders and 17240 kN/m^2 in alloy steel cylinders. The cylinder capacity varies from 3.4 m^3 to 6.8 m^3. The acetylene is supplied in a thick-walled solid drawn steel cylinder painted maroon. These are shorter and squatter than the oxygen cylinders for easy identification. High-pressure acetylene is dangerously unstable and, for this reason, it is dissolved in acetone which is capable of absorbing a large volume of gas and releasing it as the pressure in the cylinder falls. The acetylene is stored in the cylinder at a pressure of 1152 kN/m^2. Compressed acetylene is susceptible to dangerous explosions and for this reason the cylinder is filled with an inert porous substance that can absorb the dissolved acetylene.

The mixture of these two gases is regulated in the mixing chamber with the help of adjustable valve. The proportion of oxygen and acetylene makes different types of the flames. This flame is adjusted based on the type of material is to be welded. The types of flames are shown in figure 5.18

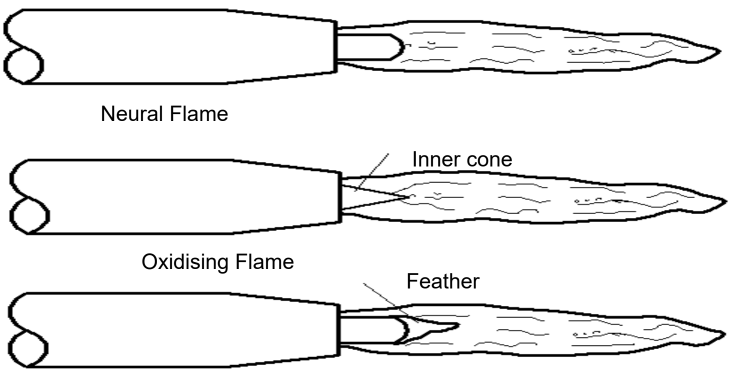


Fig. 5.18: Types of Flame

- **Neutral Flame:** As the name implies, this flame has equal amount of oxygen and gases fuel by the volume. This flame burns fuel completely and does not produce any chemical effect on metal to be welded. It is easily recognized by its characteristic clearly defined white inner cone at the tip of the welding torch nozzle. It is commonly used for welding mild steel, stainless steel, cast iron, copper etc. It produces little smoke. This flame has two zones. The inner zone has white in color and has temperature about 3100°C and outer zone has blue color and have temperature about 1275°C.
- **Oxidizing Flame:** When the amount of acetylene reduces from natural flame or amount of oxygen increases, the inner cone tends to disappear and the flame obtained is known as oxidizing flame. The oxidizing flame is recognized by the shorter and sharply pointed inner cone and by a noisier (roaring) combustion process. It is hotter than neutral flame and has clearly defined two zones. The inner zone has very bright white color and has temperature of about 3300^0C. The outer flame has blue in color. This flame is used to weld oxygen free copper alloy like brass, bronze etc.
- **Carburizing Flame:** This flame has excess of fuel gas. This flame chemically reacts with metal and form metal carbide. Due to this reason, this flame does not used with metal which absorb carbon. It is smoky and quiet flame. This flame is recognized by the 'feather' of incandescent carbon particles between the inner cone and the outer envelope. This flame has three regions. The inner zone has white color, the intermediate zone which

is red in color and outer cone has blue color. The inner cone temperature is about 2900°C. This flame is used to weld medium carbon steel, nickel, aluminum and its alloys etc.

The total oxy-acetylene welding process is shown in figure in 5.19.

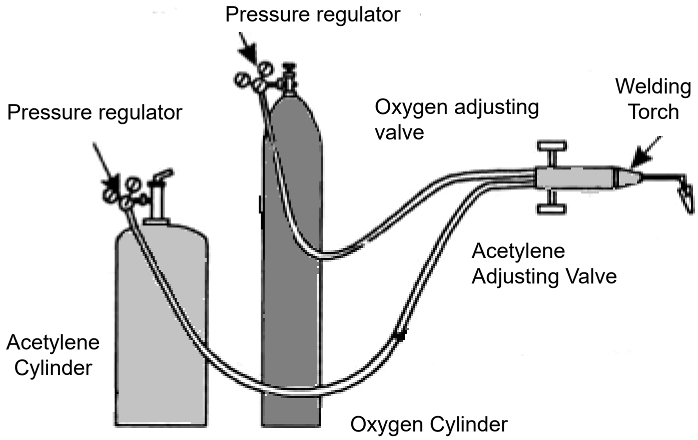


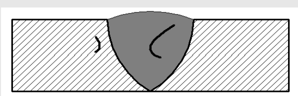
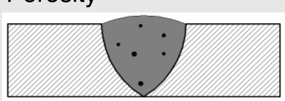
Fig. 5.19: Oxy-Acetylene Welding Process

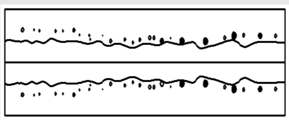
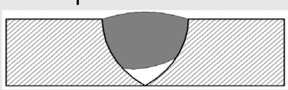
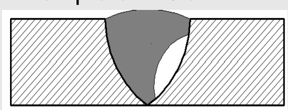
Gas Welding

5.2.3 Welding Defects

Welding is very skilled job; it requires the experience for an operator. If the operator is inexperienced then it may lead to welding defects. Most of the welding defects are carried out by visual inspection for normal welding products. But the engineering welding joints are tested by non-destructive testing (NDT) methods. The most common non-destructive tests to check welds are Liquid Penetration, Magnetic Particle, Eddy Current, Ultrasonic, Acoustic Emission and Radiography etc. The following are the few common defects found in welding due to some reasons. The list is made with causes and remedies for the same. In the following table

Table 5.1: Welding defects and remedies

Defect	Causes	Remedies
Crack 	• Residual stress caused by the solidification shrinkage. • Base metal contamination. • Poor joint design. • A high content of sulfur and carbon in the metal.	• Use proper joint design. • Remove impurities. • Use appropriate metal. • Make sure to weld a sufficient sectional area.
Porosity 	• Inadequate electrode deoxidant. • The presence of moisture. • Incorrect surface treatment. • Presence of rust, paint, grease or oil.	• Clean the materials before you begin welding. • Use dry electrodes and materials. • Use correct arc distance. • Use the right electrodes.

Defect	Causes	Remedies
Undercut 	• Too high weld current. • Too fast weld speed. • Incorrect usage of gas shielding. • Poor weld technique.	• Reduce the arc length. • Reduce the electrode's travel speed, but it also shouldn't be too slow. • Choose a correct welding technique that doesn't involve excessive weaving.
Slag Inclusion 	• The weld speed is too fast. • Not cleaning the weld pass before starting a new one. • The weld pool cools down too fast.	• Increase current density. • Reduce rapid cooling. • Remove any slag from the previous bead. • Adjust the welding speed.
Spatter 	• Voltage setting is too low. • The work angle of the electrode is too steep. • The arc is too long. • Incorrect polarity	• Clean surfaces prior to welding. • Reduce the arc length. • Use proper polarity.
Incomplete Penetration 	• There was too much space between the metal you're welding together. • Large electrode diameter. • Misalignment. • Improper joint	• Use a properly sized electrode. • Reduce arc travel speed. • Choose proper welding current. • Check for proper alignment.
Incomplete Fusion 	• Electrode angle is incorrect. • The electrode diameter is incorrect for the material thickness you're welding. • Travel speed is too fast.	• Use a sufficiently high welding current with the appropriate arc voltage. • Before you begin welding, clean the metal. • Avoid molten pool from flooding the arc

5.3 BRAZING

Brazing is again a metal-joining process in which two or more metal of similar or dissimilar items are joined together by melting and flowing a filler metal into the joint. The filler metal usually has a lower melting point than the base metal. The melting point of the filler metal is above 450°C, but always below the melting temperature of the parts to be joined. This distinguishes the process from welding where high temperatures are used to melt the base metals together.

The filler metal, while heated slightly above melting point, is protected by a suitable atmosphere which is often a flux. The molten filler metal cools to join the work pieces together providing a strong join between similar or dissimilar metals. The atmospheres in which the brazing process can be undertaken include air, combusted fuel gas, ammonia, nitrogen, hydrogen, noble gases, inorganic vapours and vacuum, using a variety of heating sources such as torch, furnace, and induction coil. To achieve a sound brazed joint, the filler and parent materials should be metallurgically compatible, and the joint design should incorporate a gap into which the molten braze filler can be drawn or distributed by capillary action. The required joint gap is dependent on many factors, including the brazing atmosphere and the composition of the base material and braze alloy.

Ideal for joining dissimilar metals, brazing is a commercially accepted process used in a wide range of industries due to its flexibility and the high integrity to which joints may be produced. This makes it reliable in critical and non-critical applications, and it is one of the most widely used joining methods. Brazing can join dissimilar metals such as aluminum, silver, copper, gold, and nickel. Flux is often used during brazing. It is a liquid that promotes wetting, which lets the filler flow over the metal parts to be joined. It also cleans the parts of oxides so that the filler bonds more tightly to the metal parts.

Brazing is basically the same as soldering, but it gives a much stronger joint than soldering. The principal difference is the use of harder filler material, commercially known as a speller, which fuses at some temperature above red heat, but below the melting temperature of the parts to be joined. The process is shown in figure 5.20. The joints to be joined should be filled with the filler material. The torch is used to heat the metal. By the application of heat the filler material melts between the spaces and seals the gap between the metals.

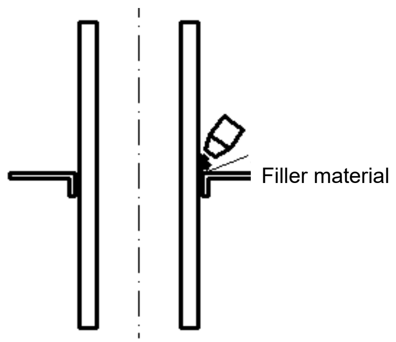


Fig. 5.20: Brazing Process

5.3.1 Advantages of Brazing

- Dissimilar metals and parts having a thin section can be easily joined.
- Brazing avoids the metallurgical damage to the base metal.
- The strong joint obtained
- Brazed joints are pressure-tight.
- Economical and quick process.
- Comparatively less heating is required than welding.

5.3.2 Applications of Brazing

- Vacuum interrupters.
- Transport applications.
- Constructions.
- Medical equipment.
- Art and jewellery

INTERESTING FACTS

Metal Inert Gas (MIG) welding was first patented in the USA in 1949 for welding aluminium. The arc and weld pool formed using a bare wire electrode was protected by helium gas, readily available at that time. From about 1952, the process became popular in the UK for welding aluminium using argon as the shielding gas, and for carbon steels using CO_2. CO_2 and argon-CO_2 mixtures are known as metal active gas (MAG) processes. MIG is an attractive alternative to MMA, offering high deposition rates and high productivity.

"Forge welding" is the process of joining two pieces of metal by heating them both, then hammering them together. This process originated in the Bronze and Iron Ages in both Europe and the Middle East – it could have been used as far back as 3,200 BC!

Today's modern welding process originated with Sir Humphry Davy in 1800, and Russian scientist Vasily Petrov in 1802 – these men discovered the continuous electrical arc that's still used in welding today.

Russian cosmonauts from the Soviet Union welded the first metal in space in 1969 on the Soyuz 6, creating welds with electron beam welding, plasma arc welding, and arc welding. They reported that these welds were "just as strong" as Earth-based welds.

VIDEO RESOURCES

Weldability

Fundamentals of Welding

Joining

UNIT SUMMARY

- Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods.
- Casting processes involve the use of molten material, usually metal. This molten material is then poured into a mould cavity that takes the form of the finished part. The molten material then cools, with heat generally being extracted via the mould, until it solidifies into the desired shape.
- Welding processes are commonly used across a range of industries including aerospace, automotive, energy and construction and others. Used to join metals, thermoplastics for a variety of applications.
- Gas welding provides better control over the temperature of the metal in the weld zone by controlling the gas flame.
- Brazing, process for joining two pieces of metal that involves the application of heat and the addition of a filler metal. This filler metal, which has a lower melting point than the metals to be joined, is either pre-placed or fed into the joint as the parts are heated.

EXERCISES

Subjective Questions

S.No.	Question	CO	BL	PO	PI Code
1.	Describe the casting phenomena	5	L1	1	1.4.1
2.	Classify the casting processes	5	L1	1	1.4.1
3.	Differentiate the permanent and temporary castings	5	L1	1	1.4.1
4.	Discuss the various design considerations in casting design.	5	L1	1	1.4.1
5.	What is importance of welding technology	5	L1	1	1.4.1
6.	Explain the arc welding process	5	L1	1	1.4.1
7.	Explain the gas welding process	5	L1	1	1.4.1
8.	Describe the welding defects.	5	L1	1	1.4.1
9.	Discuss the brazing operation	5	L1	1	1.4.1
10.	Enlist the advantages of brazing	5	L1	1	1.4.1
11.	Enlist the applications of brazing operation	5	L1	1	1.4.1

Multiple Choice Questions

S. No	Question	Ans.	CO	BL	PO	PI Code*
1.	Piston rings are produced using which pattern? (a) Sweep pattern (b) Gated pattern (c) Match plate pattern (d) Loose piece pattern	c	5	L1	1	1.4.1
2.	Which of the following is not a type of moulding sand? (a) Red sand (b) Natural sand (c) Synthetic sand (d) Loam sand	a	5	L1	1	1.4.1
3.	Electrodes used in spot welding are made up of which material? (a) Only Copper (b) Copper and tungsten (c) Copper and chromium (d) Copper and aluminium	d	5	L1	1	1.4.1
4.	Which of the following joint have high corrosion resistance? (a) Welding joint (b) Riveted joint (c) Bolted joint (d) Butt joint	a	5	L1	1	1.4.1
5.	The liquid temperature of the filler metal used in brazing is __________ (a) 150°C (b) 427°C (c) 723°C (d) 1000°C	b	5	L1	1	1.4.1

*The Performance Indicator code is referred from the AICTE exam reform document

KNOW MORE

- The various casting techniques for precision metals
- The applications of low cost casting methods
- The applications welding for metallurgic ally unstable materials
- The brazing applications in thermal stations

REFERENCES & SUGGESTED READINGS

- Groover, Mikell P, "Fundamentals of modern manufacturing: materials, processes and Systems", 4th Ed. 2007, John Wiley & Sons, Inc.
- Roger Timings, "Fabrication and Welding Engineering", Elsevier Ltd, USA
- Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGrawHill House, 2017.
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Part-B

WORKSHOP PRACTICE LABORATORY

Workshop Practice Laboratory

RATIONALE

A famous writer Confucius says, **"I hear and I forget, I see and I remember, I do and I understand",** with this quote we can understand the importance of the hands on practice or performing the laboratory work. In engineering the application of theory is very much required and it is executed in the laboratory. In this subject **Workshop / Manufacturing Practices** the theoretical aspects are dealt in Part-A of this text book and the respective laboratory / workshop practices are discussed in the Part-B of the text book for convenience of the readers.

We know that laboratory and workshops are exciting learning environments they provide learners with real life experiences to implement theoretical knowledge what they learn in class room. The laboratory and workshop classes become the bridge between theory and practice.

Workshop is the place where one can learn and experience the core learning about different materials, equipment, tools and manufacturing practices that are observed in different manufacturing functions and operations. So the workshop practice gives the basic working knowledge required for the production of various engineering products. It explains the construction, function, use and application of different working tools, equipment, machines as well as the technique of manufacturing a product from its raw material.

The laboratory / workshop create an industrial atmosphere where they can experience the real practices of the industry. Hence the workshop practice is the backbone of the real industrial environment which helps to develop and enhance planning skill, time management, visualization, hard work, relevant technical, social, ethical, teamwork, communication skills along with hands on skills required by the technician working in industries. With such kind of activities the workshop becomes the place for creativity, innovation and skill development house. The workshop gives an opportunity to learn very specific skills and expertise in turner (machine shop), fitter (fitting shop), carpenter (wood working) electrician (electrical circuits), welder (welding), metal worker (casting), blacksmith (smithy) and plastic moulding operator and many more skills. It is necessary to learn the safety precautions in all the operations along with the required skills.

The various learning outcomes after conducting this workshop practice are as fallows.

LABORATORY LEARNING OUTCOMES

The students will be able to:

LO-1: Develop the various models based on manufacturing process they learnt with dimensional accuracy and tolerances.

LO-2: Get proficiency in reading the drawings for given models.

LO-3: Use the tools required to perform the final product.

LO-4: Prepare the models based on the drawing requirements.

LO-5: Practice the safety precautions required in the workshop.

MACHINE SHOP

The machine shop includes the lathe machine, drilling machine, shaping machine and milling machine.

Safety Precautions

- Always wear lab coat in the machine shop. Wear closed shoes with rubber sole to avoid hot chips burns and electric shocks.
- Don't wear neckties, bangles, bracelets, watch, identity card tag etc. while working on lathes the risk of their getting caught in lathe chuck is more.
- The girl students don't go with long loose hair, duppattas and neckles and other hanging ornaments.
- Never operate the Machine unless you are instructed to operate it.
- Never try to stop the moving parts like Chuck, Wheels, Belt or rotating grinding wheels etc.
- Maintain the safe distance from the rotating parts.
- Use fire extinguishers in case fire hazards.
- Don't clean the machines with bear hands always use the wire brushes for machine cleaning.
- Use the first aid box when met with an accident.

Lathe Machine

Turning Job Preparation

The students can be given with three to five operations in one laboratory experiment to perform the job. Minimum three jobs can be performed in 10 hours of allocated practical hours.

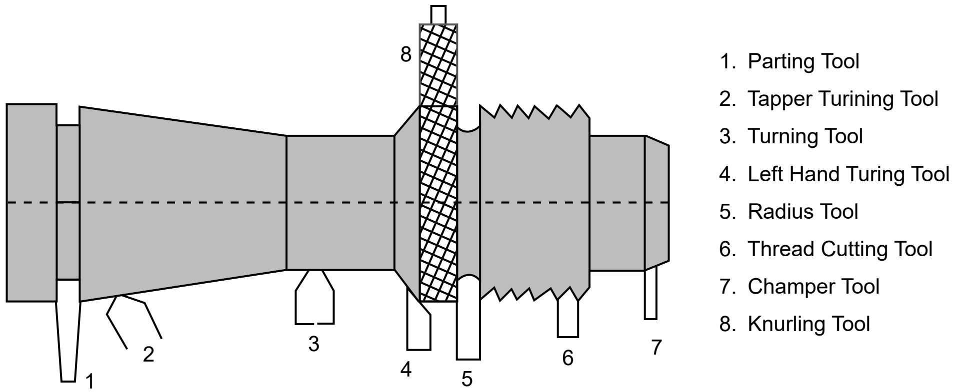
The job/models can be prepared with the help of lathe machine may contain the fallowing operations:

- Marking
- Facing operation
- Plain turning
- Step turning
- Taper turning
- Grooving

- Threading
- Knurling
- Chamfering etc

Turning Operation Sample Model

The following figure shows the operations to be performed on the lathe machine



Aim: To perform the machining operation on the given Mild Steel work piece as per the drawing provided

Drawing: add the given drawing for turning operation; all the dimensions should be in millimeter scale.

Tools Required: Vernier Caliper, Single point cutting tool, Parting Tool, Left Hand turning Tool, Knurling Tool, Champer tool

Sequence of Operations: Facing, plane turning, step turning, taper turning, groove cutting, radius cutting, thread cutting, knurling, champering

Procedure: only in points to be written, the speed, feed, depth of cut, taper angle can be calculated based on the dimensions given.(Refer Theory for calculations)

Result: example is given; all the dimensions are listed in the given table according to the drawing given.

S. No.	Drawing Dimensions (Given) In mm Diameters & Lengths	Actual Dimensions (Measured after completion of the job) in mm	Name of the Measuring Instruments Used
1.	20	20	Vernier Caliper
2.	Ø25	Ø25	Vernier Caliper

Conclusion:

Milling Machine And Shaping Machine

The gear cutting / shaping operations can be demonstrated. *If the institute has a provision of CNC machine the demonstration of CNC machining can be performed on simple job.

FITTING SHOP

Machine tools are meant for mass production of the work at a faster rate but there are occasions where the machineries require the components made by hand tools. Care must be taken to replace or repair component which must fit accurately with another component on reassembly. This involves a certain amount of hand fitting. The assembly of machine tools, jigs, gauges, etc, involves certain amount of bench work. The accuracy of work done depends upon the experience and skill of the operator. The term 'bench work' refers to the production of components by hand on the bench, where as fitting deals which the assembly of mating parts, through removal of metal, to obtain the required fit. Both the bench work and fitting requires the use of number of simple hand tools and considerable manual efforts. The operations in the above works consist of filing, chipping, scraping, sawing drilling, and tapping. The theoretical details you have studied in UNIT-2 of this book.

Safety Precautions

Fallowing safety precautions to be taken care during fitting operation

- Wear the workshop suite, shoes.
- Don't rub the tools with bear hands; be cautious while cutting by using hacksaw blade.
- Use appropriate tools for the given operation
- Maintain proper body posture while marking, filing and cutting operation otherwise it strains the body parts.
- Clean the table only with wire brush not with the hands.
- Punching operation to be carried out only on the anvils.
- Don't work on machines with empty stomach. Have Breakfast / Lunch before entering the laboratory.

Operations in Fitting Job

The various operations in fitting shop are as fallows

- Facing- The edges to be made straight by filing and confirmed with try square
- Pasting- the chalk powder on the surface to be marked
- Marking-with the height gauge the horizontal and vertical line marking
- Punching- along the marking line for guiding the hacksaw blade for cutting
- Cutting- using hack saw blade
- Rough Filing- the more material removed
- Smooth filing- the minimal material removal and operated slowly

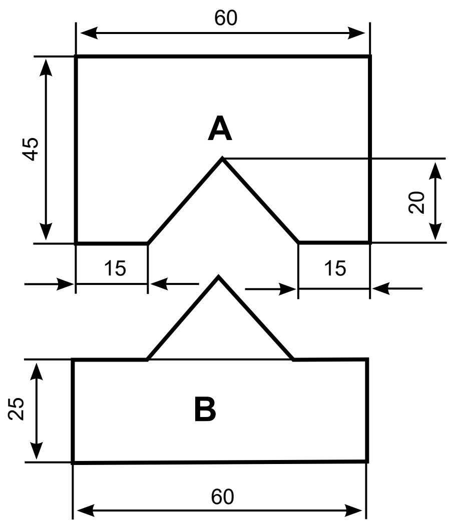
The fitting operation requires an imagination to mark and to cut the material in small quantity, to make the final fit. The parts may be noted as male and female parts or named with alphabets for easy identification. Let's study with one sample experiment. The instructors are advised to prepare the drawings with increased complexity in the jobs and minimum two jobs can be prepared in 08 hours of practical schedule. The module should ensure the utilization of all variety of filing tools.

Experiment : Prepare V-Joint

Aim: prepare a V-joint for the given dimensions

Apparatus: Steel rule, Scriber, Centre punch, Surface plate, Vernier height gauge, Hack saw, Flat file, Try square etc

Drawing:

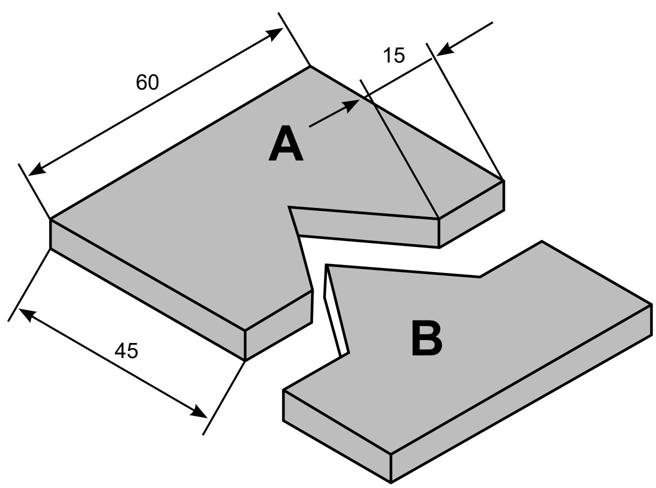


Sequence of Operation:

- Facing
- Marking
- Punching
- Cutting,
- Rough Filing
- Smooth filing

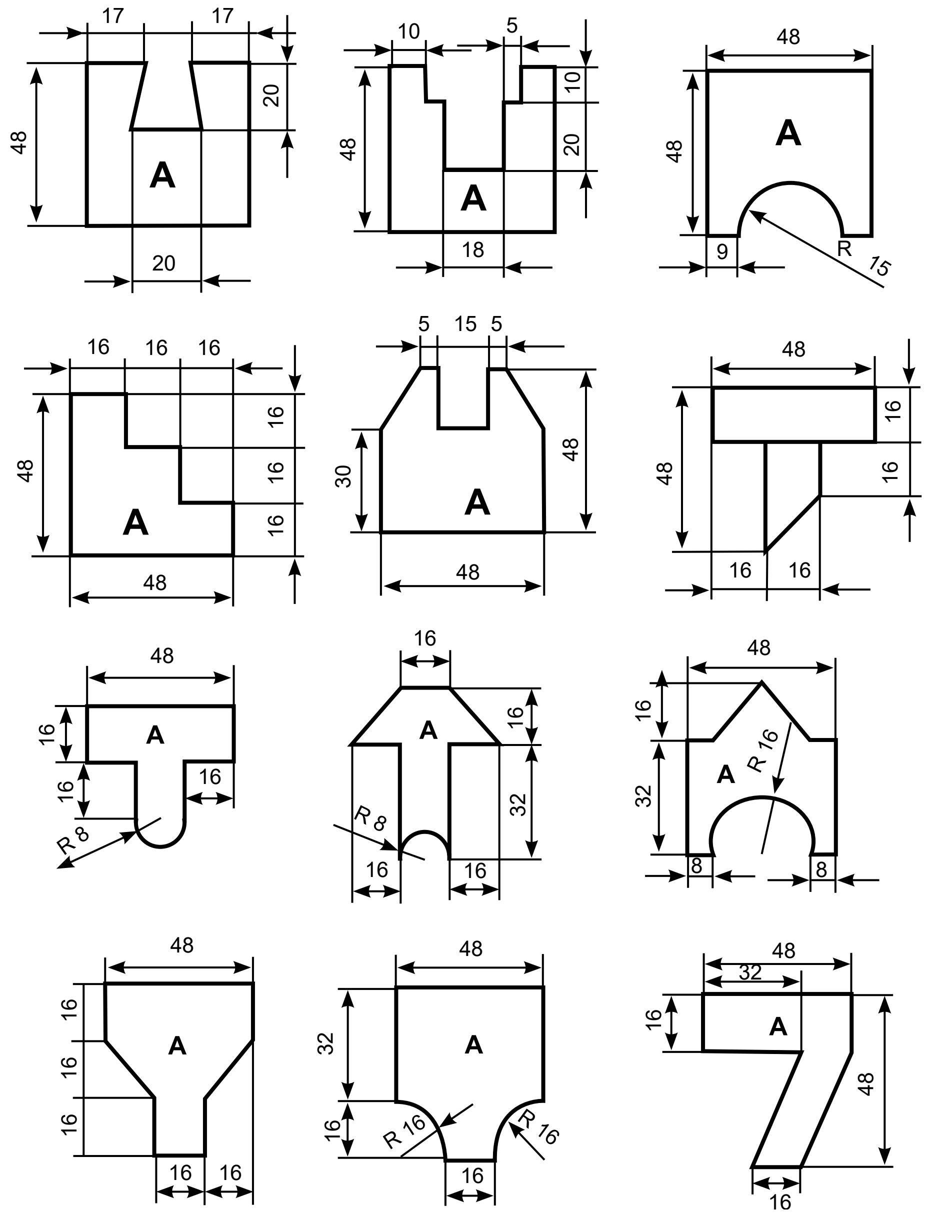
Procedure: The operation sequences in terms of steps to be written.

Result:



Conclusion: The required V-joint is obtained.

Some sample model's one part (Part-A) is shown here, similar kind of the models can be given for practice.



CARPENTRY

Carpentry is a skilled work and recognized as a trade in modern industrial age. Basically deals with working on wood and wood related product construction. The carpentry is as old as human civilization. It ranges from large ship building to smaller harmonium string.

This trade requires specialized skill to understand the drawings and smooth operation. The person who practices carpentry is known as carpenter. His roles are measuring, marking, cutting, shaping, fitting and finishing the timber. In this connection he has to use hand held tools and nowadays the power tools assisting him a lot.

In this laboratory we will study the preparation of some joints from the given dimensions.

Safety Precautions

Fallowing safety precautions to be taken care during carpentry work.

- Wear the workshop suite, shoes.
- Don't touch the tools with bear hands; be cautious while using chisels and hacksaw blade.
- Use appropriate tools for the given operation
- Maintain proper body posture while marking, cutting operation otherwise it strains the body parts.
- Don't play with the tools.
- Be cautious while using the chisel and mallets.

The carpentry has six hours of laboratory schedule; minimum two models can be prepared in this laboratory.

Operations in Carpentry Job

- Planing- The surface is made ready with given dimensions
- Marking- to the actual given dimensions
- Cutting- using hack saw cut on the marking lines
- Chiseling-start with rough chiseling and finishing the corners and edges with appropriate size chisels
- Measuring- the obtained dimensions verification against the given drawing dimensions.
- Finishing- the finishing operation according to variations.

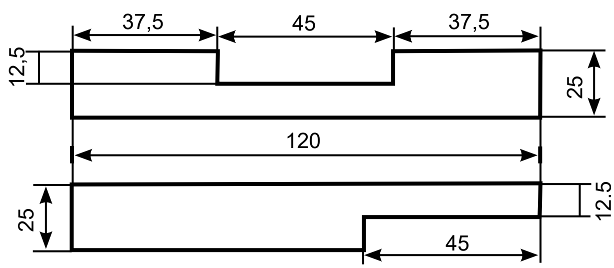
The sample of carpentry job is discussed below on the same lines the laboratory activities can be conducted.

Experiment: T- Lap Joint

Aim: Prepare a T- Lap Joint from the given specifications.

Tools Required: -Steel rule, Try square, Metal jack plane, Marking gauge, Carpentry Vice, Hand saw

Drawing:

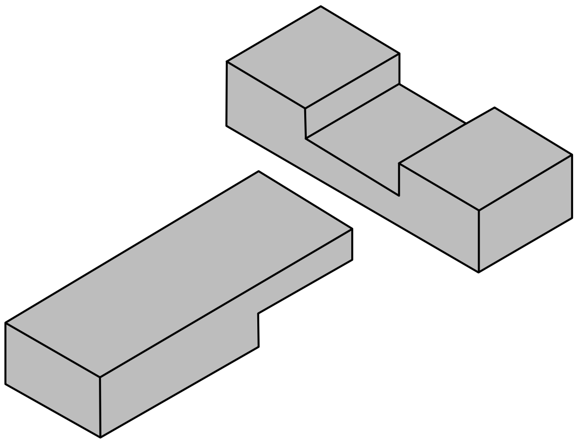


Sequence of operations:

- Planing
- Marking
- Cutting
- Chiseling
- Finishing

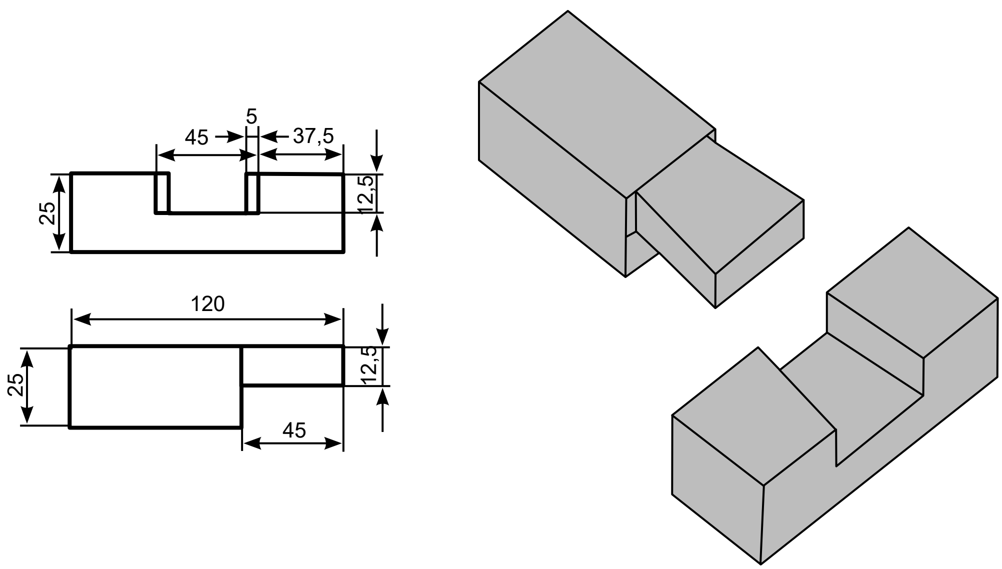
Procedure: The operations to be explained in a brief step

Result:

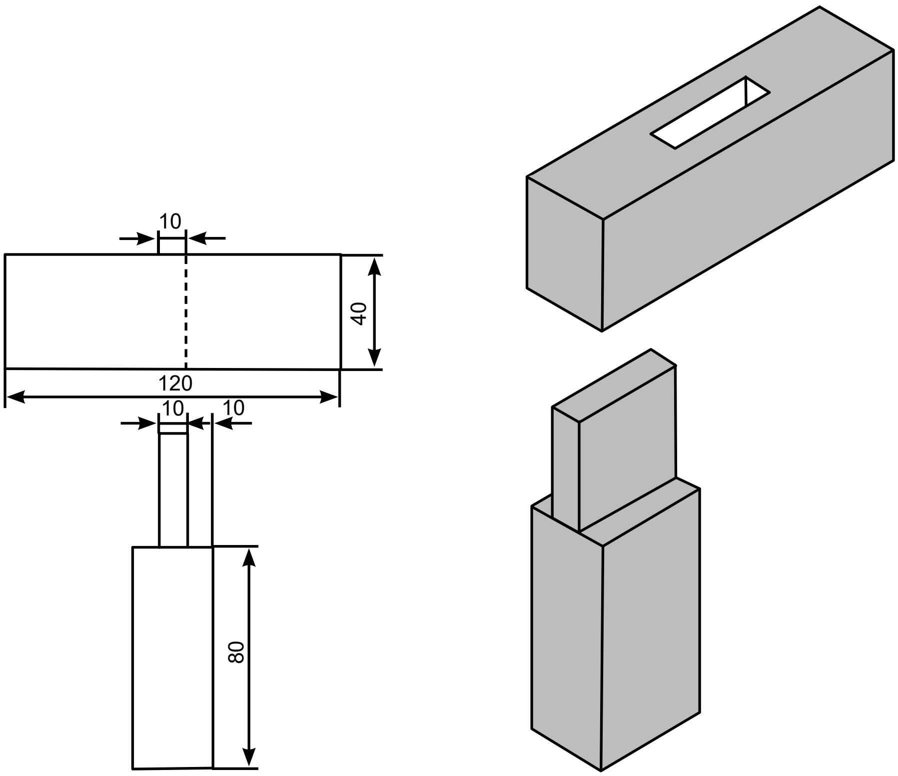


Conclusion: The required T-Lap Joint is obtained from the given work piece. The various shapes of carpentry joints can be prepared

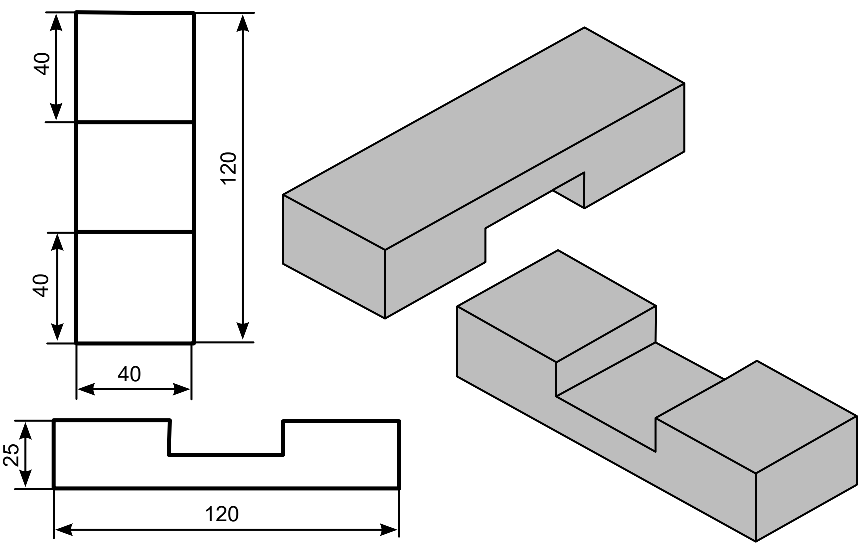
Dove-tail Lap Joint



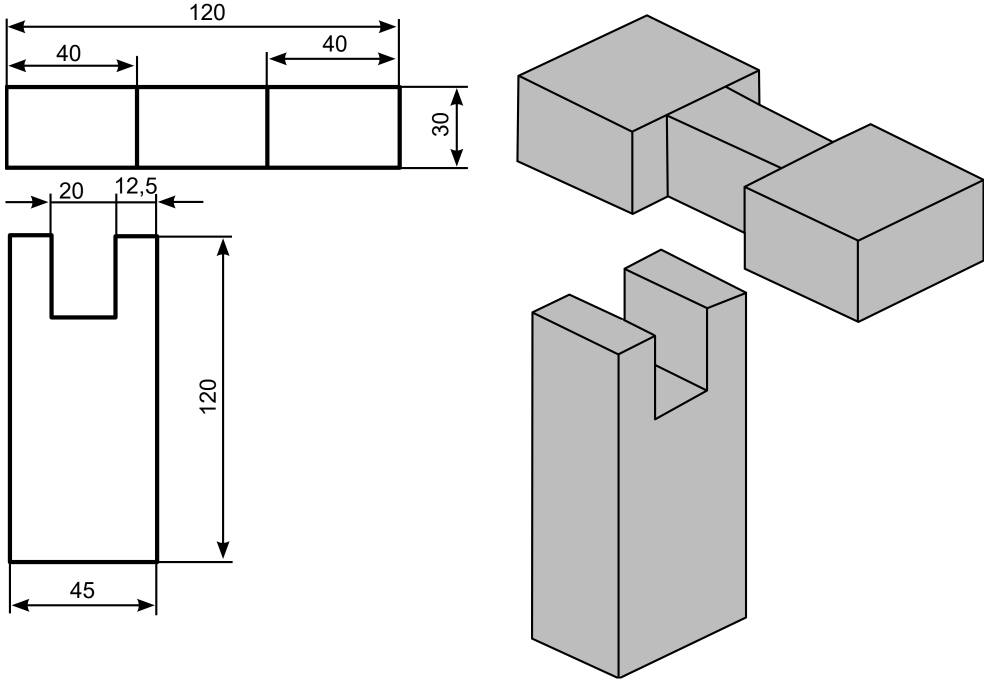
Mortise & Tenon Joint



Halving Joint



Bridle Joint



ELECTRICAL AND ELECTRONICS

The electrical and electronics laboratory intends to give basics of electricity transmission, application, and conversion. The electronics deals with micro electrical applications. In this laboratory the focus should be on basics of electrical and electronic components used in day today life and applicable to all the streams of engineering.

Safety Precautions

- Wear the workshop suite, shoes.
- Use appropriate tools, equipment's and protective devices.
- Don't touch the open circuits, live wires.
- Don't work under poor light.
- Don't work in wet areas or in wet shoes or clothes.
- Keep tools and equipment's clean and in good working condition away from water and moisture.
- Don't work on machine without the consent of an instructor.
- Read and fallow the procedure / instructions before conducting the experiment.
- Don't connect the circuits with live wires, switch off the power connection and make the circuits.
- Use the mats on floor while operating the machineries.

This topic has 8 hours of laboratory sessions, minimum two practical's can be performed. As the topic is interdisciplinary the electrical / electronic engineering department support may be sought to perform the experiments.

Experiment: Tools and Abbreviations in Electrical / Electronic Engineering laboratory

Aim: To study and to use various tools and understand the abbreviations used.

Tools: Channel Lock Pliers, Lineman's Pliers, Diagonal Pliers, Long Nose Pliers, Wire Strippers, Crimps, Roto Split , Volt Meter, Voltage Tester, Receptacle Tester, Pipe Reamer, Insulated Screwdrivers, Screwdriver Set, Square Tip Screwdriver, Stubby Screwdriver, Hacksaw, Jab/Rock Saw, Razor Knife, Torpedo Level, Hammer, Measuring tape etc.

List of abbreviations: Prepare a table of abbreviations used

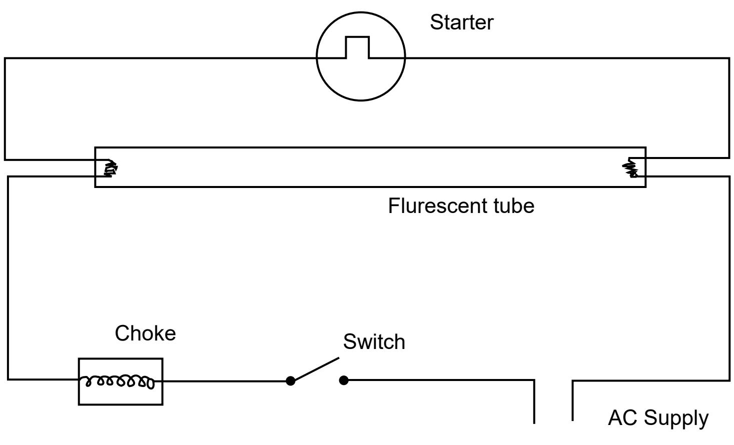
Experiment: To conduct an experiment to make wiring for a fluorescent tube light with switch control.

Tools/ Material Required: Screw driver, Hammer, Pliers, Line tester, Tube light, tube base, starter, choke, and wire.

About the Fluorescent Light:

Fluorescent tube is a low-pressure mercury vapour lamp. The lamp is in the form of long glass tube due to low pressure, with fluorescent powder coating to its inner surface. Tungsten filaments coated with barium oxide are placed at each side of the tube. The tube contains small amount of mercury with small quantity of argon gas at low pressure. When the temperature increases mercury changes into vapour form. At each end of the tube, electrode in spiral form is made of tungsten coated with electrons emitting barium. A capacitor is connected across the circuit to improve the power factor. The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

Circuit Diagram



Procedure:

- Mark the switch and tube light location points and draw lines for wiring on the wooden board.
- Place wires along the lines and fix them with the help of clips.
- Fix the tube holder and the choke on the tube base.
- Phase wire is connected in the choke and neutral direct to the tube.
- Fix the fluorescent tube between the holders.
- Finally connect the starter in series with the tube
- Complete the wiring as per the wiring diagram.
- Test the working of the tube light by giving electric supply to the Circuit

Conclusion:

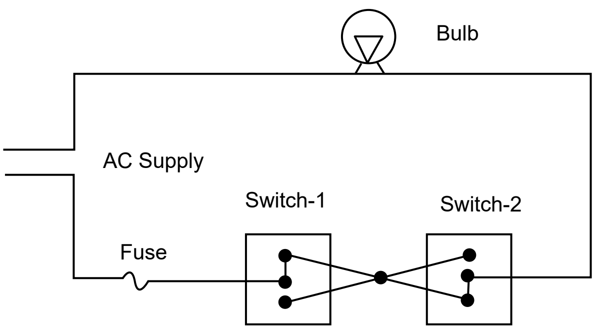
Experiment: two-way switch for stair case lighting

Aim: Prepare a circuit diagram for two-way switch for stair case lighting and validate the connections.

Tools/Material required: Screw driver, Hammer, Pliers, Line tester, Two-way switches, Bulb holders, Bulbs, Joint clips, Wires, Screws, Switch board

About the functioning of two-way switch: The two-way switches are used when the distance is more and it is convenient to switch of the light at that particular point itself comparatively going back to the initial position. It is that wiring which makes use of two switches to operate bulb at the beginning of the stair case light and off the bulb by pushing the button on the other end. One of the terminals of the bulb is connected to the main line whose power line is connected to middle slot of two-way switch. Remaining first of their slots is connected in parallel as in crossed node.

Circuit Diagram



Procedure:

- Prepare a layout on the wooden board
- Mark switch and bulb location points and mark the lines for wiring on the Board.
- Place wires along the marked lines and fix them with the help of clips.
- Fix the two-way switches and bulb holder in the marked position on the Board.
- Connect the complete wiring and switches as per the wiring diagram.
- Test the working of the bulbs by giving electric supply to the circuit.
- Validate the results in the table

Result:

Switch Position		Lamp Condition
Switch-1	**Switch-2**	
OFF	OFF	OFF
ON	OFF	ON
OFF	ON	ON
ON	ON	OFF

Conclusion:

WELDING SHOP

Welding is the process of joining metals by melting the parts by using heat energy with or without the addition of a filler material to form a joint. Welding can be done using different energy sources may be a gas flame, electric arc, laser or ultrasound and any other energy source. Earlier the welding is used for weapons making now it has expanded its horizon to all the fields. The worn out parts maintenance/ replacement is also possible with welding work. The arc or gas wildings are used based on the application requirement. Kindly refer for the more details, discussed in UNIT-5 of this text book.

Safety Precautions

Arc Welding

- Ensure that always you wear the safety hand gloves, apron and leather shoes.
- Use the welding goggle, shield while performing the welding
- Make sure that welding machine is properly grounded and leads are properly insulated.
- Always use a face shield while welding; the arc may burn your eyes severely.
- Ensue that welding cables will not be in contact with hot metal, water, oil and grease.
- Avoid dragging the cables around sharp comers.
- Stand on dry footing and keep the body insulated from the electrode before you start the welding.
- Ensure proper insulation of all the connected cables.
- Immediately turn-off the machine before leaving the work.
- Keep the fire extinguisher at nearest place for easy accessibility.

Gas Welding

- Ensure that always you wear the safety hand gloves, apron and leather shoes.
- Use the spark lighter to light the torch and instead of a match box.
- Do not allow blow pipe to heat the cylinders, hoses or any other equipment.
- Ensure that the hose pipes not get warmed by continuously using.
- Don’t operate the valves with sharp tools.
- Keep the gas cylinders in designated places/on trolley

- Frequently check the leakage of the gas in hose pipes
- Leakage may be checked only with soap water not with fire stick.
- Keep the fire extinguisher at nearest place for easy accessibility.
- The oil and other susceptible materials should be kept away from the welding zone.
- The instructor advice is sought before to perform the job.

The welding topic has 8 hours of laboratory sessions minimum two models in each arc and gas welding may be performed.

How to prepare the weld

Once the material is ready for welding, the cut pieces of the work pieces to be checked for its readiness for welding. It is necessary to ensure the cleanliness of the work pieces before the welding operation. It is necessary to remove any mill scale, chemicals, contaminants, oils, grease and any coatings from the base material. That may help to ensure proper weld penetration and eliminates impurities, porosity, and any inclusions. So it leads to defect free welding.

Properly preparing work pieces for welding is key factor for producing high-quality results, maintaining consistent productivity levels, and minimizing costs. Making the initial clean, straight, and consistent as much as possible will make it easier to produce quality welding. There are many tools and techniques to prepare the surfaces for welding ready, they are use of sand paper, cloth and solvent, angle grinder, chop saw, band saw, oxy-fuel cutting, plasma cutter etc.

Essential factors for welding

Following are the few essential requirements to get the sound welding outputs.

- The suitable work piece
- Proper base plate for welding
- Correct Electrode size
- Appropriate arc length or voltage need
- Correct current supply
- The arc travel speed
- The holding electrode angle while welding
- Suitable safety equipments and tools.
- The exeprty of the welder
- Proper mixing of the gas in gas welding

Let's study the some of the laboratory welding model preparations with the following examples. The appropriate size and shapes can be decided by the instructor. But it is requested to ensure that the complexity in the welding joints may enhance their welding capability. With this approach the welding joints can be prepared and executed in the laboratory. The instructors are advised to take utmost care while performing the welding operation.

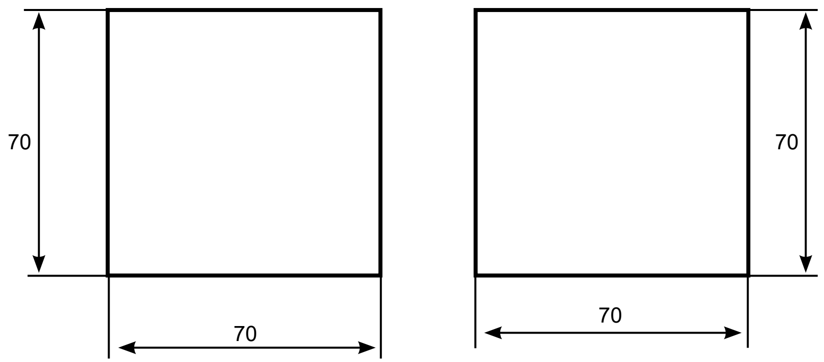
Experiment: Butt Joint

Aim: To prepare a Butt joint by Arc Welding process.

Material Required: Mild steel plates

Tools and Accessories required: Rough and smooth files, Protractor, Arc welding machine, Mild steel electrode and electrode holder, Ground clamp, Tongs, Face shield, Chipping hammer.

Drawing: the given size work pieces

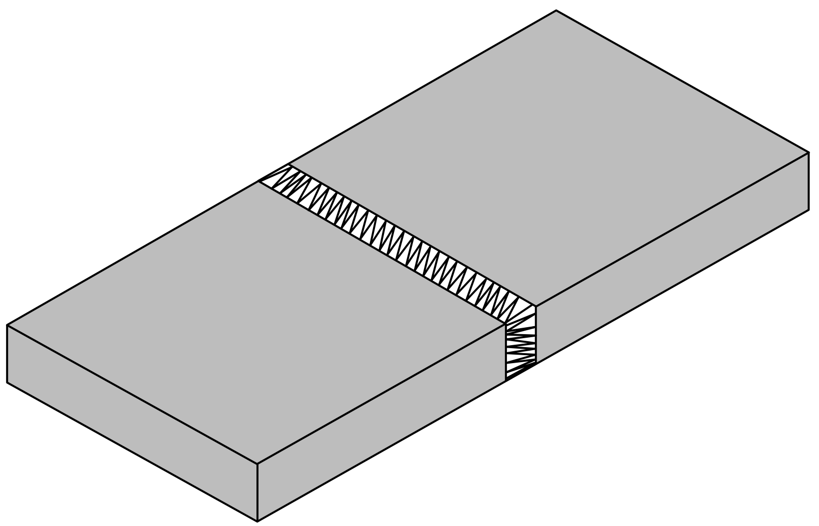


Sequence of operations:

- Marking
- Cutting
- Edge preparation (Removal of rust, scale etc.) by filling
- Try square leveling
- Tacking
- Welding
- Cooling
- Chipping

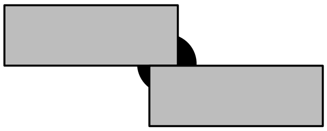
Procedure: write the procedure in simple steps.

Result:

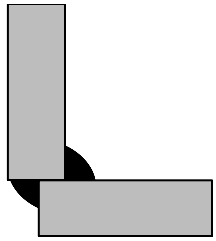


Conclusion:

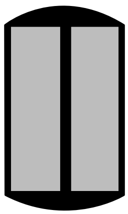
Some more joint types are mentioned below for referances.



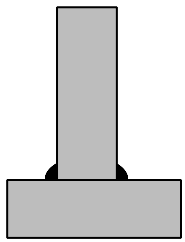
Lap Joint



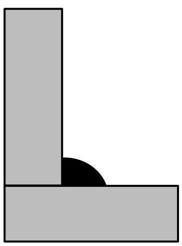
Corner Joint



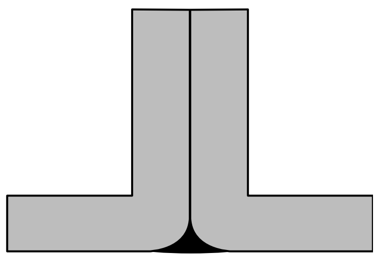
Edge Joint



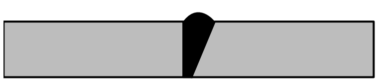
T-Joint



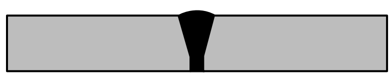
L-joint



Flare V-Joint



Bevel Joint



U-Groove

CASTING

In any manufacturing industry the foundry section occupies an important place from so many years. In foundry the complicated shapes of the jobs can be manufactured with less investment and time. It is done by pouring molten metal usually the cast iron, brass, aluminum etc into moulds prepared by wooden or metal patterns. The process of shaping metals by pouring them takes very less time and much cheaper than any other manufacturing methods. That is how casting is practiced everywhere.

The product shapes are replicated in the form of pattern. The pattern is the principal element in the casting process. It is a model or the replica of the object to be cast. This model is used to create the cavity in the sand. Once the pattern is removed it creates the cavity for filling the molten metal. Once the cavity is filled with molten metal allow some time for solidification so it produces a casting i.e. the required final product.

The pattern is always made somewhat larger than the final job to be produced. This excess in dimensions is referred to as the pattern allowances. They are Shrinkage allowance, Machining allowance and Draft or Taper Allowance. Shrinkage allowance is provided to take care of the contraction of a casting. Machining operations are required to produce the finished surface of the final product of the casting. It is taken care by Machining allowance. Taper allowance is a positive allowance and is given on all the vertical surfaces of pattern so that its withdrawal becomes easier. The most commonly used pattern material is wood, since it is readily available and of low weight. Also, it can be easily shaped and is relatively cheap

Safety Precautions

The fallowing safety pre cautions to be taken care in the casting laboratory.

- Wear the workshop suite, shoes.
- Use appropriate tools, equipment's.
- Arrange all the equipments as per the requirement.
- Take care of the hands while ramming the sand during pattern making.
- The mould box are made of cast iron and bulky in nature, handle them carefully.
- Wash the hands properly after the laboratory work is over
- Don't perform the jobs with empty stomach.
- Fallow the instructor instructions regularly
- Take care of while preparing the molten metal while heating in furnace.
- Avoid the inhaling of gases / fumes coming out of molten metal and from the mould.
- Don't touch the castings unless until they completely cooled.
- Don't vibrate the moulds, once they are filled with molten metal

Sequence of operations:

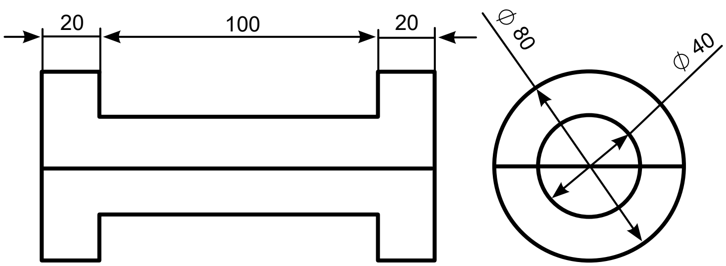
- Selection of the pattern based on the requirement
- Preparation of the green sand
- Filling the moulding sand into the drag and cope along with Pattern, Riser, Sprue.
- Remove the pattern
- Put a parting sand thin layer between the cope and drag.
- Pouring the molten metal into the sprue and confirm it by seeing the rise of molten metal in riser.
- Allow for solidification
- Open the mould
- Finishing operation

The topic has 8 hours of laboratory session; minimum two models can be prepared in this laboratory.

Experiment: Bearing Pattern Preparation

AIM: Prepare a sand mould by using the given bearing pattern

Drawing:



Materials Required: Moulding sand, parting sand, water.

Tools Required: Cope & Drag mould box, Shovel, Hand rammer, Round rammer, Strike off -bar, Vent -wire, Trowel, Slick, Lifter, Sprue , Runner& Riser, Hand riddle etc.

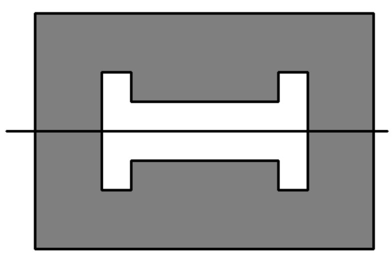
Major operations:

- Preparation of moulding sand
- Preparation of mould cavity using pattern
- Withdrawal of pattern
- Gate cutting
- Finishing

Procedure:

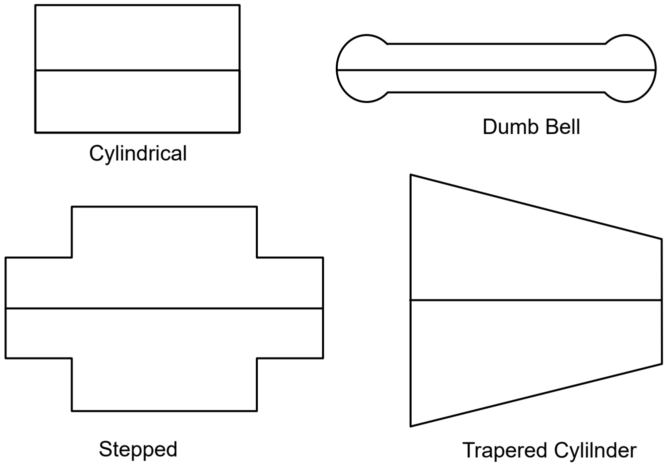
- Select the pattern
- Prepare the moulding sand and check the quality.
- Placed the drag box keeping upside down and place the half of the pattern piece.
- Fill the sand, ramming by hand rammer and remove excess sand by using strike -of bar.
- Keep the drag box in normal position and place the remaining half portion of the pattern, prepare the mould.
- Remove the pattern and see that the mould cavity is not disturbed.
- Sprinkle the parting sand above the drag box and place the cope box slowly.
- Fix the cope box over the drag box and place the sprue pins

Result:



Conclusion:

The fallowing patterns may be practiced for mould making



SMITHY

Smithy or hand forging is an ancient trade. Here heating a metal stock is done till it becomes red hot and simultaneously acquires plasticity. At this moment hammering by hand forging leads to acquire the desired shape and size. This can be achieved by compression, bending, tapping etc. till the desired shape is attained. For large equipment forging machines are used.

Hearths are used for heating small jobs to be forged by hand. Gas, oil or coal firing may be used for this purpose. The required air for the fire is supplied under pressure by a blower through the pipe into the hearth. The blowers may either be hand operated or power driven.

Safety Precautions

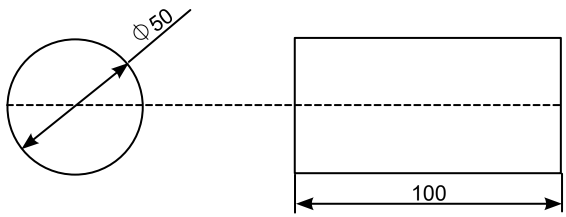
- Wear the workshop suite, shoes.
- Use appropriate tools and equipment's.
- Hammering should not be done carelessly.
- Heavy blows should not be given on the tail of the anvil.
- Sufficient length should be provided for Hammer handle.
- Blunt chisels should not be used in the forging shop
- Never use fullers and swages for cold metal.
- keep the fire small but deep in furnace
- Keep the fire clear from clinkers
- Do not add fresh coke on the top of the fire, put it from the side.

This topic has 6 hours of laboratory session so minimum two models can be prepared. The various types of jobs can be prepared either by compacting or bending the given work piece.

Experiment: Convert the given work piece from circular to square.

Aim: Prepare a Square rod from a given round rod by following hand forging operation.

Drawing:

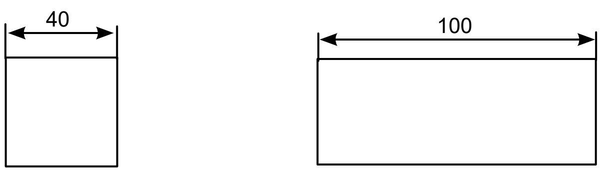


Tools required: Smith's forge, Anvil, Ball-peen hammers, Flatters, Swage block, Half round tongs, Pick- up tongs, Cold chisel.

Sequence of operations:

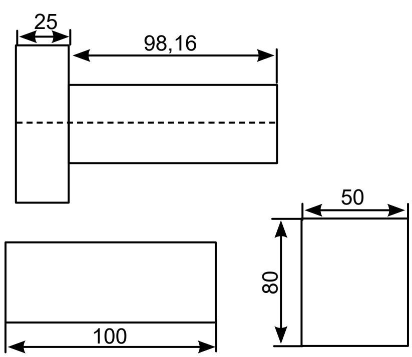
- Measure the dimensions of the given work piece.
- Handle specimen with round tong and heat in furnace / open hearth till it appears red cherry color.
- Place the hot work piece on the anvil.
- The part is held with the help of the tongue and blow with sledge hammer for obtaining the square shape on all edges
- The above mentioned all steps are repeated if the metal gets cooled in between.
- Check the dimensions after quenching the work piece.

Result:



Conclusion: the required square job is done

The sample jobs may be performed in smithy lab may include reducing the length of given bar, converting square to round bar, creating square head on the given length bar.



PLASTIC MOULDING AND GLASS CUTTING

Plastic moulding process gives the required shape to the final product by compressing in the injection moulding machine. The plastic may be used in the form of liquid or granules based on the requirement. The glass cutting operation involves either manual or laser cutting techniques. The glass cutting process involves making a score in the glass surface with a diamond or special tungsten carbide cutting wheel and then running or snapping the cut to break the glass at the score line. The score line can be straight or shaped to follow a template.

Safety Precautions

- Wear the workshop suite, shoes.
- Use appropriate tools and equipment's.
- Don't hold the plastic / glass without hand gloves
- Be careful while using the glass cutter
- Keep away from the heating coils of the injection moulding machine.
- Don't inhale the emissions of plastic.

As this topic has 6 hours of laboratory session, so two experiments may be conducted. One from plastic moulding and another on glass cutting.

Experiment: injection moulding machine

Aim: prepare the plastic parts by using injection moulding machine.

Tools/ material required: die set, plastic granules

Procedure:

- Turn on switches of heater
- Pour the raw material in hopper of machine, pour and fill it.
- Adjust the temperature of heater around 320 to 350 degree centigrade
- Clamp injection moulding tool at correct position so that the axis of sprue hole and barrelhole is in one line.
- open mould halves and start pump
- Adjust the pressure and by lever manually apply pressure to inject molten plastic.
- Allow for cooling
- Eject the die and remove the finished product.

Result:

Experiment: Glass cutting

Aim: perform the glass cutting operation to get the given dimensions

Tools/Materials: glass cutter, glass

Procedure:

- The glass is to be placed on plane table and the cloth is laid beneath the glass to be cut.
- Mark the cutting line or use the template
- Apply etchant on the marked line
- Slowly move the diamond cutter across the line or template.

- Tap the glass with rubber mallet or use the flier for cutting the glass
- The final product is obtained

Result:

(Courtesy: https://www.instructables.com)

Appendices

APPENDIX-A

Disposal of Waste

The waste generated in this work shop laboratory is to be segregated at the initial level. The students should be made aware about the disposal of particular waste in respective dustbins after performing the practical.

Experiment Name	Type of Waste	Colour of Bins
Machine Shop	Metal Waste	 Blue
Fitting Shop	Metal Waste	 Blue
Carpentry	Biodegradable waste (wood)	 Green
Electrical & Electronics	e-Waste	 Black
Welding Shop	Metal waste & e-Waste	 Blue  Black
Casting	Metal waste	 Blue
Smithy	Metal waste	 Blue
Plastic Moulding	Plastic waste	 Blue
Glass cutting	glass waste	 Blue

APPENDIX-B

Indicative Guidelines for Evaluation of Practical Work

Process /Product Related Skills can be evaluated with the following table with grades / marks for each experiment with convenient scale (may be 15 marks for each experiment)

With the following table each experiment can be evaluated on the scale of 15 marks each criteria carry maximum 3 marks. For developing give 1 mark, for competent 2 marks and for proficient 3 marks.

Criteria	Developing	Competent	Proficient
Handling of Equipment / Apparatus			
Recording of Observations (during conduction)			
Time management (performing the job)			
Group Efforts / Individual Efforts			
Record submission & Viva-voce			
Total			

APPENDIX-C

CO and PO Attainment Table

Course outcomes (COs) for this course can be mapped with the programme outcomes (POs) after the completion of the course and a correlation can be made for the attainment of POs to analyze the gap. After proper analysis of the gap in the attainment of POs necessary measures can be taken to overcome the gaps.

TABLE FOR CO AND PO ATTAINMENT

Course Outcomes	Attainment of Programme Outcomes *(1- Weak Correlation; 2- Medium correlation; 3- Strong Correlation)*											
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
CO-1												
CO-2												
CO-3												
CO-4												
CO-5												
CO-6												

The data filled in the above table can be used for gap analysis.

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