

BASIC MECHANICAL ENGINEERING

BME-1

FUNDAMENTALS

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q1. Discuss different modern tools used in mechanical engineering. [R.T.C. 2019]

- Ans. Modern tools used in Mechanical Engineering:
1. AutoCAD
 2. MATLAB
 3. CATIA
 4. ZW3D
 5. MechDesigner
 6. PTC Creo
 7. BricsCAD
 8. Solid Edge

Q2. Describe law of thermodynamics. [R.T.C. 2019]

Ans. Law of Thermodynamics:

1. **Zeroth Law of Thermodynamics:** According to this law, if two thermodynamic system A and B are in thermal equilibrium with a third system C, then the two system A and B are also in thermal equilibrium with each other.

2. **First Law of Thermodynamics:** It gives the law of conservation of energy according to which, Energy can neither be created nor destroyed, it only transforms from one form to another form. If Q is heat given to the system and W is work done by the system, then total energy stored in the system is given by the difference of heat supply and work done.

Mathematically,

$$\Delta Q = \Delta U + W$$

3. **Second Law of Thermodynamics:**

(i) Kelvin - Planck Statement: "It is impossible for a heat engine, working on cyclic process, to convert total heat supplied into mechanical work". This law is also called law of degradation of energy.

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Scope: Talking about the scope of an industrial engineer in India, engineers can pursue different career options from safety measures engineer, production manager, industrial technician, management engineer, systems engineer etc. working both in offices and site locations. Job placement for industrial engineers is always a rising graph, as they are trained to work in virtually every industry. It is a versatile and successful career choice. The demand for industrial engineers and technicians is growing being produced in India. With more than 1000 MNC's having their companies all across the country, the option of salaries is also better then before. Hence, making this occupation a better option in this rapidly emerging sector.

Q3. What is a thermodynamic system?

Ans. Thermodynamic System: A fixed area or region or space in which different thermodynamic processes take place is called 'System'. It is divided into three group:

- (i) Open System
- (ii) Closed System
- (iii) Isolated System

Q4. Define power. Give its unit.

Ans. Power: Power is defined as the work done in unit time. In other words, it is the rate of work done by the system or on the system and time taken to complete the work. Mathematically,

$$\text{Power} = \frac{\text{Work done}}{\text{Total time taken}}$$

Unit of power is given by Watt (W).

Q5. What is total energy?

Ans. Total Energy: Total energy of the system is equal to the sum of potential energy, kinetic energy and internal energy. Mathematically,

$$E = PE + KE + U$$

Q6. What is the role of an industrial engineer in industry?

Ans. An industrial engineer works in the field of manufacturing engineering, safety engineering, data science, quality control engineering, project management, supply chain management, operations research and management, logistics etc.

BASIC MECHANICAL ENGINEERING

II. LONG ANSWER TYPE QUESTIONS

Q1. Discuss different laws of perfect gas.

Ans. Different Laws of Perfect Gas

(1) Boyle's Law: At constant temperature, pressure of a given mass of perfect gas is inversely proportional to its volume.

$$P \propto \frac{1}{V}$$

$$PV = \text{Constant}$$

(2) Charles's Law: At constant pressure, for a perfect gas, volume of given mass is directly proportional to its temperature.

$$V \propto T$$

$$\frac{V}{T} = \text{Constant}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{Constant}$$

(3) Gay-Lussac Law: At constant volume, the pressure of a given mass of perfect gas is directly proportion to its temperature.

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BASIC MECHANICAL ENGINEERING

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Q2. What is manufacturing technology? How is manufacturing process classified?

Ans. Manufacturing Technology: Manufacturing technology is the detailed study of various processes used to produce different parts and to assemble them into a machine. The word 'manufacturing' is derived from the latin word 'manus' which means hand and 'fact' which means made. Its overall meaning is made by hand.

Classification of Manufacturing Processes: Refer to Short answer Q.1

BOILERS 2

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 Define steam boiler and write different types of boiler. [R.T.U. 2018]

Ans. A steam generator or a steam boiler is a steel enclosure used to transfer the heat generated by the burning of fuel (solid, liquid, gas) to water, which leads to production of steam.

Types of Boiler : Boilers are generally classified as follows :

- Fire tube and water tube boilers
- Horizontal, vertical and inclined
- Externally fired and internally fired
- Locomotive, marine, stationary and portable
- Natural circulation and forced circulation

Q.2 Write down the Difference between water tube boiler and fire tube boiler. [R.T.U. 2018]

Ans. Water Tube Boiler

- Water is circulated inside the tubes surrounded by hot furnace gases.
- Steam pressure is higher and goes upto 165 bar.
- Rate of steam generation is as high as 450 tonnes per hour.
- Overall efficiency reaches up to 90% with economizer.
- Lesser area is required to generate a given amount of power, around 5 meter square per tonne per hour.
- It is separable into its various components and hence can be transported and assembled easily.
- It can be operated easily at fluctuating load.

- Water circulation is done in a well-defined direction.
- There are chances of bursting.
- Bursting does not lead to complete destruction of the boiler.
- The operating cost is high.
- It is suitable to use in large power plants.

Fire Tube Boiler

- Hot gases from the grate are passed through 1 tubes surrounded by water.
- Steam pressure can rise only up to 24.5 bar.
- About 9 tonnes of steam per hour are generated.
- Overall efficiency reaches up to 75%.
- To generate given power, more floor area (about meter square per tonne per hour) is required.
- It is difficult to transport and set up.
- It can handle fluctuations only for a shorter period.
- Direction of circulation of water is not fixed.
- There is lesser probability of bursting.
- If bursting occurs, the damage to the property is vast.
- Operating cost is low.
- It cannot be used for large plants.

Q.3 Write down the various factors affecting the selection of steam boiler.

Ans. Selection of Steam Boiler : The following factors affect the selection of a steam boiler:

- Availability of fuel and water.
- Type of fuel used.
- Expected load factor.

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- Suitable geographical location for power house.
- Amount of power and working pressure required.
- Rate of steam generation.

Q.4 Name the different parts of a Cochran boiler.

Ans. Parts of a Cochran Boiler

- Cylindrical shell
- Fire box
- Flue pipe
- Combustion chamber
- Smoke tubes
- Chimney
- Manhole
- Grate

II. LONG ANSWER TYPE QUESTIONS

Q.1 What are the essential requirements of a good steam boiler?

Ans. Essential Requirements of a Good Steam Boiler

- The installation costs should be economical.
- It should be light in weight and occupy less space.
- It should start quickly.
- It should be able to adjust quickly to the fluctuations in load.
- It should be fuel efficient and produce maximum amount of steam.
- Heating plates should not be covered by mud and waste deposits.
- Tubes should not be choked by soot or other deposits. They should have enough strength to withstand considerable amount of wear and corrosion.
- Refractory material produced should be just in the right amount to sustain easy ignition and prevent smoke from burning the fuel.
- The amount of maintenance required should be minimum.
- There should be lesser and easily accessible joints.
- Frictional losses due to movement of water and flue gas in the circuits should be minimal along with optimum fluid velocity.

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- It should follow all the safety rules as per the Boilers Act.

Q.2 Discuss the important terminology related to steam boilers.

Ans. Important Terminology of Steam Boilers : From the subject perspective, it is important for one to know and understand the important terminology related to the steam boiler. The essential terms related to steam boilers are listed below :

- Boiler Shell** : This cylindrical shell is formed by welding or riveting the steel plates whose ends are sealed by end plates. It is used to store the water to be heated. Also, it contains the steam that is formed as a result of heating. Therefore, it should have sufficient storage capacity.
- Combustion Chamber** : The combustion chamber, usually located below the boiler shell, is used to burn fuel so that water in the boiler shell can be heated to produce the steam.
- Grate** : A grate acts as a platform inside the combustion chamber to burn the coal or wood fuel. It is made from cast iron bars, the space between which allows the air to pass for combustion. The total surface area of the grate on which combustion takes place is called grate surface.
- Furnace** : It is located between the grate and the boiler shell. The fuel is actually burnt here. It is also known as fire box.
- Heating Surface** : The portion of the boiler surface exposed to fire and hot gases is called heating surface.
- Mountings** : Certain components are fitted on the boiler to ensure proper functioning and safety. These are called mountings. For example- safety valve, water level indicator, pressure gauge etc.
- Accessories** : These are the additional devices used with the boiler without mounting them on it. These are used to increase the efficiency of the boiler. For example- superheater, economizer, feed pump etc.

Q.3 Explain Lancashire boiler with neat sketch.

Ans. Lancashire Boiler : It is a horizontal axis, stationary fire tube boiler that uses natural circulation of water and flue gases. Heat is transferred through convection and a low pressure steam is generated. This steam is used to drive steam turbines which require moderate power.

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What is the principle of steam turbine? ✓

Ans. In steam turbine, first energy of steam is converted into kinetic energy by nozzle and followed by blade passage. Thus a high velocity steam generates, that acts on the curved blades, which changes the flow direction of steam, due to which momentum of steam changes. Due to change in momentum of steam, a force is to be exerted on the blades fixed on a rotor according to "Newton's Second Law of Motion", and power (rotary) is developed due to the rotation of these blades.

Q.2 Write down the assumptions made while examining the flow through the stages in an axial flow turbine.

Ans. While examining the flow through the stages, the following assumptions will be made:

1. Flow conditions are evaluated at the mean radius unless otherwise stated.
2. Radial velocity is zero.

Q.3 Define blade velocity coefficient.

Ans. Blade Velocity Coefficient : If there is no frictional losses, relative velocities V_{r1} and V_{r2} will be same but this is impossible practically. So practically always V_{r2} is always less than V_{r1} and "ratio of Relative velocity at exit V_{r2} and V_{r1} is known as Blade Velocity Co-efficient".

$$K = \frac{V_{r2}}{V_{r1}}$$

II. LONG ANSWER TYPE QUESTIONS

Q.1 Differentiate between impulse and reaction turbine. ✓
[R.T.U. 2018]

OR

Give comparison between impulse and reaction turbine. PPF

Ans. Comparison Between Impulse and Reaction Turbine

S. No.	Features	Impulse Turbine	Reaction Turbine
1.	Blade types	Profile	Aerofoil
2.	Blade passage area	Constant	Varying, converging
3.	Admission of steam	Not all over complete	Complete all over
4.	Drop of pressure	Pressure drops in nozzle, and not through moving blade passages	Pressure drops through, both fixed and moving blade passages
5.	Nozzles or fixed blades	Diaphragm contains nozzles	Fixed blades are attached to casing serving as converging passages or nozzles, which also guide steam path
6.	Suitability	Suitable for small power demand	Suitable for medium and high power demand
7.	Space for same power	Occupies less space for same power	Occupies more space for same power
8.	Efficiency	Lesser	Higher
9.	Manufacturing	Simple and cheap	Difficult and costly

Water
Nuclear
Core

4

INTRODUCTION TO POWER PLANTS

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 Write down the main components of a HEPP

Ans. Main components of HEPP is listed below :

- (1) Catchment area
- (2) Reservoir
- (3) Dam
- (4) Spillways
- (5) Conduit
- (6) Surge tank
- (7) Draft tubes
- (8) powerhouse

Q.2 What is the role of conduit in HEPP?

Ans. Role of Conduit : Different pipelines or channels are used in dam. A penstock is the long pipe that carries the flowing water from reservoir to turbine. Headrace of dam leads water from reservoir to turbine and tailrace carries out the water from turbine.

Q.3 Why deaerator is used in thermal power plant?

Ans. Deaerator : Dissolved oxygen and flue gases in feed water can cause serious corrosion problem that can damage the metallic surfaces. To eradicate this problem an auxiliary device is fitted in the system, which is called deaerator. Most of the deaerators are designed to remove oxygen and carbon dioxide. Carbon dioxide combines with water and form carbonic acid which can damage metal surface.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Write a short note on different types of power plant

Ans. A power station (also referred to as a generating station power plant, powerhouse or generating plant) is an industrial facility for the generation of electric power.

Types of Power Plants

1. COAL thermal Power Plants
2. HYDRAULIC Power Plants
3. NUCLEAR Power Plants
4. GEOTHERMAL Power Plants
5. SOLAR Power Plants
6. WIND Power Plants
7. BIOMASS Power Plant

1. Coal Thermal Power plant

- (i) In coal thermal power plants the heat produce by burning fossil fuel materials boils water and transform in into steam.
- (ii) The steam is then piped to a turbine. The impulse of turbine moves the turbine. Finally, steam is condensed and move into the boiler to repeat the cycle.

Basic Mechanical Engineering

(iii) Rotation of the turbine rotates the generator to produce electricity.

2. Hydraulic Power Plant

- (i) The hydroelectric power plants are stations where energy is produced by the force of falling water.
- (ii) The water moves a turbine connected to a generator that collect the energy that water creates.

3. Nuclear Thermal Power Plant

The heat is produced by fission in a nuclear reactor (a light water reactor). Directly or indirectly, water vapour (steam) is produced. The pressurized steam is then usually fed to a multi-stage steam turbine.

4. Geothermal Power Plant

Geothermal electricity is electricity generated from geothermal energy. Technologies in use include dry steam power plants, flash steam power plants and binary cycle power plants.

5. Solar Power Plant

That kind of power plants creates energy by transforming the heat and light from the sun.

6. Wind Power Plant

Wind station are the ones that transform wind energy into another useful kind of energy.

A wind farm consist of almost a hundred of winds turbines connected to electric power transmission network.

7. Biomass Power Plant

The Biomass thermal energy consist in burning the natural waste and rubbish, such as plants animals, food.

It produces natural gases that provides heat to water and which transforms it into steam, that later will move a turbine connected to a generator that collects energy.

Q.2 Describe the factors which affect the selection of site for HEPP.

Ans. Selection of Site for HEPP

- (1) Availability of Water: The power generated by HEPP is dependent on availability of water at site. Design and capacity of HEPP is determined by the water available in dam. It also provides a brief idea for spillways or gate relief during flood.
- (2) Capacity: Variation in rainfall all the year makes it necessary to store a large amount of water for continuous power generation. Water storage capacity of HEPP can be determined by using mass curve.
- (3) Water Head: A large quantity of water with sufficient head is required for generation of desired quantity of power. For a given power output, if available water head increases then supply of water to the turbine reduces.

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(4) Transportation Facility: The site should have well transportation facility so that men and materials can easily come and go. In absence of transportation facility, it becomes hard to reach at site.

(5) Distance from the Load Centre: Site is constructed nearer to the load center so that transmission cost and losses can be minimized.

(6) Land Type of Site: Land of site should be cheap and rocky. The catchment area of dam should be large so that large amount of water can be stored. The foundation of the dam should be strong enough to withstand the stresses and thrust of water.

Q.3 Discuss various components of nuclear power plant.

Ans. Components of Nuclear Power Plant

- (1) Nuclear Reactor: Nuclear reactor is the heart of the nuclear power plant. Energy released by controlled nuclear fission of radioactive element is used for generating steam. ^{235}U is used as radioactive element in reactor.
- (2) Steam Turbine : Steam generated by nuclear reactor strikes on turbine blades which in turn, rotates generator. Electricity generated by generator is supplied through transmission line.
- (3) Moderator : To slow down the chain reaction (Fission process) moderator is used in nuclear reactor. Neutrons produced by fission process are very fast moving neutrons. If they are not controlled, they may escape from the reactor, that can be hazardous. Thus, moderator (heavy water, graphite, beryllium) is used to control the movement of neutrons.
- (4) Coolant : The sole purpose of using coolant is to remove the heat from reactor generated by fission process. Generally, water, carbon dioxide and liquid sodium are used as coolant in nuclear reactor.
- (5) Control Rods : These rods have great importance in nuclear reactor. These control rods absorb neutrons and control the fission chain reaction. These are made up of cadmium and boron. If these rods are fully inserted into moderator block, all neutrons are absorbed. Thus chain reaction can be controlled by these control rods.
- (6) Shielding: Shielding of nuclear reactor is required so that the radiation can be prevented reaching outside the reactor. Lead or concrete made wall having meters of thickness is used as shielding.

Q.4 Give comparison of various types of power plant.

Ans. Comparison of Various Types of Power Plants

Particulars	Hydro-electric Power Plants	Steam Power Plants	Nuclear Power Plants	Diesel Power Plants	Gas Turbine Power Plants
Site	The site should be such that sufficient area is available, water in huge quantity and at sufficient head is available, the land is cheap and transportation facilities are available. Such power plants are usually located for from the load centres.	These power plants are located near the load centre but other factors such as supply of fuel and water, cost of land, available area and transportation facilities are also to be kept in view. Location of steam power plants is some what flexible as compared with that of hydroelectric power plants.	These plants are located away from thickly populated areas to avoid radioactive pollution but as near the load centre as possible.	These plants can be installed anywhere.	These plants can be installed anywhere.
Space requirements	Very large space is required because of the reservoir (Maximum)	Space required is much more than diesel plant. Gas turbine and nuclear power plants but less than that for hydro electric power plants.	Space required is less than that for hydro and steam power plants but more than that for diesel and gas turbine power plants.	Space required is minimum.	Space required is more than that for diesel power plants but less than that for other power plants.
Auxiliaries requirements	Small	Large	Less than that required in steam power plants but more than that for other power plants.	Minimum	More than that required in diesel and hydro but less than that for steam and nuclear power plants.
Simplicity and cleanliness	Most simple and clean air pollution	Less clean because of atmosphere pollution and ash handling. High air pollution.	Handling of equipment is very complicated. Nuclear waste disposal is, however, a major problem. No air pollution.	Simpler and cleaner than steam power plants and nuclear power plants. Air pollution low.	Simpler and cleaner than steam power plants. Air pollution less than steam but more than hydro and nuclear.
Starting time	5-10 minutes.	2-3 hours.	2-3 hours	5-10 minutes.	10-15 minutes.
Reliability	Simple, robust and more reliable	Less reliable.	Reliable	Less reliable	Reliable

Plant life	30-50 years.	20-30 years	20-30 years.	15-20 years.	15-20 years.
Overall efficiency	Most efficient (80-85%)	30-40%	30-40%	30-35%	30-60%
Erection period	10-15 years.	10-12 years	1-2 years	1-2 years	1-2 years
Limit sources of power	Source of power i.e. water in case of hydro power plants is not dependable because it depends upon the rain fall which is at the whim of nature.	Sources of power i.e. coal reserves all over the world are limited and therefore coal mines are being exhausted and the time may come when all of these might finish.	The source of power is unlimited since large deposits of fissionable materials over the world are available.	Source of power i.e. diesel is not available in plenty.	Available in sufficient quantity.
Maintenances requirements	Very low as few skilled engineers and small operating staff is required	Quite high because large operating staff and more skilled engineers are required	Very high because skilled and well trained staff is required for operation and maintenance.	Very low because lesser operating and supervising staff is required	Low
Capital cost	Quite high (Rs. 10,000-50,000 per kW of installed capacity)	Medium (Rs. 4,000-5,000 per kW of installed capacity)	Very high (Rs. 20,000-55,000 per kW of installed capacity)	Quite low (Rs. 3,000-7,000 per kW of installed capacity)	Very low (Rs. 5000-15000 per kW of installed capacity)
Operating cost	Minimum (paise 25-30 per kWh)	Medium (Rs. 1.0-1.25 per kWh)	Quite low (paise 30-35).	Very high (Rs. 4.0-5.0 per kWh)	Quite high (Rs. 1.50-2.0 per kWh)
Overall generation cost	Rs. 1.0-2.0 per kWh	Rs. 2.0-3.0 per kWh	Rs. 1.0-2.50 per kWh	Rs. 4.50-5.50 per kWh	Rs. 2.0-3.0 per kWh
Transmission and distribution cost	Long transmission lines are required and hence transmission and distribution cost is very high	Short transmission lines are required and so transmission and distribution cost is moderate.	Moderate	Transmission cost is nil and distribution cost is also very low.	Transmission and distribution cost is very low.
Outage rate	Very low	High	Low	Low	Low
Maximum unit size in India	165 MW	500 MW	235 MW	About 10 MW	30 MW
Installed capacity in India (utilities only)	21,891 MW	55,970 MW	2,225 MW	About 350 MW	7,660 MW
Installed capacity in India as % of total	24.6	63.1	2.5	0.4	8.1

PUMPS

MODEL QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What is a pump? Give its applications.

Ans. A hydraulic machine, which convert the mechanical energy into hydraulic energy, is called pump. The hydraulic energy of pump is available in the form of pressure energy. Different types of pumps are used for industrial purposes, irrigation system, domestic usage, sewage treatment etc.

Q.2 Why priming of a pump is required?

Ans. Priming of pump is the process of filling liquid in suction pipe, casing of pump and delivery pipe upto delivery valve, so that the air from these parts of the pump can be removed and filled with the liquid to be pumped. Priming action is independent of density of liquid.

It is impossible to operate a centrifugal pump, when its casing is filled with vapour or air. In this condition, pump becomes incapable of pumping. If the pump runs without liquid, there are chances of damaging rotary parts of pump. To avoid this problem priming of centrifugal pump is required.

Q.3 Define the phenomenon of cavitation in pump.

Ans. When the pressure of liquid flowing through pump becomes lower than its vapour pressure then vapour bubbles generate in liquid. These vapour bubbles strike on the metal surface and generates high pressure. This high pressure can damage the surface of pump. Also noise and vibrations are produced. This phenomenon is called cavitation. Cavitation resistant materials such as aluminium-bronze and stainless steel can be used for coating to eliminate the problem of cavitation.

Q.4 Write down the various applications of reciprocating pump.

Ans. Applications of Reciprocating Pump : Reciprocating pump is widely used for the following purpose :

- (1) In wind mill
- (2) In hand pump
- (3) In axial and radial pump
- (4) In boiler water feed
- (5) Some drip irrigation system also uses reciprocating pump
- (6) It is used for inflation of tyres

Q.5 Why casing of centrifugal pump is required?

Ans. Casing : The casing is the outermost covering of centrifugal pump. It is an air tight passage surrounding the impeller. The kinetic energy of water discharged from the impeller is converted into pressure energy. Then the water leaves the casing and enters into delivery pipe.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Give working principle of reciprocating pump.

Ans. Working Principle : A single acting reciprocating pump is shown in above figure. A piston is fitted in cylinder and is connected with crank by means of a connecting rod. When the crank rotates, the piston moves forward and backward in cylinder. While its backward motion, the liquid in sump is sucked in cylinder and delivered to delivery pipe as soon as

Basic Mechanical Engineering

Piston moves forward. Suction and delivery valves are provided in pipes and make the flow unidirectional. These valves are also called non-return valves. Liquid in sump flows through suction pipe and goes to cylinder and then delivery pipe. Air vessel is used to get uniform discharge rate.

Let, d = Diameter of cylinder

$$A = \text{Cross-section area of piston/cylinder} = \frac{\pi}{4} d^2$$

r = Radius of crank

N = Speed of crank (in rpm)

L = Stroke length = $2r$

H_s = Suction head

H_d = Delivery head

$$\text{Discharge in one revolution} = \text{Area} \times \text{Stroke length} = A \times L$$

$$\text{Number of revolution per second} = \frac{N}{60}$$

Discharge of pump per second

$$Q = \text{Discharge in one revolution} \times \text{Number of revolution per second}$$

$$= \frac{A \times L \times N}{60} \quad \dots (i)$$

Weight of water delivered per second

$$W = \rho g Q$$

$$W = \rho g \frac{A \times L \times N}{60} \quad \dots (ii)$$

Workdone per second = Weight of water delivered per second $\times$ total height

$$= W (H_s + H_d)$$

$$= \rho g \frac{A \times L \times N}{60} (H_s + H_d) \quad \dots (iii)$$

Power generated by pump

$$= \frac{\text{Work done per second}}{1000} \text{ kW}$$

$$= \frac{\rho g A L N (H_s + H_d)}{60 \times 1000}$$

$$= \frac{\rho g A L N (H_s + H_d)}{60000} \text{ kW} \quad \dots (iv)$$

Q.2 Differentiate between centrifugal and reciprocating pump.

Ans. Difference between Centrifugal Pump and Reciprocating Pump

S.No.	Centrifugal Pump	Reciprocating Pump
1.	Works on the principle of centrifugal force.	Works on the principle of reciprocating motion of piston.
2.	It is small head, high discharge pump.	It is high head, low discharge pump.
3.	Discharge is uniform and smooth	Fluctuating discharge
4.	Priming is required for centrifugal pump.	No need of primary.
5.	Construction is very simple.	Complicated construction
6.	Installation and maintenance cost is low	High installation and maintenance cost.
7.	High efficiency	Low efficiency
8.	Operation is very simple and noise free.	Operation is complicated and noisy.
9.	This pump can pump viscous fluid.	Difficult to pump viscous fluid.

INTERNAL COMBUSTION ENGINE

6

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What is external combustion engine?

Ans. External Combustion Engine : In external combustion engine, combustion of fuel takes place outside of the cylinder. For example, in a steam engine or a steam turbine, the heat generated due to the combustion of fuel is employed to generate high pressure steam which is used as the working fluid in a reciprocating engine or a turbine.

Q.2 What is the role of gudgeon pin?

Ans. Gudgeon Pin (Or Wrist Pin Or Piston Pin) : It forms a link between the small end of the connecting rod and the piston. These pins are press fit in the piston bosses of light alloy pistons when cooled. For removal or fitting, the piston should be dipped in hot water or hot oil, this expands the bosses and the pins can be removed or fitted freely without damage. It is made up of hollow for lightness.

Q.3 Define stroke of the engine.

Ans. Stroke (L) : The linear distance along the cylinder axis between two limiting positions is called stroke. It may also be defined as the nominal distance through which a working piston moves between two successive reversals of its directions of motion. It is usually expressed in millimeter (mm).

Q.4 Define compression ratio. Also give its formula.

Ans. Compression Ratio (r) : It is the ratio of the total cylinder volume when the piston is at the bottom dead centre (V_1), to the clearance volume, V_c . It is represented by letter 'r'.

Q.5 Define indicator power of the engine.

Ans. Indicated Power : This is defined as the power actually developed in the cylinders and measured with the help of a pressure indicator connected to the cylinder head.

$$\text{Force on piston} = P_m \cdot A$$

$$\text{Workdone per stroke} = P_m \cdot A \cdot L$$

$$\text{Work done per second} = P_m \cdot A \cdot L \cdot n$$

Therefore, the indicated power is written as

$$IP = P_m \cdot A \cdot L \cdot n$$

Where,

P_m = indicated mean effective pressure

L = length of stroke

A = area of the piston

n = number of working stroke per minute or explosion per minute

If the number of cylinders are K , then

$$IP = K \cdot P_m \cdot L \cdot A \cdot n$$

Q.6 What do you understand by the term mechanical efficiency of the engine?

Ans. Mechanical Efficiency (η_{mech}) : The ratio of the brake power delivered by the engine to the indicated power is called the mechanical efficiency (η_{mech}).

$$\eta_{mech} = \frac{BP}{IP} = \frac{BP}{IP} = \frac{IP - FP}{IP}$$

Since the FP includes the power required to pump gas into and out of the engine, mechanical efficiency depends on throttle position as well as engine design and engine speed. It is also defined as the ratio of the brake thermal efficiency to the indicated thermal efficiency.

Basic Mechanical Engineering

BAME-17

Q.1 What is the meaning of calorific value of fuel used in engine?

Ans. Calorific Value (CV) : Calorific value of a fuel is the thermal energy released per unit quantity of the fuel when

the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture. Other terms used for the calorific value are heating value and heat of combustion.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Differentiate between 2 stroke and 4 stroke engine.

[K.T.U. 2018]

Ans. Difference between Two Stroke and Four Stroke Engine are as follows :

Table : Comparison between Two Stroke Engine and Four Stroke Engine

S.No.	Aspects	Two stroke Engine	Four stroke Engine
1.	Completion of cycle	The cycle is completed in two stroke of the piston or in one revolution of the crankshaft. Thus one power stroke is obtained in each revolution of the crankshaft.	The cycle is completed in four strokes of the piston or in two revolution of the crankshaft. Thus one power stroke is obtained in every two revolutions of the crankshaft.
2.	Valves	Generally no valves. Valves are replaced by inlet, exhaust and transfer ports. In two stroke diesel engines, conventional exhaust valves are present.	It contains valve and valve mechanism.
3.	Flywheel	More uniform turning moment and hence lighter flywheel is needed.	Turning moment is not uniform hence heavier flywheel is needed.
4.	Moving parts	Less in number	More in number
5.	Wear and tear	Greater cooling and lubrication requirements due to one power stroke in one revolution, therefore lesser rate of wear and tear.	Lesser cooling and lubrication requirements due to one power stroke in two revolution, therefore greater rate of wear and tear.
6.	Volumetric efficiency	Volumetric efficiency less due to lesser time of induction	Volumetric efficiency more due to more time of induction.
7.	Mechanical efficiency	Lower	Higher
8.	Thermal efficiency and part load efficiency	Thermal efficiency lower, part load efficiency lesser than four stroke engine	Thermal efficiency higher, part load efficiency better than two stroke
9.	Scavenging	Less efficient. Scavenging losses are more	More efficient. Scavenging losses are less.
10.	Cost	Initial cost is less due to light weight and absence of valve mechanism	Higher in cost due to heavy weight and complicated valve mechanism
11.	Uses	Two stroke (air cooled) petrol engines used in very small size only : Scooters, motorcycles, mopeds etc. (lubricating oil mixed with petrol). Two stroke diesel engines used in very large sizes. It is generally used when low cost, compactness and light weight are important in ship propulsion because of light weight and compactness. It is generally used where low cost, compactness and light weight are important	Cars, buses, trucks, tractor efficiency is more important. Hero Honda motorcycle-better fuel economy. Airplanes, industrial engines and power generation etc.

Q2) Describe the ideal Otto cycle and derive formula for its efficiency. [K.T.U. 2018]

Ans. Air Standard Otto Cycle :

The air-standard Otto cycle is the idealized cycle for the spark-ignition internal combustion engines. This cycle is shown above on p-v and T-s diagrams. The Otto cycle 1-2-3-4 consists of following four processes :

- Process 1-2 : Reversible adiabatic compression of air.
- Process 2-3 : Heat addition at constant volume.
- Process 3-4 : Reversible adiabatic expansion of air.
- Process 4-1 : Heat rejection at constant volume.

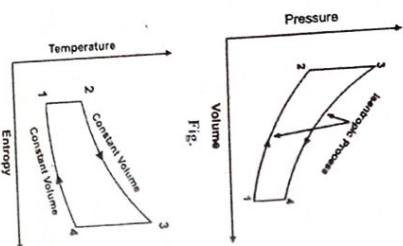


Fig. : Otto cycle on p-v and T-s diagrams

Air Standard Efficiency :

$$\eta_{th} = \frac{\text{Net workdone}}{\text{Net heat added}}$$

Since processes 1-2 and 3-4 are adiabatic processes, the heat transfer during the cycle takes place only during processes 2-3 and 4-1 respectively. Therefore, thermal efficiency can be written as,

$$\eta_{th} = \frac{\text{Heat added} - \text{Heat rejected}}{\text{Heat added}}$$

$$\begin{aligned} \text{Consider 'm' kg of working fluid,} \\ \text{Heat Added} &= m C_v (T_3 - T_2) \\ \text{Heat Rejected} &= m C_v (T_4 - T_1) \\ m C_v (T_3 - T_2) - m C_v (T_4 - T_1) &= 1 - \frac{T_4 - T_1}{T_3 - T_2} \end{aligned}$$

For the reversible adiabatic processes 3-4 and 1-2, we can write,

$$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{\gamma-1} \text{ and } \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

$$V_3 = V_4 \text{ and } V_2 = V_1$$

$$\frac{T_4}{T_3} = \frac{T_1}{T_2} \Rightarrow \frac{T_4 - T_1}{T_3 - T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

$$\eta_{th} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

The ratio $\frac{V_1}{V_2}$ is called as compression ratio, r.

$$\eta_{th} = 1 - \left(\frac{1}{r}\right)^{\gamma-1}$$

Q3)

Diesel cycle with compression ratio of CR = 20 : 1 and cut-off ratio $\alpha = 2$. The air is at 100 kPa = 1 bar, 20°C (293K), and the volume of the chamber is 500 cm³ prior to the compression stroke.

- Specific heat capacity at constant pressure c_p of air at atmospheric pressure and room temperature: $c_p = 1.01 \text{ kJ/kgK}$.
 - Specific heat capacity at constant volume c_v of air at atmospheric pressure and room temperature: $c_v = 0.718 \text{ kJ/kgK}$.
 - $K = c_p/c_v = 1.4$
- Calculate :** The mass of intake air, the temperature T_2 , the pressure P_2 , the temperature T_3 , the amount of heat added during the combustion process, the thermal efficiency of this cycle. [K.T.U. 201

Ans. At the beginning or calculations we have to determine the amount of gas in the cylinder before the compression stroke. Using the ideal gas law, we can find the mass:

Where :

- p is the absolute pressure of the gas
- m is the mass of substance
- T is the absolute temperature
- V is the volume
- $R_{specific}$ is the specific gas constant, equal to universal gas constant divided by the molar mass (M) of gas or mixture. For dry air $R_{specific} = 287.1 \text{ J/kg} \cdot \text{K}^{-1}$

Therefore

$$m = \frac{p \cdot V}{R_{specific} \cdot T} = \frac{100000 \times 500 \times 10^{-6}}{287.1 \times 293} = 0.605 \text{ kg}$$

2. In this problem all volumes are known :

$$V_1 = V_2 = V_3 = V_4 = V_{max} = 500 \times 10^{-6} \text{ m}^3 (0.5 \text{ l})$$

$$V_3 = V_4 = V_{max} = V_{min} / CR = 25 \times 10^{-6} \text{ m}^3$$

Note that $(V_{max} - V_{min}) \times \text{number of cylinders} = \text{total engine displacement}$

Since the process is adiabatic, we can use the following p, V, T relation for adiabatic process :

$$\left(\frac{V_2}{V_1}\right)^{\frac{1}{\gamma}} = \left(\frac{T_2}{T_1}\right)^{\frac{1}{\gamma-1}}$$

$$\left(\frac{V_4}{V_3}\right)^{\frac{1}{\gamma}} = \left(\frac{T_4}{T_3}\right)^{\frac{1}{\gamma-1}}$$

$$T_2 = T_1 \cdot CR^{\gamma-1} = 293 \cdot 20^{\gamma-1} = 971 \text{ K}$$

Again, we can use the ideal gas law to find the pressure at the end of the compression stroke as:

$$P_2 = m R_{specific} \cdot T_2 / V_2 = 5.95 \times 10^{-4} \times 287.1 \times 971 / 25 \times 10^{-6} = 6635000 \text{ Pa} = 66.35 \text{ bar}$$

Since process 2-3 occurs at constant pressure, the ideal gas equation of state gives

$$T_3 = (V_3/V_2) \times T_2 = 1942 \text{ K}$$

To calculate the amount of heat added by burning of fuel-air mixture, Q_{add} , we have to use the first law of thermodynamics for isobaric process, which states:

$$Q_{add} = m c_p (T_3 - T_2) = 5.95 \times 10^{-4} \times 1010 \times 971 = 583.5 \text{ J}$$

Thermal efficiency for this Diesel cycle :

As was derived in the previous section, the thermal efficiency of Diesel cycle is a function of the compression ratio, the cut-off ratio and k .

$$\eta_{Diesel} = 1 - \frac{1}{CR^{k-1}} \left(\frac{\alpha^k - 1}{k(\alpha - 1)} \right)$$

Where

- η_{Diesel} is the maximum thermal efficiency of a Diesel cycle.
 - α is the cut-off ratio V_3/V_2 (i.e. the ratio of volumes at the end and start of the combustion phase)
 - CR is the compression ratio
 - $k = c_p/c_v = 1.4$
- For this example :

$$\eta_{Diesel} = 0.6467 = 64.7\%$$

Q4) Describe four stroke spark ignition engine cycle.

Ans. Four Stroke Spark-ignition Engine Cycle

In four stroke cycle engine, the cycle of operation is completed in four stroke of the piston or two revolutions of

the crankshaft as discussed earlier. The four stroke cycle principle can be described as follows and p-V diagram is also shown.

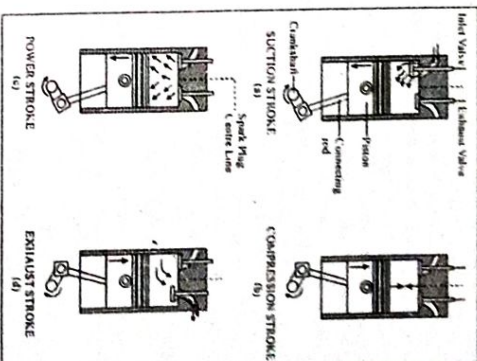


Fig. : Working of Four Stroke Petrol Engine

- Suction Stroke (Intake Stroke) :** During the suction stroke (0-1), the piston travels downward in the cylinder from TDC to BDC, creating a partial vacuum in the cylinder. Atmospheric pressure forces air through the carburetor where it mixes with petrol and enters the cylinder through the intake manifold and the open intake valve. The exhaust valve remains closed during this stroke and the crankshaft turns through half a revolution. The engine operating temperature is somewhere between 82°C and 116°C. At the end of the suction stroke, inlet valve closes.
- Compression Stroke :** During the compression stroke (1-2), a further half revolution of the crankshaft causes the piston to move upwards from BDC to TDC. Since both the valves are closed, the mixture is now compressed into the small cavity remaining above the piston. This cavity is known as combustion or firing chamber. Just before the end of this stroke the mixture is ignited with the help of an electric spark between the electrodes of the spark plug located in combustion chamber wall. The friction between the compressed gas molecules causes a further temperature rise of several hundred degrees. This prepares the gas for firing and pressure is also considerably increased.

3. **The Power Stroke or Firing Stroke or Working Stroke or Expansion Stroke :** In this stroke (3-4), piston now approaches TDC and both valves remain closed. Of the four-strokes only during this stroke power is produced. Both pressure and temperature decreases during expansion.
4. **Exhaust Stroke :** In this stroke (4-0), the crankshaft has now rotated one and one half revolution and the cylinder is now filled with burnt gases which must be removed. The exhaust valve opens and the piston moves from BDC to TDC, forcing the burnt gases out of the cylinder. This is known as the exhaust stroke. During this stroke the intake valve remains closed. The crankshaft has completed two revolutions. The piston is at TDC and the engine is ready to repeat the cycle of operation. Simultaneously emptying of burnt gases and filling with fresh air or air-fuel mixture is known as

"scavenging." Since the crankshaft makes half a revolution during each stroke, the four stroke of one complete cycle equal to two revolution of the crankshaft. Because each valve opens only once during the four stroke cycle, the camshaft makes only one revolution. Therefore, the ratio of crankshaft to camshaft speed is 2 : 1.

Obviously a single cylinder engine will run unevenly at lower rpm. The problem is that the power stroke is the only lift stroke, it is followed by the three dead strokes, namely the exhaust stroke, the intake stroke and the compression stroke. This is the main reason why a flywheel is needed. While most of the mechanical energy released by the power stroke is available to do useful work, some of the energy is stored in the flywheel. During the dead strokes this energy called kinetic energy is released to carry the engine from one power stroke to the next without any appreciable change in the engine speed.

□□□

PREVIOUS YEARS QUESTIONS

REFRIGERATION AND AIR CONDITIONING

7

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What do you understand by the term unit of refrigeration?

Ans. Unit of Refrigeration : The practical unit of refrigeration is "tonne of refrigeration" which is abbreviated as TR.

1 TR is defined as the amount of cooling effect generated by continuous melting of 1000 kg of ice (1 tonne) at 0°C temperature in 24 hours.

Mathematically,

$$1 \text{ TR} = 1000 \times 335 \text{ kJ in 24 hrs}$$

Where, latent heat of 1 kg of ice = 335 kJ/kg

$$= \frac{1000 \times 335}{24 \times 60} = 232.6 \text{ kJ/min}$$

for practical use: 1 TR = 210 kJ/min

$$= 3.5 \text{ kW}$$

Q.2 Define coefficient of performance of refrigerator.

Ans. Coefficient of Performance : The ratio of heat extracted from the refrigerator to the work done on refrigerant is called coefficient of performance of refrigerator. It is abbreviated as COP.

Mathematically,

$$\text{COP} = \frac{Q}{W}$$

Where, Q = Heat extracted

W = Work done on refrigerant

COP is the reciprocal of the efficiency $\left(\frac{1}{\eta}\right)$. So its value is always greater than unity.

$$\text{COP} = \frac{1}{\text{Efficiency}}$$

Q.3 What is the role of analyzer in vapour absorption refrigeration system?

Ans. Analyzer : The water particles vaporized on heating concentrated ammonia by the generator can be entered in the condenser through the medium of discharge line. If the refrigeration system is operated at a temperature lower than the freezing point of water, the water particles can get frozen in the way which can block the refrigeration system. So, analyst is used to separate the water vapour particles from ammonia.

II. LONG ANSWER TYPE QUESTIONS

Q.1 What is meant by refrigeration system? Describe vapor compression refrigeration system. [R.T.U. 2018]

Ans. Refrigeration is the science of producing and maintaining temperatures below that of the surrounding atmosphere. This means the removing of heat from a substance to be cooled. Heat always passes downhill, from a warm body to a cooler one, until both bodies are at the same temperature. Maintaining perishables at their required temperatures is done by refrigeration.

In simple, refrigeration means the cooling of or removal of heat from a system. The equipment employed to maintain the system at a low temperature is termed as refrigerating system and the system which is kept at lower temperature is called refrigerated system.

Vapour compression refrigeration system is an important refrigeration system in which refrigerant is used, which can easily flow and vapourises in different atmospheric range of temperature and pressure. In this refrigerant is compressed at high pressure in this, so it is called vapour compression refrigeration. Ammonia, Freon, carbon dioxide and sulphur dioxide are used as refrigerants in it.

Principle : Refrigerant is not released out in vapour compression refrigeration system but it condenses and evaporates sequentially and circulates in the refrigeration system. Refrigerant takes up heat from the salt water in the refrigerated space, which has very low melting point on converting from liquid state to gaseous state. In this way, expulsion of heat from the refrigerated space cools down the refrigeration system and releases the absorbed heat while changing from gaseous state to liquid state. Refrigerated space cools down on repeating this process again and again.

Construction : Vapour compression refrigeration system is shown in figure 1.

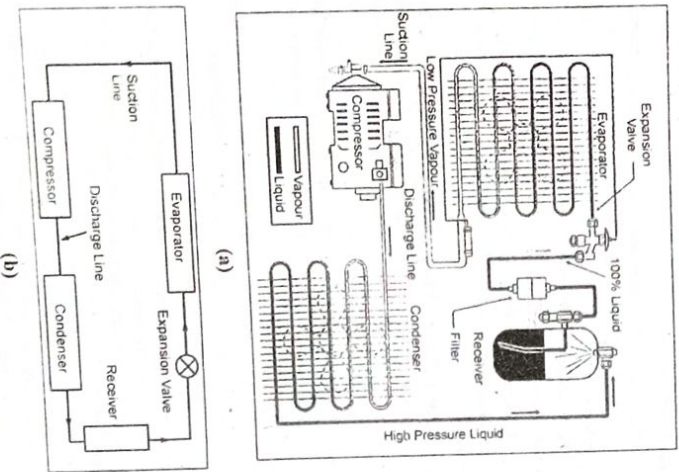


Fig. 1 : Vapour Compression Refrigeration System

Its main parts are given as follows :

- Compressor :** It converts the refrigerant with low pressure and temperature, obtained from evaporator into a refrigerant with high pressure and temperature. It is used to change the pressure of the refrigerant. The capacity of the compressor depends on the number, size of its cylinders and efficiency of compression. This refrigerant is used in the form of refrigerant carrying resource from the evaporator to the condenser. A cylinder with piston fitted in it in the compressor is generally used to produce high pressure.

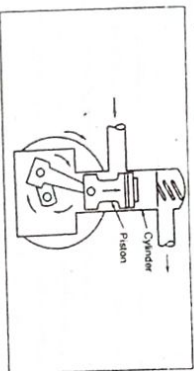


Fig. 2 : Compressor

- Condenser :** Condenser is a heat transfer equipment that absorbs the latent heat from the vapour refrigerant obtained from compressor and converts it into liquid refrigerant.

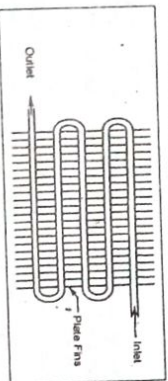


Fig. 3 : Condenser

- Its selection is done on the basis of the capacity of the refrigeration system and the quantity of the refrigerant used. It is used to produce cooling in the refrigeration system.

- Evaporator :** It is also used like condenser transferring heat but in this, the heat is provided to refrigerant, obtained from receiver through expansion valve and is converted into vapour for its also known as cooling unit and freezer.

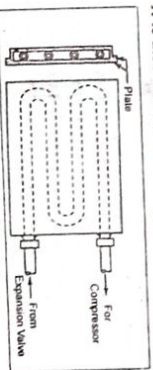


Fig. 4 : Evaporator

- Receiver :** The working of an evaporator depends on the essential cooling in the refrigeration system. If high cooling is required in the refrigeration system, it will require greater amount of refrigerant and just opposite to this, lesser refrigerant is required for low cooling. So receiver is used to gain refrigerant as per requirement in which the liquid acquired from the condenser accumulates and refrigerant is provided to the evaporator as per requirement.
- Expansion Valve :** The amount of refrigerant used in the evaporator keeps changing. Expansion valve is used for controlling it. It is also called control valve.
- Suction Line :** Its work is to supply the low pressurized vapour obtained from the evaporator to the compressor.
- Discharge Line :** It is used to supply high pressurized vapour obtained from the compressor to the condenser.
- Filter :** It is used to keep the refrigerant clean so that no problem can arise in the flow of refrigerant used further in the suction line, discharge line.

- Working :** As per figure 1, vapour refrigerant with low pressure and high temperature enters into the compressor from the evaporator through suction line. Here vapour gets compressed up to high pressure and reaches the condenser through discharge line. Refrigerant vapour in the condenser releases the latent heat in the evaporator, absorbed from the refrigerated space, and changes it into liquid and collects it in the receiver. The controlled refrigerant from the expansion valve gets collected in the evaporator and after this the liquid absorbs latent heat from the refrigerant space in the evaporator and changes it into gaseous state and enters into the condenser. In this way, the refrigerated space is cooled when the heat absorbed in the evaporator is released from the condenser. This process is repeated again and again. In this the objects remain cool continuously.

- What is air conditioning? Draw and describe different components used in it.** [R.T.U. 2018]

Ans. Air conditioning refers to maintaining a pleasant environment in a specific area. In this process, the regulation of temperature, humidity and purification of air takes place in a special environment.

Different seasons experience variations in the temperature, speed, humidity, etc. But with the help of air conditioning, temperature can be regulated between 22°C-26.5°C and humidity can be maintained between 30-70%. This range of temperature and humidity is more appropriate for human beings.

Air Conditioner Compressor : The AC compressor is the workhorse of the system and is driven by our car's engine via a series of belts and pulleys. Its function is to transfer and compress gas from the low-pressure (intake) side of the AC system to the high pressure (discharge) side of the closed system. The AC compressor draws the refrigerant (while in gas state) from the AC evaporator, where it has gathered heat from your vehicle interior. It then compresses the gas refrigerant under high-pressure and send it off to the AC condenser. Once the hot compressed gas enters the condenser, it begins to cool and expel heat as it travels towards the bottom of the AC condenser where it has reverted back to a cool liquid state. The cooled liquid gas then begins its journey back toward the AC evaporator. This gives a general idea (oversimplified) how the process works.



Fig.

Receiver drier : Air conditioning systems utilize a receiver drier to extract moisture from the system. The receiver drier is used on AC systems which make use of an expansion valve to control refrigerant flow and is located on the high-pressure side of the system, between the compressor and the condenser. The receiver drier stores a portion of the system's refrigerant and contains a moisture absorbing substance to remove any moisture the system may become contaminated with.



Fig.

Condensor : The AC condenser and your car's radiator often look quite similar in appearance. The compressor of the car generate compressed gas and sends it along to the top of the condenser, where the gas begins to cool. The gas continues to cool and condense as it makes its way through the serpentine-like coil arrangements, before exiting the bottom of the condenser as a high-pressure liquid. The condenser is usually located in front of your car's radiator.



Fig.

Evaporator : The AC evaporator serves in multiple capacities, but its function is to absorb heat which may have built up on a hot day inside your car's interior. The evaporator contains cold Freon gas. The cold Freon gas passes through the evaporator and makes the evaporator very cold. The AC blower fan is located behind the evaporator and blows air across it and that cold air travels through the dash duct work and out the vents inside the car. The water you see dripping from under the passenger side of the car is coming from condensation at the evaporator core and is a result of the AC system doing its job.



Fig.

Condenser Fan : The AC condenser fan's job is to assist in cooling the hot compressed gasses supplied by the compressor as they pass through the condenser. The function of the condenser fan, is also to supply additional cooling to the vehicle's radiator located just behind the condenser. In the event the condenser fan is not operating as intended, or has ceased to function at all, your system will not operate efficiently. Air flow over the condenser and engine radiator is essential. Inoperative fans will always cause higher than normal HI side pressure.



Fig.

AC Blower motor : The AC blower motor works in conjunction with the evaporator to remove heat and cool you vehicle interior. He is usually located underneath the dash and connected to ducting where it pulls-in the warm air from the interior and pushes it across the cool coils and fins of the evaporator and send the cold air back to the car's interior.



Fig.

Expansion Valves : Expansion valves regulate the amount of liquid refrigerant flowing from the condenser to the evaporator based upon the evaporator pressure. A thermodynamic expansion valve will include a temperature sensor and meter the amount of refrigerant flowing into the evaporator.



Fig.

Q.3 Ice is formed at 0°C from water at 20°C , if temperature of refrigerant is 10°C . Find the latent heat of refrigerant in perfect Carnot cycle, kJ/kg. Assume working in perfect Carnot cycle, [R.T.U. 20.

Ans. Latent heat of ice = 334 kJ/kg

$$T_1 = 20 + 273 = 293 \text{ K}$$

$$T_2 = 10 + 273 = 283 \text{ K}$$

$$\frac{T_2}{T_1} = \frac{283}{293} \Rightarrow 28.3$$

Heat to be extracted per kg of water (to from 0°C i.e. 273 K)

$$Q_{O.P.} = \frac{T_2}{T_1 - T_2} = \frac{283}{293 - 283} \Rightarrow 28.3$$

$$R_n = 1 \times c_{pw} \times (293 - 283) + \text{Latent heat of ice}$$

$$\Rightarrow 1 \times 4.18 \times 20 + 334$$

$$\Rightarrow 375.8 \text{ kJ/kg}$$

Also, $1 \text{ kWh} = 1 \times 3600 = 3600 \text{ kJ}$

$$C.O.P. = \frac{R_n}{\text{Work done in kJ}} = \frac{\text{Refrigerating Effect in kJ/kg}}{\text{Work done in kJ}}$$

$$28.3 = \frac{M_{ice} \times 375.8}{3600}$$

$$M_{ice} = \frac{28.3 \times 3600}{375.8} = 271.10 \text{ kg}$$

Hence ice formed per kWh = 271.10 kg

Q.4 Describe electrolux refrigerator with neat sketch.

Ans. Electrolux Refrigerator or Three Fluids Refrigeration system : This refrigerator of vapour absorption type was first of all developed by 'Electrolux Company' of England, so it is named after the manufacturing company itself as Electrolux refrigerator.

This type of refrigerator is also called three fluids system because three liquids- ammonia, water and hydrogen are used in it. Out of these liquids, ammonia is used as refrigerant and water is used in the absorber form whereas hydrogen gas is used in the form of an inactive gas to evaporate ammonia quickly at a relatively low pressure.

The main purpose of this system is to end the requirement of the pump so that there are no moving parts in the refrigerator and the operation of refrigeration takes place without any noise.

Principle : Electrolux refrigerator system works on the principle of Dalton's partial pressure law. In this, an approximate pressure of 15 Bar is maintained in the entire system and ammonia is filled in the evaporator at almost 12 bar. Therefore, the ammonia is evaporated at partial pressure of almost 3 Bar. The saturated temperature of ammonia at this pressure is almost -10°C where at almost 38°C temperature, it converts into liquid and provides its heat to cooling medium.

Working : The concentrated ammonia solution moves from the absorber through the heat exchanger to the generator where it is heated by an external heat source like- electric heater, gas burner, etc. On heating the solution, ammonia vapourises from the solution and flows towards the condenser where an analyst is placed before the condenser to stop the particles of water vapour, so that only ammonia vapour reaches the condenser. The remaining hot diluted solution reaches the absorber through the medium of heat exchanger. Diluted solution gives its heat to concentrated solution and makes it little hot, while flowing through the heat exchanger.

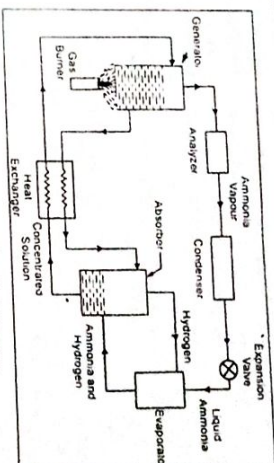


Fig. : Electrolux Refrigerator

Ammonia vapour releases its latent heat in the condenser and changes into liquid state. Liquid ammonia which is released out of the condenser flows through the medium of expansion valve to the evaporator. Liquid ammonia meets hydrogen gas in the evaporator and evaporates due to partial pressure and temperature. Ammonia absorbs required latent heat from the refrigerator during evaporation and in this way produces cooling effect.

The mixture of ammonia and hydrogen gas enters the absorber due to gravity where hydrogen being light in weight is collected in the upper part of the absorber and again flows in the evaporator, and ammonia vapours are absorbed by water. In this way, one cycle of refrigeration is completed.

Characteristics of Electrolux Refrigerator : The main characteristics of Electrolux refrigerator are as follows :

1. Pump or any other types of moving parts do not exist in this system. As a result of which, there is no noise when the machine operates and the maintenance expenses is also minimum.
2. The hydrogen gas in this is transmitted only from absorber to evaporator and from evaporator to absorber.
3. The performance coefficient of the unit is very less. So, this unit is not suitable for industrial work.
4. It can be easily controlled.

Q.7 Discuss the nomenclature of refrigerant.

Ans. Nomenclature of Refrigerator : According to the methodology suggested by American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) the refrigerant should be named starting with English letter 'R' (For Refrigerant) and then a specific number should be suffixed to it.

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 Why the transmission of power is required?

Ans. The objectives of the power transmission are :

1. Transmission of power from one shaft to another shaft.
2. For changing speed.
3. Used to fill the gap between motor and machine.
4. To transmit the power from main source to different shafts.

Q.2 Write down the selection criteria for belt drive.

Ans. Selection Criteria for Belt Drive : Apart from the nature of the work carried out several other factors play an important role in belt drive selection. Some of these factors are (a) driver and driven shafts speed, (b) amount of power to be transmitted, (c) distance between shafts, (d) speed or velocity ratio of belt drive, (e) positive drive requirements, (f) shaft relationships and arrangements, (g) diameter of pulleys, (h) space available and (i) service conditions.

Q.3 Give expression for the power transmitted by the belt drive.

Ans. T_1 = Tension of tight side

T_2 = Tension of slack side

obvious $T_1 > T_2$

Let v is the velocity of belt in m/sec

Now effective turning force = $T_1 - T_2$

work done = Force $\times$ distance

$$= (T_1 - T_2) \times v \text{ N-m/s}$$

and power = $(T_1 - T_2)v \text{ J/s}$

$$= (T_1 - T_2)v \text{ watt}$$

Q.4 Mention advantages of the fibre rope drive.

Ans. Advantages of Fibre Rope Drives

1. They provide a smooth and noiseless operation.
2. They are suitable to work with in outdoor conditions.
3. Perfect shaft alignment is not necessary.
4. Fractional and bidirectional application of power is allowed.
5. High Mechanical efficiency can be achieved.

II. LONG ANSWER TYPE QUESTIONS

Q.1 What is gear transmission? Describe different types of gear. [R.T.U. 2018]

Ans. Gear Transmission : Gearbox is a speed and torque changing device between the engine and the driving wheels. It serves the following purposes in the transmission system of an automobile:

1. It exchanges engine power for greater torque and thus provides a mechanical advantage to drive the vehicle under different conditions.
2. It exchanges forward motion for reverse motion.
3. It provides a neutral position to disallow power flow to the rest of power train.

Types of Gear

Spur Gear : Gears having cylindrical pitch surfaces are called cylindrical gears. Spur gears belong to the parallel shaft gear group and are cylindrical gears with a tooth line which is straight and parallel to the shaft. Spur gears are the most widely used gears that can achieve high accuracy with relatively easy production processes. They have the characteristic of having no load in the axial direction (thrust load). The larger of the meshing pair is called the gear and smaller is called the pinion.

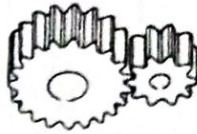


Fig.

Helical Gear : Helical gears are used with parallel shafts similar to spur gears and are cylindrical gears with winding tooth lines. They have better teeth meshing than spur gears and have superior quietness and can transmit higher loads, making them suitable for high speed applications. When using helical gears, they create thrust force in the axial direction, necessitating the use of thrust bearings. Helical gears come with right hand and left hand twist requiring opposite hand gears for a meshing pair.



Fig.

Gear Rack : Same sized and shaped teeth cut at equal distances along a flat surface or a straight rod is called a gear rack. A gear rack is a cylindrical gear with the radius of the pitch cylinder being infinite. By meshing with a cylindrical gear pinion, it converts rotational motion into linear motion. Gear racks can be broadly divided into straight tooth racks and helical tooth racks, but both have straight tooth lines. By machining the ends of gear racks, it is possible to connect gear racks end to end.

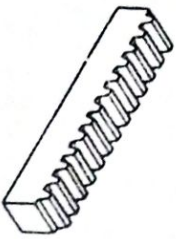


Fig.

Bevel Gear : Bevel gears have a cone shaped appearance and are used to transmit force between two shafts which intersect at one point (intersecting shafts). A bevel gear has a cone as its pitch surface and its teeth are cut along the cone. Kinds of bevel gears include straight bevel gears, helical bevel gears, spiral bevel gears, miter gears, angular bevel gears, crown gears, zero bevel gears and hypoid gears.



Fig.

Spiral Bevel Gear : Spiral bevel gears are bevel gear with curved tooth lines. Due to higher tooth contact ratio they are superior to straight bevel gears in efficiency strength, vibration and noise. On the other hand, they are more difficult to produce. Also, because the teeth are curved they cause thrust forces in the axial direction. Within the spiral bevel gears, the one with the zero twisting angle is called zero bevel gear.



Fig.

Screw Gear : Screw gears are a pair of same hand helical gears with the twist angle of 45° on non-parallel non-intersecting shafts. Because the tooth contact is a point their load carrying capacity is low and they are not suitable for large power transmission. Since power is transmitted to the sliding of the tooth surfaces, it is necessary to pay attention to lubrication when using screw gears. There are no restriction as far as the combinations of number of teeth.



Fig.

Miter Gear : Miter gears are bevel gears with a speed ratio of 1. They are used to change the direction of power transmission without changing speed. There are straight miter and spiral miter gears. When using the spiral miter gears, it becomes necessary to consider using thrust bearings since they produce thrust force in the axial direction. Besides the usual miter gears with 90° shaft angles, miter gears with any other shaft angles are called angular miter gears.

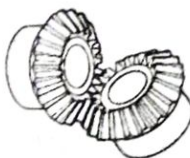


Fig.

Worm Gear : A screw shape cut on a shaft is the worm, the mating gear is the worm wheel, and together on non-intersecting shafts is called a worm gear. Worms and worm wheels are not limited to cylindrical shapes. There is the hour-glass type which can increase the contact ratio, but production becomes more difficult. Due to the sliding contact of the gear surfaces, it is necessary to reduce friction. For this reason, generally a hard material is used for the worm, and a soft material is used for worm wheel. Even though the efficiency is low due to the sliding contact, the rotation is smooth and quiet. When the lead angle of the worm is small, it creates a self-locking feature.



Fig.

Internal gear : Internal gears have teeth cut on the inside of cylinders or cones and are paired with external gears. The main use of internal gears are for planetary gear drives and gear type shaft couplings. There are limitations in the number of teeth differences between internal and external gears due to involute interference, trochoid interference and trimming problems. The rotational directions of the internal and external gears in mesh are the same while they are opposite when two external gears are in mesh.



Fig.

Q.2) Describe with figure different types of belt drive. [R.TU.2019]

Ans. Types of Belt Drive : Flat belt drives are of following types:

1. Open belt drive
2. Cross belt drive
3. Jockey/ idler pulley belt drive
4. Stepped belt drive
5. Right angle belt drive
6. Loose and fast pulley drive

1. **Open Belt Drive :** This is the simplest type of belt drive. In this arrangement, the direction of rotation of the driver and the driven pulley is the same. The lower is tight side and the upper side is the slack side.

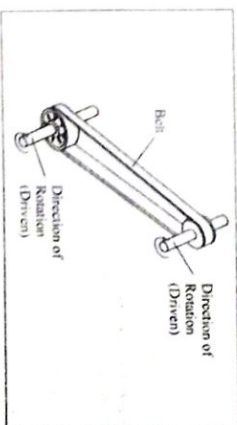


Fig. 1 : Open Belt Drive

2. **Cross Belt Drive :** In this type of belt, the driven pulley rotates in direction opposite to that of the driver pulley (Figure 2). The arrangement of shafts is usually parallel. The power transmitting capacity of a cross belt drive is more than an open belt drive. This is due to high value of the angle of wrap. The belt rubs against each other at the point of intersection which leads to excessive wear and tear. To reduce excessive wear, shafts should have optimum distance between them, i.e., a distance of more than $20b$ where b is the belt width. Also, they should be operated around a speed of 15 m/s .

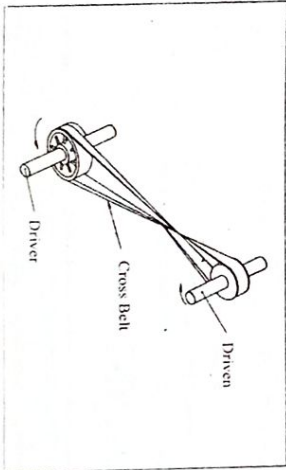


Fig. 2 : Simplified View of Cross Belt Drive

3. Jockey/Idler Pulley Belt Drive : Generally, the belt drive loses its initial tension with constant use as the belt gets permanently stretched along the length.

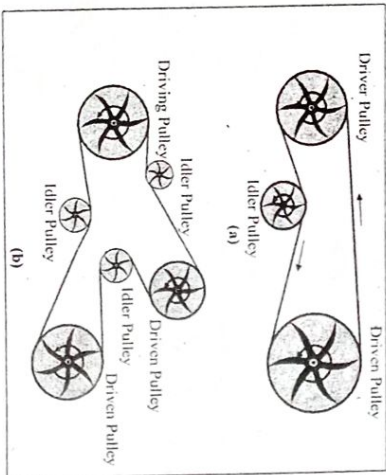


Fig. 3 : Idler Pulley Belt Drive

This drastically reduces the power transmission capacity of the drive. For such cases, idler pulley is used to recover the tension of the belt to its original value. An idler pulley is a pulley which is free to rotate on its axis. Sometimes, for example, an open belt drive cannot be used due to small arc of contact (small angle of lap) on the small pulley. In this case, idler pulley is used to increase the angle of lap and tension of the belt (Figure 3(a)). Also, open belt drive with several idler and driving pulleys can be used to transmit power from one shaft to several shafts arranged in parallel (Figure 3(b)).

4. Stepped Belt Drive : It is also known as con pulley belt drive. It is used to change the speed of drive shaft while the driver shaft runs at a constant speed. It is done by shifting the belt from one part of the step to another.

5. Right Angle Belt Drive : It is used to transmit power when the shafts are arranged at right angle. The speed of the horizontal or vertical drive is changed with the help of guide pulleys.

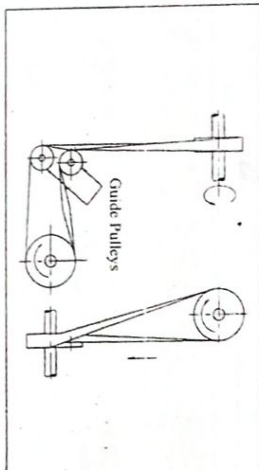


Fig. 4 : Right Angle Belt Drive

6. Loose and Fast Pulley Drive : This type of drive is used when the power transmission is not consistent & continuous. The system consists of two pulleys, namely, fast pulley which is fixed rigidly with the shaft and a loose pulley which rotates freely.

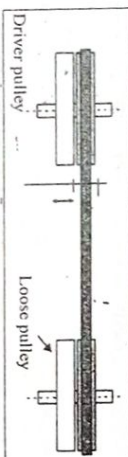


Fig. 5 : Loose and Fast Pulley Drive

The power can only be transmitted by the fast pulley. The belt is pushed from the fast pulley to the loose pulley when power is not required.

Q.3 Two spur gear have velocity ratio 1/3 driven gear has 72 teeth of 8 module and rotate at 300 rpm. Calculate no. of teeth and speed of driver, also calculate pitch line velocity. Given :

$$T_2 = 72, VR = 1/3, N_2 = 300 \text{ rpm}, m = 8 \text{ mm}$$

$$VR = N_2/N_1 = R_1/T_2 = 1/3 \quad [R.T.D. 201]$$

$$[\text{Note : Read } "N_2, N_1, T_2, T_1" \text{ as } "N_p, N_d, T_p, T_d" \text{ respectively}]$$

$$\text{Ans. } T_1 = 72; VR = 1/3; N_1 = 300 \text{ rpm}; m = 8 \text{ mm}$$

$$(i) VR = \frac{N_2}{N_1} = \frac{T_1}{T_2} = \frac{1}{3} \text{ or } \frac{300}{N_1} = \frac{1}{3} \text{ or } N_1 = 900 \text{ rpm}$$

$$\text{Also } \frac{T_1}{T_2} = \frac{1}{3} \text{ or } T_1 = 24$$

$$(ii) \text{ Pitch line velocity, } v_p = \omega_1 r_1 \text{ or } \omega_2 r_2$$

$$= 2\pi N_1 \times \frac{d_1}{2} \text{ or } 2\pi N_2 \times \frac{d_2}{2}$$

$$= 2\pi N_1 \times \frac{m T_1}{2} \text{ or } 2\pi N_2 \times \frac{m T_2}{2}$$

$$= 2\pi \times 900 \times \frac{8 \times 24}{2} \text{ or } 2\pi \times 300 \times \frac{8 \times 72}{2}$$

$$= 542,867 \text{ mm/min}$$

$$= 9047.8 \text{ mm/s or } 9.0478 \text{ m/s}$$

Q.4 Derive expression for the length of belt of open belt drive.

Ans. Length of Belt : The total length of the belt required to connect a driver and a follower is known as the length of a belt.

Case 1 : Open belt drive

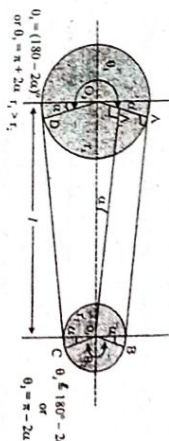


Fig. 6

Let us consider an open belt drive (Fig.) where O_1 and O_2 are the centers and r_1 and r_2 are the radii of pulleys 1 and 2 respectively. The distance between the centers of the two pulleys is L . Let us assume L_0 is the total length of the belt of open drive.

Draw O_1A , parallel to AB (Fig.). Points A, B, C and D are points of tangency. We can see that O_2A is perpendicular to O_1A . Let us assume that $\angle O_1O_2A = \alpha$. Then

$$\sin \alpha = \frac{r_1 - r_2}{L}$$

As α is very small, we can write $\sin \alpha = \alpha = \frac{r_1 - r_2}{L}$

Angle subtended by arc AD on the center O_1 is $\theta_1 = (180 + 2\alpha)^\circ = \pi + 2\alpha$ radians

Similarly, angle subtended by arc BC on the center O_2 will be

$$\theta_2 = (180 - 2\alpha)^\circ = \pi - 2\alpha \text{ radians}$$

Now, length of belt for open drive will be

$$L_0 = \text{Arc } AD + \text{Arc } BC + \text{Free length } AB + \text{Free length } CD$$

$$L_0 = r_1 \theta_1 + r_2 \theta_2 + 2AB \quad \dots (1)$$

$$L_0 = r_1 (\pi + 2\alpha) + r_2 (\pi - 2\alpha) + 2L \cos \alpha \quad \dots (2)$$

The exact length of the belt for the open drive is given by Eq. (1) and (2).

Approximate length of belt for open drive

From above, we know $\sin \alpha = \frac{r_1 - r_2}{L}$

Then, we have $\cos \alpha = \sqrt{1 - \sin^2 \alpha} = \sqrt{1 - \left(\frac{r_1 - r_2}{L}\right)^2}$

Expansion using Binomial theorem yields

$$\cos \alpha = 1 - \frac{1}{2} \left(\frac{r_1 - r_2}{L}\right)^2 + \frac{1}{4} \left(\frac{r_1 - r_2}{L}\right)^4 - \dots$$

We can neglect the small terms to obtain

$$\cos \alpha = 1 - \frac{1}{2} \left(\frac{r_1 - r_2}{L}\right)^2$$

$$\cos \alpha = 1 - \frac{(r_1 - r_2)^2}{2L}$$

Because α is small, we can use

$$\alpha = \sin \alpha = \frac{r_1 - r_2}{L}$$

Thus, approximate length of belt, $L_{0 \text{ approx}}$ will be

$$L_{0 \text{ approx}} = \pi(r_1 + r_2) + 2 \left(\frac{r_1 - r_2}{L}\right) (r_1 - r_2) + \left(2L - \frac{(r_1 - r_2)^2}{L}\right)$$

$$L_{0 \text{ approx}} = \pi(r_1 + r_2) + \frac{2}{L} (r_1 - r_2)^2 + 2L - \frac{(r_1 - r_2)^2}{L}$$

$$L_{0 \text{ approx}} = \pi(r_1 + r_2) + 2L + \frac{(r_1 - r_2)^2}{L} \quad \dots (3)$$

The difference between the exact length and the approximate length is between 2 to 5% for open belt drive. However, one should always remember that exact length is always greater than the approximate length.

Q.5 What is centrifugal tension? Derive expression for the same.

Ans. Centrifugal Tension When power is being transmitted with a belt drive system a part of the belt in contact with the pulley move in a circular path around the pulley because of it having mass and speed it is subjected to centrifugal force, which tends to lift the belt or rope from the pulley.

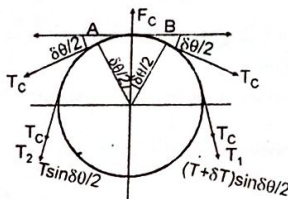


Fig.

Thereby reducing the normal reaction and hence the frictional resistance. The centrifugal force produces additional tension. This reduce the driving power capacity. And this additional tension called centrifugal tension. At low speeds this tension is negligible, but at speeds more than 750 m/min or 15 m/s it become a very important factor.

m = Mass of belt per unit length, kg

v = Linear velocity of the belt, m/s

r = Radius of the pulley over which the belt runs, m

T_C = Centrifugal tension acting tangentially at all fibres in the belt, N-m

$\delta\theta$ = Angle subtended by the belt element AB at the centre of the pulley

F_C = Centrifugal force N
length of the belt = AB
 $= r\delta\theta$

Total mass = $M = m \cdot r\delta\theta$

Centrifugal force on the belt element

$$F_C = M \frac{v^2}{r} = (m \cdot r\delta\theta) \left(\frac{v^2}{r} \right)$$

$$F_C = m\delta\theta v^2 \quad \dots(1)$$

Resolving the forces (F_C & T_C) vertically and equating the same (Fig.)

$$2T_C \sin \frac{\delta\theta}{2} = F_C$$

$\therefore \frac{\delta\theta}{2}$ is very small

$$\text{Therefore } \left(\sin \frac{\delta\theta}{2} \right) = \frac{\delta\theta}{2}$$

$$2T_C \frac{\delta\theta}{2} = F_C \quad \dots(2)$$

[From eq. (1) & (2)]

$$2T_C \frac{\delta\theta}{2} = m\delta\theta v^2$$

$$T_C = mv^2$$

As shown in above equation that the centrifugal tension is independent of the angle of lap and tension in the slack and tight side. It only depends on the velocity of the belt.

Now,

Total tension on the tight side when centrifugal tension is considered

$$T_T = T_1 + T_C$$

Total tension on the slack side when centrifugal tension is considered

$$T_S = T_2 + T_C$$

Q.6 Two parallel shafts 6 m apart are to be connected by a belt running over pulleys of diameter 50 cm and 30 cm respectively. Determine the exact and approximate lengths of the belt required :

(a) If the belt is open

(b) If the belt is crossed.

Ans. Given

Distance between the center of shafts (or of pulleys),

$$x = 6 \text{ m} = 600 \text{ cm}$$

Diameter of larger pulley = 50 cm

Radius of larger pulley, $r_1 = \frac{50}{2} = 25 \text{ cm}$

Diameter of smaller pulley = 30 cm

Radius of smaller pulley, $r_2 = \frac{30}{2} = 15 \text{ cm}$

Let L = required length of the belt.

(a) When the belt is open

Exact length for the open belt is given as

$$L = 2 \left[\frac{\pi}{2} (r_1 + r_2) + \alpha (r_1 - r_2) + \sqrt{x^2 - (r_1 - r_2)^2} \right]$$

where, α for open belt drive is given by

$$\sin \alpha = \frac{r_1 - r_2}{x}$$

$$\alpha = \sin^{-1} \left(\frac{r_1 - r_2}{x} \right)$$

$$= \sin^{-1} \left(\frac{25 - 15}{600} \right)$$

$$\alpha = \sin^{-1} \left(\frac{10}{600} \right)$$

$$= \sin^{-1} 0.01666 = 0.955^\circ$$

$$\alpha = 0.955^\circ \times \frac{\pi}{180} \text{ radians}$$

$$= 0.01666 \text{ radians}$$

The value of α is 0.955° which is very small. The value of α in radians will be equal to $\sin \alpha$. Here is also 0.01666 and $\sin \alpha = 1/60 = 0.01666$.

Substituting values, we get exact length as

$$L = 2 \left[\frac{\pi}{2} (25 + 15) + 0.01666(25 - 15) + \sqrt{600^2 - (25 - 15)^2} \right]$$

$$L = 2[20\pi + 0.1666 + 599.916] = 2[662.916]$$

Approximate length is given as

$$L = \pi(r_1 + r_2) + \frac{(r_1 - r_2)^2}{x} + 2x$$

METAL CASTING PROCESS

9

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 Give the applications of the casting process.

Ans. Some common applications of casting are given below :

1. Various components of vehicles like engine block, piston, piston rings, connecting rod etc.
2. Machine structures like lathe bed, planer bed, shaper bed etc.
3. Steam and hydraulic turbine, turbine blades.
4. Aircraft engine blades.
5. Water supply and sewer pipes.
6. Sanitary fittings and agricultural instruments.

Q.2 What are the purposes of pattern making?

Ans. Purpose of Pattern Making

1. Preparing a mould cavity for making a casting.
2. Preparing core prints for making core if casting have hollow parts.
3. Runner, gate and riser are made for feeding the molten metal.
4. Locating points in mould for dimensional checking.
5. Helps in making parting lines and parting surfaces in mould.

Q.3 Name the different types of pattern.

Ans. Different Types of Pattern :

- (i) Single piece pattern
- (ii) Split pattern
- (iii) Loose piece pattern
- (iv) Gated pattern
- (v) Match plate pattern
- (vi) Cope and drag pattern
- (vii) Sweep pattern
- (viii) Skeleton pattern

II. LONG ANSWER TYPE QUESTIONS

Q.1 What is metal casting? Describe different methods of metal casting. [R.T.U. 2018]

Ans. Metal Casting : Casting is one of the oldest processes of manufacturing metallic parts. A wide variety of simple and complex parts having different shape and size can be manufactured by this method.

Casting Methods : Metal casting process begins by creating a mold, which is the 'reverse' shape of the part we need. The mold is made from a refractory material, for example sand. The metal is heated in an oven until it melts, and the molten metal is poured into the mold cavity. The liquid takes the shape of cavity, which is the shape of the part. It is cooled until it solidifies. Finally, the solidified metal part is removed from the mold. A large number of metal components in designs we use every day are made by casting. The reasons for this include:

- (a) Casting can produce very complex geometry part with internal cavities and hollow sections.
- (b) It can be used to make small (few hundred gram) to very large size parts (thousands of kilograms)
- (c) It is economical, with very little wastage: the extra metal in each casting is re-melted and re-used.
- (d) Cast metal is isotropic - it has the same physical mechanical properties along any direction.

Common examples: door handles, locks, the outer casing or housing for motors, pumps, etc., wheels of many cars. Casting is also heavily used in the toy industry to make parts e.g. toy cars, planes, and so on.

Table 1 : Summarizes different types of castings, their advantages, disadvantages and examples

Process	Advantages	Disadvantages	Examples
Sand	Wide range of metals, sizes, shapes, low cost	Poor finish, wide tolerance	Engine blocks, cylinder heads
Shell mold	Better accuracy, finish, higher production	Limited part size	Connecting rods, gear housings
Expendable pattern	Wide range of metals, sizes, shapes	Patterns have low strength	Cylinder heads, brake components
Plaster mold	Complex shapes, good surface finish	Non-ferrous metals, low production rate	Prototypes of mechanical parts
Ceramic mold	Complex shapes, high accuracy, good finish	Small sizes	Impellers, injection mold tooling
Investment	Complex shapes, excellent finish	Small parts, expensive	Jewellery
Permanent mold	Good finish, low porosity, high production rate	Costly mold, simpler shapes only	Gears, gear housings
Die	Excellent dimensional accuracy, high production rate	Costly dies, small parts, non-ferrous metals	Precision gears, camera bodies, car wheels
Centrifugal	Large cylindrical parts, good quality	Expensive, limited shapes	Pipes, boilers, flywheels

Q.2 Discuss the three types of the moulding sand. What is the significance of the fettling?

Ans. There are three types of sand :

1. **Natural Sand** : Natural sand is easily available and is deposited naturally. Binder such as clay is already mixed with natural sand in abundance. So, only additives and water need to be mixed.
2. **Synthetic Sand** : Synthetic sand is a mixer of natural sand with or without clay, binder, moisture, and water. Sand grain of requisite composition and properties can be prepared by this method.

3. **Loam Sand** : It contains more clay than other sand. Fine sand, refractories, clay, graphite, and fibrous reinforcement are the major ingredients of loam sand. It dries and becomes hard. Mould for large bell is made by loam sand.

Significance of Fettling : Fettling is the process of removing the casting out of the moulding sand and making its surface clean. It includes removal of cores, gates, risers, runner etc. Outer and inner surface of the casting is cleaned so that they look good in appearance. The surface cleaning method depends on the scale formed on the casting surface and size of the casting.

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PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What is forging?

Ans. Forging is one of the oldest manufacturing processes, which aims at shaping the metal into required shape with the help of dies and power packs.

Q.2 Define the term drilling.

Ans. Drilling : Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Write a short note on

- Extrusion
- Rolling
- Drawing

[R.T.U. 2018]

Ans. (i) **Extrusion** : Extrusion is the process used to make a product of fixed cross section. The metallic object is pushed through the die of desired cross section. A complex cross section of product is easily made by this method. Since only compressive and shear stresses are applied on object, this method is also used for brittle metals. The surface finish of parts made by this process is excellent. The extrusion process in metal also increases the strength of the metal. This method can be used for metals, ceramics, plastics, concrete etc. The products made by this process, are generally called 'Extrudates'. Extrusion process can be broadly divided into two types based on the working temperature – hot and cold extrusion. Copper, lead, tin, aluminum alloy, molybdenum, titanium, vanadium, steel etc. are some common metals that can be extruded.

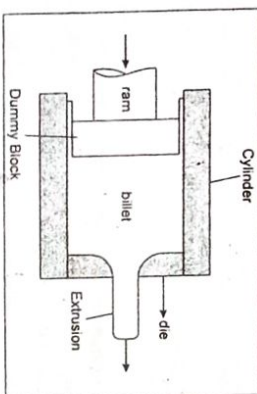


Fig. : Extrusion

At first, material is loaded into the container in the press. A block made of metal is placed behind the material and then it is pushed using a ram out of the die. The cross section equal to the outlet of the die is thus obtained. The extruder parts are used in automobile, construction equipment, railing window frame member etc. The ratio of starting cross sectional area to the final cross sectional area is called extrusion ratio. Surface cracking, surface lines, internal cracking are some common types of extrusion defects occur due to high temperature, friction and high speed.

Advantages

- There is no need of secondary machining process.
- Wide variety of cross section can be made.
- This method is very cost effective.
- Extrusion enhances the mechanical properties of part.
- Good surface finish is achieved.

Disadvantages

- Defect and impurities on the billet's surface affect it extrusion's surface.

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- More force is needed in direct extrusion method and indirect extrusion method is less versatile.

(ii) **Rolling** : Rolling process is the most commonly used metal forming process, used for manufacturing metal sheets of required thickness. This method is used for converting metal ingots into simple stock members like slabs, sheets, plates, strips etc. The main objective of this process is to reduce the thickness of the metal. The metals are plastically deformed by passing through rollers rotating in opposite direction. While rolling, there is negligible change in width, so the decrease in thickness results an increase in length.

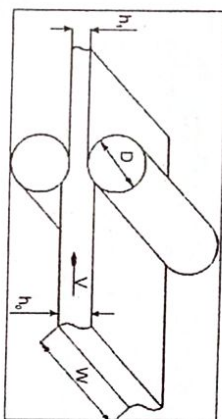


Fig. : Rolling

The materials mostly used for rolling are steel, copper, aluminum and their alloys. Rolling is of two types based on recrystallization temperature – hot rolling and cold rolling. Common defects of rolling are – edge cracking, folds, alligating and scale formation.

Advantages

- It is simple and economical method.
- There is no loss of metal in this process.
- Required thickness of products is achieved by adjusting the gap between the rollers.
- Uniform cross-section of product can be achieved.
- This process has comparatively higher productivity.

Disadvantages

- Various defects arise in rolling process are harmful for products.
- Products made by this process are semi finished. It requires further surface finishing.

(iii) **Drawing** : Drawing is also a metal forming process in which tensile force is used to draw the metal in form of sheet, wire, bar and tube. In this method, metal is pulled and drawn into desired shape and thickness. This method is usually done at room temperature so it is cold working process

however it may be done at an elevated temperature. Drawing is classified into two types – first is sheet metal drawing and second is wire, bar and tube drawing. This method is opposite to the extrusion method. In extrusion method, metal is pushed through the die whereas in drawing method metal is pulled through the die. Metal drawing imparts the products with great accuracy, improved grain and material properties and better surface finish.

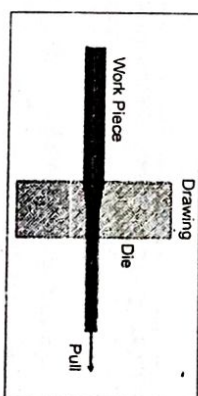


Fig. : Drawing

The material that has to be drawn, should have high ductility, higher tensile stress, and should be clean and rust free. The die, through which work piece is pulled, is mostly made by chilled cast iron, tungsten carbide, diamond or other tool material.

Advantages

- A variety of metals can be drawn very easily.
- This method is very economical for drawing wire.
- This method is also used for making tube, rod and sheet.
- Better surface finish of work piece is obtained.

Disadvantages

- A large amount of force is required to pull the work piece through die.
- Defects like surface crack, inner cracks, surface lines etc. are harmful for work piece.

Q.2 What is drilling operation? Give advantages and disadvantages of drilling.

Ans. Drilling : Refer to Short Answer Q.2.

The drill bit is usually a rotary cutting tool, often multipoint. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the workpiece, cutting off chips (swarf) from the hole as it is drilled.

Advantages

- Forged parts are highly ductile and resistant to the impact and fatigue load.
- Structure of the metal is refined by forging.

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What do you understand by the term welding?

Ans. Welding is a technique or method using which two metals are permanently joined by providing high temperature along with pressure or without pressure.

Q.2 What are the common gases used in welding?

Ans. The gases which are mostly used in gas welding are oxygen, acetylene, hydrogen, argon, coal gas, etc.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Differentiate between soldering and brazing.

Ans. The main differences between soldering and brazing are as follows :

Table : Difference between Soldering and Brazing

S. No.	Soldering	Brazing
1.	Its joint is weak.	Its joint is strong.
2.	It has low melting point.	It has high melting point.
3.	Lead and tin alloy is used in it.	Copper-zinc, copper-silver and silver-zinc alloys are used in it.
4.	Its joint cannot bear jerks or vibrations.	Its joint can bear vibrations and jerks.

5.	Light joints are made by it like- electricity wires, TV., tape recorder, thin sheets, etc.	Jobs or parts are connected by it.
6.	Its joint can be easily taken out by heating it.	Its joint cannot be separated easily by heating.
7.	Different flux is used in it as per the metals.	Only borax is used as flux.

Q.2 Write down the applications, advantages and disadvantages of welding process.

Ans. Applications of Welding : The main uses of welding are as follows :

1. For making aircrafts.
2. For making and repairing train compartments.
3. In small and large bridge construction.
4. In automobile industries- making of moped, scooter, car, truck, bus, etc.
5. In tractor industries- making of tractor and trolley.
6. In construction industries- construction of gates, railings, doors and stairs of huge buildings.
7. In construction of dam.
8. Cycle industries- in manufacturing of cycles.
9. Heavy machinery- in manufacturing of heavy machinery like-JCB machine, bulldozer, roller, etc.
10. Repairing work- used in repairing related work.
11. Ordnance factory- used in the manufacturing of ammunitions like- tank, cannon, gun, rocket, etc.

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12. Heavy industries- used in heavy industries for welding works like- sugar mills, cement industries, oil refinery industries, and medicine industries.

Advantages of Welding : The main advantages of welding are as follows :

1. Welding joint is stronger than other joints.
2. Welding joints takes longer time and less costing.
3. The efficiency of welding joint is 100% which is not in other joints.
4. Welding joint remains strong at high temperature.
5. Lesser metal is required in filling the welding joint and time is also saved.
6. Welding can be used in repairing work easily and quickly.

Disadvantages of Welding : Disadvantages of welding are as follows :

1. Many welding techniques require high costing.
2. The property of the metals changes at high temperature in welding process.
3. Various types of poisonous gases and smoke are produced in welding processes which is harmful for the health of the welder.
4. Ultraviolet rays produced in welding processes are harmful for the eyes.
5. Skilled labours are required for high level welding process.

Q3 Discuss the cutting technique used in gas cutting process.

Ans. Cutting Technique

It is very important for a skilled welder to have a thorough knowledge of the cutting technique. Cutting technique is the technique, the knowledge of which does not let any difficulty arise while cutting any metal and the cutting work can be performed easily and smoothly. In case of lack or no knowledge of cutting technique, the cutting cannot be done neatly and in right direction. So, cutting should be done as per the following sequence :

1. First of all draw the line diagram on the metal, of the shape to be cut out of the metal with chalk.
2. Choose the nozzle or tip according to the thickness of metal or job and place it on the cutting blow lamp.

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3. The pressure of oxygen and acetylene gas should also be set according to the nozzle.
4. Lighten the flame by opening the acetylene needle valve and oxygen needle valve of the cutting blow lamp and set it.
5. The blow lamp should be carefully used to operate on the marked line while cutting.
6. The movement of cutting blow lamp away from the line broadens the path for the cut and harms the metal, so, it should be used to move on the line.
7. Cutting speed should remain constant. If the speed increases, cutting does not take place through thoroughly.
8. Carry the blow lamp to the corner of the job (where it needs to be cut) and make the edge of the job red hot by preheated flame.
9. After this, release the valve of cutting oxygen slowly due to which oxygen oxidizes the hot melted iron which falls down in the form of jet of sparks of fire.
10. The distance of the flame from the job should not be less than 1.5 mm and this distance should be kept constant.
11. When a big hole is to be created in the centre of the job, then job should be heated a bit more and oxygen jet should be released after lifting the nozzle upto 12 mm. This creates the hole and its size can be increased as per requirement.

Q4 Give the working of welding process.

Ans. Working : This is a fusion welding process. The ends of the metal blocks to be joined under this process are melted by heating them up to their melting point. Electric arc is produced between metal segments and metal electrode for melting. First of all, electric circuit is formed by bringing metal segment in contact with the electrode and after that filler metal rod is separated from the job by a very small distance (1mm approx) in which electric current is passed through gaseous medium and arc is produced. Electric energy is converted into heat energy and produces temperature ranges from 3500°C to 4000°C in the arc field, and base metal melts and welding joint is formed. Sometimes, the gaps are filled by melting extra metal wire. This extra metal wire is known as filler rod. In this, mechanical pressure is not used for joining the metals.

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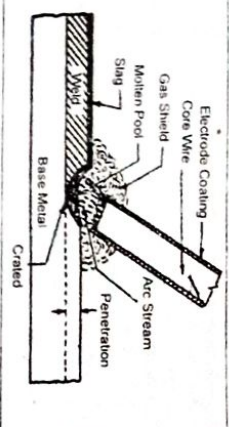


Fig : Electric Arc Welding

The metal blocks to be joined are called base metal or parent metal, and the metal obtained from the electrodes is called filler metal. The layer of flux is applied over the metal electrodes which perform the following work-

1. A gas is produced by this which covers the arc and prevents its contact with atmosphere.
2. It forms slag by mixing with the impurities of molten metal, and purifies the metal.
3. It helps in the flow of current from the arc, and stabilizes the arc.
4. Being light in weight, slag floats on the metal surface and forms a layer on the weld upon cooling.
5. Sometimes, alloying elements are also added in it which combines with the molten metal and alter the properties of metal.

Q5 Write short note on Brazing.

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Ans. Brazing : The method of making strong joints on two similar or different metals is called brazing. Soldering iron is not required for brazing. Spelter or silver solder is used in this for joining. Brazing is similar to welding. It is used for connecting carbide tips, taps, etc. and for making the radiators, on cutting tools. The brazing joint does not open on high vibrations also. It is a permanent fastener.

1. **Spelter :** Generally, copper and zinc is used together to prepare spelter. Solder used for brazing is called hard solder or spelter. Copper, brass, iron, steel, etc. is joined by it. The melting point of spelter of copper and silver is from 600°C to 850°C, the melting point of spelter of copper and zinc is from 650°C to 950°C.
2. **Silver Spelter :** It has copper and silver or silver and zinc mixed in it. It is used in the form of borax flux. It primarily has 5 parts of copper/3 parts of zinc, 2 parts of silver. Mostly goldsmiths use it.

Flux : Flux is used in the form of borax in all the metals in brazing. It is used by mixing it with water.

Brazing Procedure : Brazing procedure is completed in the following steps as per the serial number :

1. Cleaning of the surface to be brazed.
2. Applying flux on the job parts.
3. Heating the job.
4. Applying filler metal.
5. Cleaning of the brazed parts.

METAL MACHINING PROCESSES

12

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What is Milling Machine?

Ans. Milling Machine : A milling machine is a machine tool that removes metal as the work is fed against a rotating multipoint cutter.

Q.2 Define the term cutting speed.

Ans. Cutting Speed : The cutting speed of the lathe is that circumferential speed of the job at which it passes through the cutting tool. This is stated in meter per minute.

Cutting speed (v) = $(\pi d n) / 1000$ meter per minute

Where, d = the diameter of the job (in mm)

n = the rpm of the job (revolution per minute)

II. LONG ANSWER TYPE QUESTIONS

Q.1 Write a brief note on Lathe machine. [R.T.U. 2018]

OR
What is a lathe machine? Give the working of a lathe machine.

Ans. Lathe Machine : A lathe machine is commonly utilized in fitting workshops. Various operations that it can perform include cutting, knurling, drilling, deforming, etc. It can also perform other operations which are employed in production of objects which are symmetrical about the axis of rotation. The lathe machine can be used to produce a wide variety of objects such as crankshafts, camshafts, table legs, bowls, candlestick holders, etc.

Working of Lathe Machine

Lathe machine removes undesirable material from a rotating workpiece in the form of chips. This is done with the help of a tool which is traversed across the workpiece and

can be fed deep into the workpiece. Lathe machine holds the workpiece between the two rigid and strong supports called centers, or in a chuck or face plate while the latter revolves. The chuck or the face plate is mounted on the projected end of the machine spindle. The cutting tool is rigidly held and supported in a tool post and is fed against the revolving workpiece. The tool is made to move either parallel to or at an inclination with this axis to cut the required material while the workpiece revolves about its own axis. If it is fed parallel to the axis, a cylindrical surface is obtained. To obtain a tapered surface, it should be fed inclined at certain angle.

Q.2 Write short note on cutting speed and feed.

Ans.

1. Cutting Speed : Refer to Short Answer Q.2.

Factors Determining the Cutting Speed

- The depth of the cut
- The characteristics of the material of workpiece
- The desired finishing
- Tool geometry
- The strength and properties of the cutting tool and its mounting
- The strength of the workpiece
- The type of cutting fluid used

2. Feed : The feed of any tool is the distance covered by it in one revolution along the job.

This is expressed in mm/revolution.

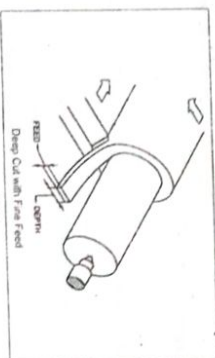


Fig.

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The Major Factors Determining the Feed

- The desired surface finish of the job
- Tool strength
- Tool geometry (shape)
- Job shape
- Job size
- Supplied power
- The depth of the cut

Increase in feed reduces cutting time but too much increase causes the reduction in the life span of the tool. A subtle feed is used for a refined finish and a gross feed is used for a gross finish.

Rate of Metal Removal : The ratio of metal cutting is determined by the amount of chips obtained from the jobs in each minute. This is obtained by the product of the cutting speed, feed rate and the depth of the cut.

Q.3 With the help of neat diagram mention the different parts of a drilling machine.

Ans. Parts of Drilling Machine

- Head :** Head contains the electric motor, V pulleys and V belt which transmit rotary motion to the drill spindle at a number of speeds.
- Spindle :** Spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve.
- Drill Chuck :** It is held at the end of the drill spindle and in turn it holds the drill bit.
- Adjustable Table :** It is supported on the column of the drilling machine and can be moved vertically and horizontally. It also carries slots for bolts clamping Base : It supports the column, which, in turn, supports the table, head etc.
- Column :** It is a vertical round or box section, which rests on the base and supports the head and the table.

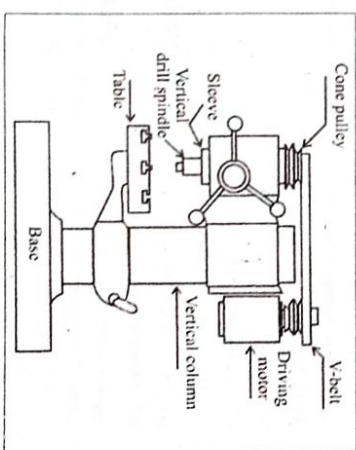


Fig. : Drilling machine

Q.4 Write comparison between lathe machine and milling machine.

Ans. Comparison Between Lathe Machine and Milling Machine

S. No.	Features	Lathe Machine	Milling Machine
1.	Cutting tool and its cost.	Single-point tool and cost of tool is much less.	Multipoint tool and cost of tool is much more.
2.	Movement of job and tool.	Job rotates and the tool having translatory motion for feeding.	Tool rotates and the job having translatory motion for feeding.
3.	Types of job suitable for machining	Generally suitable for tool room and repair type of jobs.	Mostly suitable for mass production works.
4.	Number of tools and number of operations can be performed at a time	Only one tool and one operation can be performed at a time.	One or more tools and many operations can be machined at a time.
5.	Cost of subsequent tools for subsequent operations.	Less, as one tool can be utilized for different operations by tool grinding.	High, as separate tools are needed for various types and size of operations.

ENGINEERING MATERIALS 13

MODEL QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 Write down the composition of German silver.

Ans. German Silver

German silver is an alloy of 25% nickel, 60% copper and 15% zinc. It is a white metal that is used in scientific instruments and ornaments.

Q.2 Give properties of the bearing metals.

Ans. Properties of Bearing Metals

- Low coefficient of friction.
- High melting point.
- High thermal conductivity.
- Good casting quality.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Write down the classification, properties and manufacturing process of cast iron.

Ans. Classification of Iron : Iron obtained from iron ore can be classified under 3 categories. These are :

- Cast Iron** : It is made out of pig iron. It consists of 2-4% carbon. To obtain it, cupola furnace is used. Its diameter is of 1-2 meters and height is 5-8 meters.

Cast iron is of the following types :

- Grey Cast Iron** : This is soft and is of brown colour. It contains 92% iron, 3% graphite, 0.5%

- White Cast Iron** : This is hard and brittle. It contains 9% iron, 3% carbon and 0.5% graphite.
- Mottled Cast Iron** : It contains 93.5% iron, both graphite and carbon content is 1.75%. It is brittle and is less prone to rusting.

- Malleable Cast Iron** : This is less harder than other types of cast iron and is also less tough. This is prepared by heating white cast iron with silica at 1500°C and then cooling down gradually in the same furnace.

- Alloy Cast Iron** : It is made by mixing cast iron with metals like nickel, chromium etc., therefore, its tensile strength is increased.

- Properties of Cast Iron**
 - It catches less rust.
 - It becomes soft in salt water.
 - It has more compressive strength.
 - It melts at lower temperature.
 - It is hard and brittle.
 - It can neither be welded or forged nor magnetized.

- Manufacturing Process of Cast Iron**

Pig iron retrieved from blast furnace is the raw material for cupola. It is refined for casting. This refining process is done in a cupola furnace which is a smaller version of blast furnace.

The cupola furnace is ignited using torches. The base of the furnace is filled with layers of coke. The furnace is charged by ladling coke and die iron alternatively. Depending

(Basic Mechanical Engineering)

upon the quality of steel required sometimes steel shavings are also mixed with pig iron. To reduce the carbon content, low carbon steel shavings are also mixed. A gust of air is passed while melting. Limestone, along with sand and other impurities starts floating above the molten metal which is referred as slag.

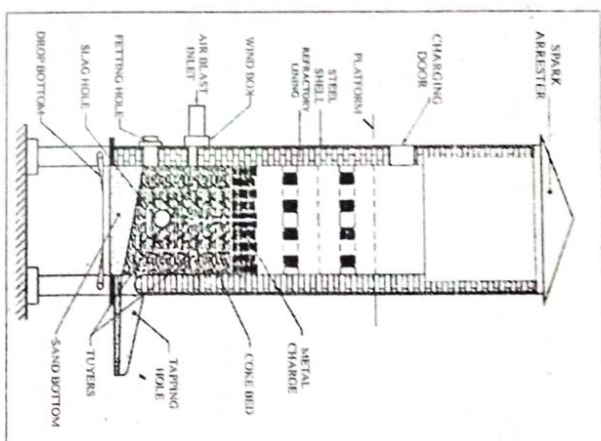


Fig. : Cupola Furnace

Q.2 Discuss various mechanical properties of metal.

Ans. Mechanical properties refer to the behaviour of metals when external forces are applied. If a metal is subjected to an external load, it may yield, deform or break depending on the magnitude and nature of the load.

(BAME-45)

These properties include stiffness, malleability, hardness, fatigue etc. Some of them are explained below:

- Elasticity** : It is the characteristic of a metal to undergo deformation on application of an external force and if this external force is removed, the metal regains its original shape.
- Plasticity** : This is the property due to which the metal undergoes permanent deformation on application of certain magnitude of force.
- Ductility** : The property by which a metal can be drawn into thin wires is called ductility.
- Brittleness** : Brittleness is that property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal, and it will break rather than bending under the shock or impact.
- Toughness** : If a metal is subjected to heavy impact loads like hammer blows, its property to resist this pressure and avoid being broken is called its toughness. It is inversely related to heating i.e., on heating a metal tends to lose its toughness.
- Hardness** : A metal can cut another metal due to its hardness. Hardness is an essential property in determining the ability of a metal to be used as a cutting tool. It also decides whether a metal can be used for a work requiring resistance to wear and tear. Hardness decreases when a metal is heated.
- Malleability** : The property which enables a metal to bear the pressure of compressive actions without undergoing any wear and tear is called its malleability. A malleable metal can be forged, or rolled.
- Tenacity** : The property enabling a metal to have tensile strength so that it can bear the effect of tensile forces in called tenacity.

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HEAT TREATMENT 14

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 What is critical temperature?

Ans. When steel is heated, its temperature rises. In this way, the heat supplied is utilized in order to increase its temperature, but after attaining 723°C, the temperature does not increase because the supplied heat is now utilized for re-arrangement of molecules. This process results in the formation of a dense fluid called austenite. This temperature is known as critical temperature, at which the formation of austenite is completed. Its magnitude depends upon the presence of existing carbon content.

Q.2 What do you mean by soaking?

Ans. Soaking : The steel is held for sometime when it has reached the required temperature. During this the entire job gets consistently heated. This is called soaking.

II. LONG ANSWER TYPE QUESTIONS

Q.1 Describe hardening and tempering of steel

[R.T.U. 2018]

Ans. Hardening : The process of hardening soft steel by heating it to a certain temperature and then cooling it is called hardening.

Hard steel does not outwear by friction and it gains capability to cut other metals. Depending upon the amount of carbon, it can be heated to 30°C to 40°C more than the critical temperature and is allowed to soak for some time. Generally, for a 10 mm thick steel, soaking for duration of 5 minute is sufficient and then to further cool it is submerged in oil or

water. In this process, the soft steel is hardened. The steel which contains 0.15% carbon cannot be hardened.

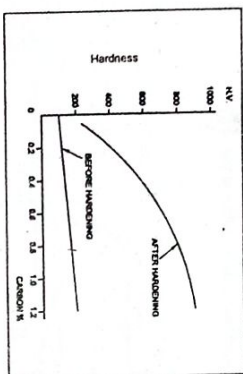


Fig. 1

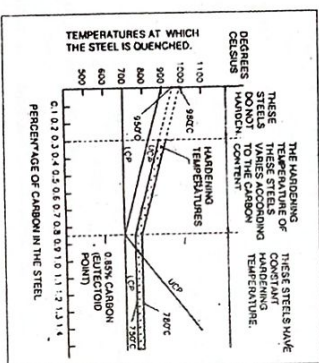


Fig. 2 : Hardening Temperature for Plain Carbon Steel. Hardness of the steel depends upon following factors-

1. Internal structure of the steel
2. Cooling medium - air, water, oil etc.
3. Rate of cooling
4. Carbon content in the steel
5. Process of heating and cooling the steel

Tempering : When a part or equipment is hardened by the process of hardening, its edges become brittle. To reduce the effect of brittleness of the edges the method of tempering is used. In this way, the hardness of the equipment is maintained and it is not brittle either.

Table 1 : Tempering Temperature

S.No.	Equipment	Temperature (°C)	Color
1.	To toughen without unnecessary hardening	450-700	No color
2.	Screw driver, spring	340 320 300	Pigeon blue Very dark blue Dark blue
3.	Cold set for steel cutting	280	Light blue
4.	Cold chisel, press equipment	270	Dark purple
5.	Snap rivet	260	Brown purple
6.	Twist drill	250	Reddish brown
7.	Punch, reamer, tap and shearing blade	240	Brown
8.	Milling cutter, drill	230	Dark straw
9.	Turning equipment	230	Light straw

For tempering, the portion of the hardened part or equipment where tempering is required, is heated at the tempering temperature. Tempering temperature for high speed steel is 220°C to 330°C, for hardened steel is 400°C and for alloy steel is 560°C. Post heating, it is cooled either in water or oil.

In the process of cooling, the heated metal changes color, after taking heat from the surface and the air contact like brown, purple, blue etc. Based on the level of tempering required, the heated metal is submerged in water as soon as the particular color is obtained. This way the tempered part can withstand any vibrations if hit or struck.

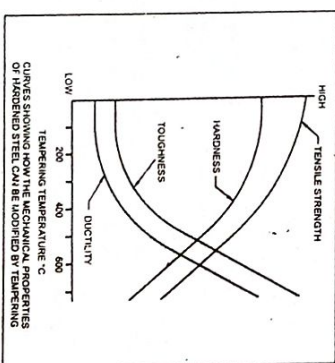


Fig. 3 : Effect of Temperature on Mechanical Properties

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Q.2 Describe the following terms-

- (i) Case hardening
- (ii) Carburizing
- (iii) Nitriding
- (iv) Cyaniding
- (v) Carbonitriding

[R.T.U. 2018]

Ans. Case Hardening : This method of hardening is used when the content of the carbon in the component is 0.15%, and it cannot be hardened easily. In mild steel, low carbon steel and wrought iron, the carbon content is less and to harden them is not possible. Case hardening or surface hardening is where the surface of the metal is hardened.

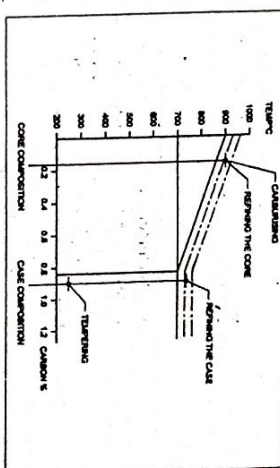


Fig. 1 : Case Hardening Temperature

It is usually used in matching parts that are in constant contact with two or more parts and the outer surface is mostly in use, for example gear teeth, shaft etc.

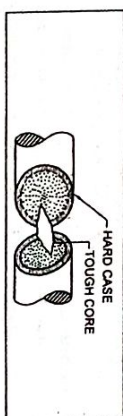


Fig. 2 : Case Hardening Surface

(ii) Carburizing : Carburizing is the most widely used technique for case hardening. In this, the carbon content is increased on the surface of carbon steel or mild steel, so that the surface becomes high carbon steel.

(iii) Nitriding : In this case, steel is case hardened by nitrogen carburizing. The steel part is kept for 100 hours at a temperature of 500°C in ammonia or close to any other substance containing nitrogen.

(iv) Cyaniding : In this process, the alloy steel is heated in molten cyanide. For deeper hardening it is often quenched, as well.

(v) **Carbonitriding** : During carbonitriding, parts are heated in a sealed chamber well into the austenitic range-around 1600 degrees Fahrenheit-before nitrogen and carbon are added. Because the part is heated into the austenitic range, a phase change occurs and carbon and nitrogen atoms can diffuse into the part.

Nitrogen is commonly added to low carbon, low alloy steels that otherwise wouldn't harden well as intended. The nitrogen comes in the form of ammonia, which cracks on the surface of the part to provide nitrogen that diffuses into the steel. Adding nitrogen also helps a part maintain hardness during use in high-heat settings.

Low-carbon, low-alloy steels with low hardenability are good candidates for carbonitriding because the process incorporates hardness to those materials that otherwise would not result from heat treating followed by quenching.

Carbonitriding typically achieves greater case depths compared to nitrocarburizing. There's no theoretical limit to how deep a case can be achieved in either process, but a practical limit is how much time and resources one is willing to spend to achieve certain case depths.

The carbonitriding process usually takes a few hours to achieve the desired results: a part with high surface hardness but with a relatively ductile core. The process concludes with a quench.

Carbonitriding is used to harden surfaces of parts made of relatively cheaper and easily-machined steels, like stamped automotive parts or wood screws. The process makes parts more resistant to wear and increases fatigue strength.

Q.3 Discuss the various processes of case hardening.

Ans. Following processes are used in carrying out case hardening-

1. Carburizing : Refer to Long Answer Q.2.

In this, the jobs are placed at a distance from each other in big boxes of steel or iron along with charcoal, bone powder, barium carbonate, sodium carbonate and hoof chipping to carry out carburizing. This box is kept at a temperature of 850°C to 930°C and is left in that state and after certain time period is cooled. This way the carbon particles spread over the low carbon steel or mild steel surface and transform it into high carbon steel and the internal structure remains the same.

The level of case hardening depends upon the time taken in carburizing. Higher is the time at which it is kept at the high temperature, greater is the case hardening.

Fluid carburizing is done by soaking the steel part in the mixture of calcium cyanide and hydrocyanic acid at 900°C for 3 hours. This way case hardening can be done up to 0.3 mm.

Various ranges of case hardening are shown in the following table.

Table : Various Range of Case Hardening

S.No.	Case hardening (mm)	Time (hrs)
1	0.5 mm to 0.9 mm	4 hrs to 6 hrs
2	1 mm to 1.5 mm	8 hrs to 12 hrs
3	1.5 mm to 2mm	12 hrs to 18 hrs
4	2 mm to 2.5 mm	18 hrs to 24 hrs

In gas carburizing, various gases like carbon monoxide, methane, ethane etc. are heated up to a temperature of 1050°C. In this way, the hardening can be done a lot quicker than other methods.

Advantages of Carburizing

- This is an economical method.
- Due to heat treatment, the upper surface can't hardened appropriately while the inner surface remains soft and mild.
- Heat treatment can be done for mild steel, low carbon steel and wrought iron.
- Internal stress and tension of a substance can't reduced using this method.

2. Nitriding : Refer to Long Answer Q.2.

3. Cyaniding : Refer to Long Answer Q.2.

- Induction Hardening** : In this, the job is kept an electrically regulated induction furnace where the coil is made up of copper.

Heat is generated in the furnace by supplying AC and maintaining a temperature of 750°C to 820°C. To cool the job after heating, water is used.

- Flame Hardening** : In this process, steel sample are constantly heated till 820°C by rotating the gas flame torch, and then cooled in water. For 0.3 mm to 0.6 mm case hardening is done by flat hardening.

Q.4 Write short note on Annealing.

Ans. Annealing : Annealing is performed in order to carry out the machining for steel metal parts. removal of internal stress, improve the structure of the internal particles, to further soften and to improve the ductility.

In the process of annealing, the steel is heated more than the critical temperature and is allowed to soak for sufficient time. In this soaking process the carbon steel is maintained at the same temperature for 5 min / 10 mm width.

In this, steel is gradually heated at a constant temperature which also depends upon the amount of carbon in it. For carbon

equal to 0.12 % to 0.25 %, the temperature range is 875°C to 925°C, for carbon equal to 0.3 % to 0.5 %, the temperature range is 815°C to 840°C, if carbon is 0.5 % to 0.9 % then the temperature range is 780°C to 810°C, if carbon is 0.9 % to 1.3 % then the temperature range is 760°C to 780°C.

To cool, the steel is covered with dry lime, ash or sand so that it doesn't come in contact with the air. Hence, the steel cools slowly and the intrinsic properties change gradually. The rate of cooling of steel is 100°C to 150°C per hour.

MODERN MANUFACTURING SYSTEMS 15

PREVIOUS YEARS QUESTIONS

I. SHORT ANSWER TYPE QUESTIONS

Q.1 Write advantages of CAD.

Ans. Advantages of CAD

- Designing is more accurate, reduce human errors.
- Design can be saved and edited further, if required.
- Reduces time in designing.
- Easy to share without any hassle.
- Reduces human effort.
- One can copy the codes of design and reuse it multiple times again and again.

II. LONG ANSWER TYPE QUESTIONS

Q.1 What is Computer Aided Design (CAD)? Describe its working. [R.T.U. 2018]

[Note: Read 'Aided' as 'Aided']

Ans. Computer Aided Design : Computer aided design or CAD is computer based designing technique, used for creation, modification and optimization of a design. CAD software is used for this purpose.

A CAD software package and sometimes a graphics card must be installed there in your computer for a typical CAD system to work. The heart of a CAD software package is its graphics kernel.

Another important part of the CAD packages is the GUI. The GUI is used for getting user input and displaying

Most of the times, the mouse and the key boards are used as input devices however, the little unknown devices like: tracker ball, digitizer etc are also used sometimes.

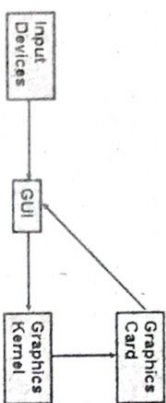


Fig. 1 : Working of CAD System

As shown in the above picture, the input from the input devices go to GUI, the GUI then send the input to the graphics kernel in suitable form. The graphics kernel generates the geometric entities and signals the graphics card to display it through the GUI. This is the explanation of the working of a CAD system in a simplest form.

Q.2 What is MEMS? Write an essay on it. [R.T.U. 2018]

OR

Explain MEMS process with its applications and advantages.

Ans. MEMS technology is also known as micromachine. It is a Japan and micro system technology in Europe. This technology works on the microscoping devices having moving parts. MEMS consists of a control processing unit which is called microprocessor or along with some component interconnected to each other which are called microprocessors. The most common material used for making MEMS is silicon. It is used because of its semiconductor, physical and commercial properties.

Basic Mechanical Engineering

Different components of a MEMS are mechanical elements, sensors, actuators, electrical and electronics devices etc. Sensor collects informations from various sources and then electronics device process the information and directs the actuators to respond.

Some of the major advantages of MEMS are :

- It is small in size and mass.
- It requires very low power consumption.
- It is highly resistant to shocks, vibrations and radiation.
- It is very simple to set up the MEMS into system.
- It facilitates the option for modification.

Application of MEMS

- It is used in automobile industry for different parts such as air bag system, brake light, doorlock active suspension and security system.
- For military purposes – tanks, planes, safety devices for soldiers.
- Commercial purposes – inkjet printers, accelerometers, biochips, optical switching technology, silicon sensors etc.
- Space exploration – gyroscope in inertial navigation, atomic clocks, thermal control, micropower sources etc.

Q.3 What role is played by CAM in manufacturing industry?

Ans. Computer aided manufacturing or CAM is the computer aided manufacturing software used to control the different machine tools while making workpiece. The main purpose of using CAM software is to increase the production rate. The design of model made in CAD and verified in computer aided engineering (CAE) is input into CAM software which controls the machine tools while manufacturing. CAM is now also used in schools, colleges and universities along with CAD to create workpiece. Some specially programmed codes, i-codes and M-codes are used in CAM software for controlling the machine tools. CAM software facilitates the axis machining along with high speed and multi-functioning machining. Manufacturing through CAM is quite complex and requires skilled programmer. The modern machine cannot

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run properly without the assistance. Different machining processes like roughing, semi-finishing, finishing and contour milling is done through this technique.

Advantages of CAM

- Helps in reducing material waste.
- Better productivity of CNC machines.
- Improves machining capabilities.
- Manufacturer may receives CAD file from their clients and set up the machine tool as per requirement.

Q.4 Write short note on FMS.

Ans. Flexible Manufacturing System

As the name suggests, flexible manufacturing system has flexibility to allow the system to work properly in case of changes. These changes may be predicted or unpredicted. There are two types of flexibility which are mentioned below :

- Routine Flexibility :** It allows the system to change as per the changed requirements. It is about system's ability.
- Machine Flexibility :** It is the ability of machine to work on large scale i.e. large volume, large capacity or capability. When requirement changes, it allows the user to use multiple machines on a single part or single job.

Advantages of FMS

- It reduces operating cost. Because of its flexibility, defective products as well as waste time decreases.
- It requires fewer works to work on machine. Thus, reduces labour cost.
- It provides continuous and smooth running of system and machine. Thus, increase efficiency of plant.
- It is helpful for faster production and reduces the idle time.

Q.5 Write down the purposes and advantages of using CIM in manufacturing industry.

Ans. Computer Integrated Manufacturing

Computer integrated manufacturing or CIM is used to control the whole manufacturing process. It is also the

computer based integrated method of manufacturing. CIM uses common technologies to make a design, to set up the program for manufacturing and to do other business functions such as accounting, finance and marketing etc.

CIM is used for various purposes, some of these are mentioned below :

- (i) In production engineering.
- (ii) In mechanical engineering for drawing and designing.
- (iii) In electronic engineering for designing circuit Board.

Advantages of CIM

- (i) Better customer service.
- (ii) Improved product quality.
- (iii) Less manufacturing time.
- (iv) Lower manufacturing cost.
- (v) Increases productivity.
- (vi) Less inventory.
- (vii) Reduces scraps.