



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous)

(ISO/IEC-27001-2005 Certified)

Winter – 2015 Examinations

Subject Code : 17413 (EME)

Model Answer

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Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.
- 5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).
- 6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept



- 1 **Attempt any Seven:** 14
- 1 a) **State the function of air heater of super-critical boiler.**
Ans:
The exhaust flue gases have high temperature and heat energy. If these gases are let out as it is then there is a loss of heat energy and hence overall boiler efficiency is reduced. It is possible to reduce this heat loss by heating the air supplied for the combustion of fuel using exhaust flue gases. The hot air supplied for combustion process leads to increase the flame temperature and enhance the heat transfer by radiation and convection. This results in increase in overall boiler efficiency. Thus air heater in super critical boiler is used to pre heat the air before supplying it for combustion. 2 marks
- 1 b) **Define annual efficiency of boiler**
Ans:
Annual boiler efficiency takes into account the total losses during the operation of a boiler over the period of a year or a season.
It is defined as the ratio of annual useful heat output of a boiler to the total annual fuel energy consumed by the boiler. 2 marks
- 1 c) **List the applications of condensing and non-condensing turbines.**
Ans:
Condensing turbines are commonly used in power plants where sole purpose is the generation of electrical energy. e.g. steam turbines used in steam power plant. 1 mark

Non condensing turbines are commonly used for process industries where, in addition to generation of electric power, low pressure exhaust steam from turbine is used for process heating purpose. e.g. steam turbines used in pulp and paper industry, sugar factory, refineries etc. 1 mark
- 1 d) **Define accident term in Boiler Act.**
Ans:
According to Indian Boiler Act 1923, 'Accident' is defined as an explosion of a boiler or steam pipe or any damage to the boiler or steam pipe which is calculated to weaken the strength thereof so as to render it liable to explode. 2 marks
- 1 e) **Describe the necessity of engine testing.**
Ans:
The necessity of testing of engine are-
1. To get information about the engine like power developed, specific fuel consumption etc. which cannot be determined by calculation. Any TWO
1 mark
2. To confirm the data used in design, the validity of which is in doubt. Each
3. To satisfy the customer as to the rated power output with the guaranteed fuel consumption.
- 1 f) **Define air compressor**
Ans:
Air compressor is a machine which sucks low pressure low temperature air from atmosphere and compresses it to high pressure high temperature using reciprocating motion of a piston and cylinder arrangement or using rotary motion 2 marks



of a set of blades enclosed in a casing.

1 g) **Define swept volume in case of air compressor**

Ans:

In case of air compressor, swept volume is defined as the total volume displaced by the piston when it moves from top dead centre to bottom dead centre.

2 marks

Swept volume = cross section of cylinder \times stroke length.

1 h) **Analyze perfect intercooling and imperfect intercooling in air compressor**

Ans:

The process in which the intercooler reduces the temperature of compressed air to its temperature before compression is called as a perfect intercooling.

2 marks

The process in which the intercooler does not reduce the temperature of compressed air to its temperature before compression is called as an imperfect intercooling.

The work done by compressor with a perfect intercooler is less than that done with an imperfect intercooler.

1 i) **State the application of roto dynamic pump.**

Ans:

Roto dynamic pumps are used where continuous supply of liquid with low or moderate pressure is required. These pumps are used in irrigation of agriculture fields and also in process industries.

2 marks

1 j) **State the function of diffuser in centrifugal pump.**

Ans:

In the diffuser of the centrifugal pump the kinetic energy of the water is converted into pressure energy before water leaves the casing. This increases overall hydraulic power output of a pump and hence its overall efficiency.

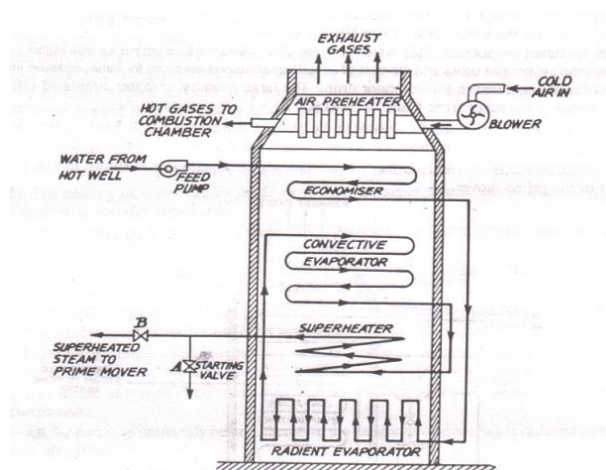
2 marks

2 **Attempt any FOUR of the following**

12 marks

2 a) **Sketch and explain Benson critical boiler, state its advantages and disadvantages.**

Ans:



Benson critical boiler is high pressure drum-less boiler. The entire process of heating, steam generation and superheating is done in a single continuous tube. Since no drum is used, this is a once through boiler and the feed water entering at one end is discharged as superheated steam at the other end. Its construction is as shown in the figure.

1 mark for Explanation

and

1 mark For sketch

Fig. Benson critical boiler



Advantages of Benson Critical Boiler

- i) Overall weight of the boiler and required floor area for the boiler is less.
- ii) Overall efficiency of the boiler is higher
- iii) Its erection is easier and quicker.
- iv) Low emission levels.
- v) Operating cost of the boiler is lower
- vi) The boiler can be started very quickly.

Any ONE
advantage
1/2 mark

Disadvantages of Benson Critical Boiler

- i) As the boiler works above critical pressure and temperature of water, the materials used for tubes should be of higher grade alloy steels. This increases the overall cost of a boiler.
- ii) At lower loads, the boiler is not suitable.

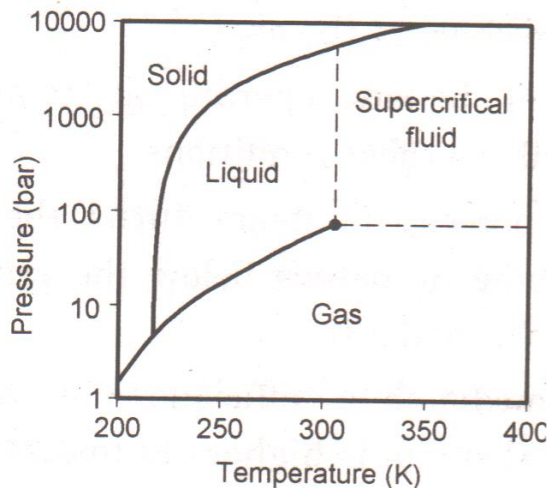
Any ONE
disadvantage
1/2 mark

- 2 b) **Draw and explain temperature verses pressure diagram showing three phases in super critical boiler.**

Ans:

In the boiler, water is heated until it becomes steam. The critical point of a substance is temperature and pressure above which the liquid and vapour state are no longer distinguishable. The super critical boiler works above the critical temperature and pressure of water. As the water is heated, its density decreases while the pressure and density of vapour increases. At the critical point, the two densities (liquid and vapour) are equal and the liquid becomes a supercritical fluid. The thermodynamic efficiency of a plant using supercritical steam is 40% higher than that of similar subcritical plant

2 marks



1 mark

Fig. Temperature verses pressure diagram showing three phase in super critical boiler

- 2 c) **Classify I.C. engine according to methods of ignition, injection, working cycle and application.**

Ans:

Classification of I.C. engines

- 1) According to methods of ignition



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- i) Spark ignition (S.I.) engine,
- ii) Compression ignition (C.I.) engine
- 2) **According to methods of injection**
 - i) Single point or Throttle body
 - ii) Multi point (MPFI)
 - iii) Gasoline Direct Injection (GDI)

3) **According to working cycle**

- i) Two stroke engine
- ii) Four stroke engine

OR

According to working cycle (Thermodynamic)

- i) Otto cycle engine
- ii) Diesel cycle engine
- iii) Dual cycle engine

(Classification according to working cycle or thermodynamic working cycle should be considered.)

4) **According to application**

- i) Stationary engine
- ii) Portable engine
- iii) Marine engine
- iv) Automobile engine
- v) Aero engine

1 mark for
each
classification
any
THREE = 3
marks

2 d) **Give possible causes and remedies of following**

Ans:

- i) **Difficulty in starting**
Cause- Electrical system problem, fuel system problems
Remedies- Check and repair battery connections, condition of battery, check and repair fuel pump and fuel supply line
- ii) **Leakage of exhaust**
Cause- Cylinder head gasket problem, cylinder head problem
Remedies- Replace gasket and tighten the cylinder head bolts properly, replace the cylinder head.
- iii) **No spark at spark plug**
Cause- spark plug faulty or worn out, faulty ignition coil
Remedies- Check spark plug condition and replace if necessary, check electrical wiring
- iv) **Low engine compression**
Cause- Worn out piston, piston rings, cylinder, damaged gasket, loose cylinder head
Remedies- Replace piston, piston rings, rebore cylinder, replace the gasket, tighten the cylinder head bolts properly

For each
problem
one
possible
cause and
its one
remedy
1 mark
(Any
THREE
problems)
=3 marks

2 e) **Explain energy saving methods in air compressor.**

Ans:

The following methods are used to save the energy in air compressor

- i) **Use multistage compression-** Use multistage compression as it



consumes less energy for the same output than single stage compressor.

ii) **Inter cooling**-The compression process is divided in multi stages. The compressed air of one stage is passed through intercooler before supplying it to the next stage. In intercooler, the air is cooled to its initial temperature due to which energy is saved.

iii) **Water jacketing**- Cold water is kept circulating around the cylinder and head assembly of a compressor to cool the compressed air.

iv) **Regenerative air dryer**- In this, compressed air is used to heat the inlet air so that inlet pressure of the air is slightly increased and also the moisture in the inlet air is reduced. hence overall input energy for the compression is reduced.

v) **Reduce compressor delivery pressure**- Reduce the deliver pressure of compressed air whenever possible to save the energy.

1 mark for
each
method
(Any
THREE)

2 f) **Explain in brief construction and working of centrifugal pump.**

Ans:

Centrifugal pump consists of

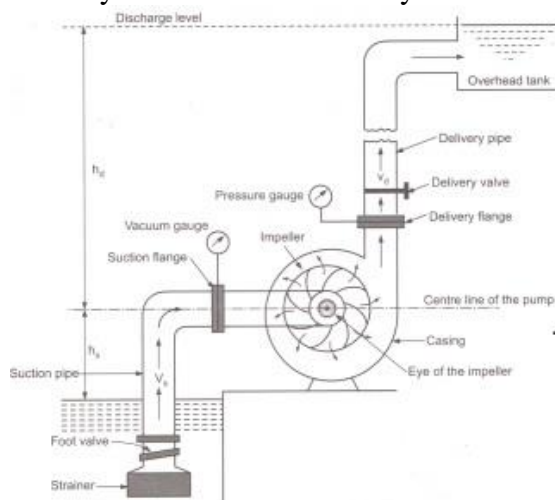
Impeller- It is a rotor having series of backward curved vanes. It is mounted on the shaft which is coupled with a motor.

Casing- It is air tight chamber of volute type. It has delivery pipe connection tangential as shown in the figure. Inlet connection to its centre i.e. eye of impeller.

Suction pipe with strainer- This is the pipe which connects the eye of impeller to sump from which liquid is to be lifted. The strainer is provided at the lower end of pipe to avoid the entry of impurities in the pump.

Delivery pipe – A pipe connected between delivery flange of the casing and delivery valve near the delivery tank is called as delivery pipe.

1 mark



1 mark

Figure. Construction of Centrifugal pump

Working- The pump works on the principle of centrifugal force. Initially pump is primed i.e. suction pipe; casing and portion of delivery pipe up to delivery valve are filled with liquid to be pumped. Then the electric motor is started to rotate the



impeller. The rotation of impeller in the casing produces a forced vortex. This forced vortex generates centrifugal head due to which liquid at centre is forced radially outward. It creates vacuum at the eye of impeller and causes the liquid to suck in to casing through suction pipe from sump. The liquid forced outward passes through volute casing where kinetic energy is converted to pressure energy. Thus at delivery end we get liquid discharge with pressure. The liquid is continuously sucked and delivered.

1 mark

3 **Attempt any four:**

12

3 a) **Write advantages and disadvantages of super critical boiler.**

Ans:

Advantages-(any 3)

- i) Short start-up time.
- ii) Less weight of plant.
- iii) Variable steam demand can be met.
- iv) Occupies less space.
- v) More efficiency of power plant.
- vi) Scale formation is eliminated as water flows with high velocity through tubes.
- vii) Less operating cost.

1 ½ marks

Disadvantages-(any 3)

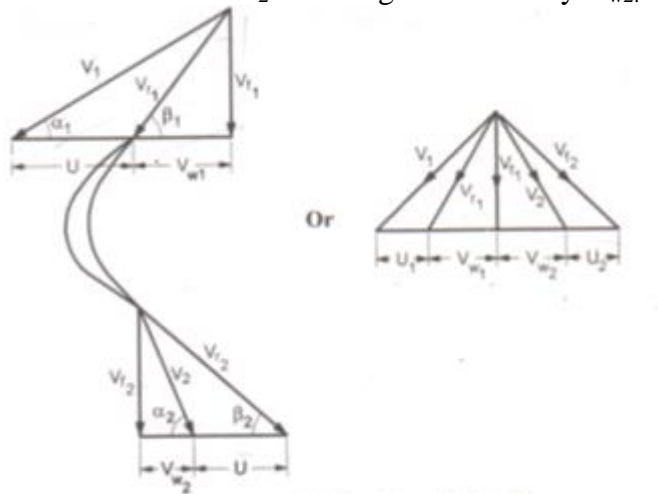
- i) Not suitable for small plants.
- ii) Boilers are subjected to high pressure so high strength of material is required.
- iii) Relatively high initial cost.

1 ½ marks

3 b) **Derive the equation for power developed by turbine.**

Ans:

The swirling fluid enters the blade at radius r_1 with tangential velocity V_{w1} and leaves at radius r_2 with tangential velocity V_{w2} .



a) Velocity triangle

b) Combined Velocity Diagram

1 mark

According to Newton's Second law of motion,



$$\begin{aligned}\text{Tangential force acting on wheel} &= \text{mass} \times \text{acceleration} \\ &= m \times (V_{w1} N - V_{w2} N) \\ &= m \times (V_{w1} - V_{w2}) N\end{aligned}$$

Where

N = Rotary speed of turbine in rpm

m = mass flow rate in kg/s

According to law of momentum

2 marks

Torque, T on the fluid,

$$T = m \times (V_{w2} r_2 - V_{w1} r_1)$$

For Impulse turbine $r_2 = r_1 = r$

Tangential force on blades,

$$F_t = T/r$$

$$= m \times (V_{w2} - V_{w1})$$

Work done per unit time or Power developed (P),

$$P = T \times \omega$$

Where ω is angular velocity.

Blade speed,

$$U = \omega \times r$$

Then Power $P = m U (V_{w1} - V_{w2})$ watts

- 3 c) **Define manometric head and also write its equation stating the meaning of notations used.**

Ans:

Manometric Head- It is defined as the minimum amount of head against which a pump has to work.

or

The required to be developed by pump.

3 marks

$$H_m = h_d + h_{fd} + h_s + h_{fs} + V^2 / 2g$$

where,

H_m - Manometric head.

h_d - Delivery Head.

h_{fd} - Head lost in overcoming friction in delivery pipe.

h_s - Suction Head.(lift)

h_{fs} - Head lost in overcoming friction in suction pipe.

V-velocity of water in pipe.



- 3 d) Explain working of two stage reciprocating air compressor. Show work saved on p-v diagram with respect to single stage compression.

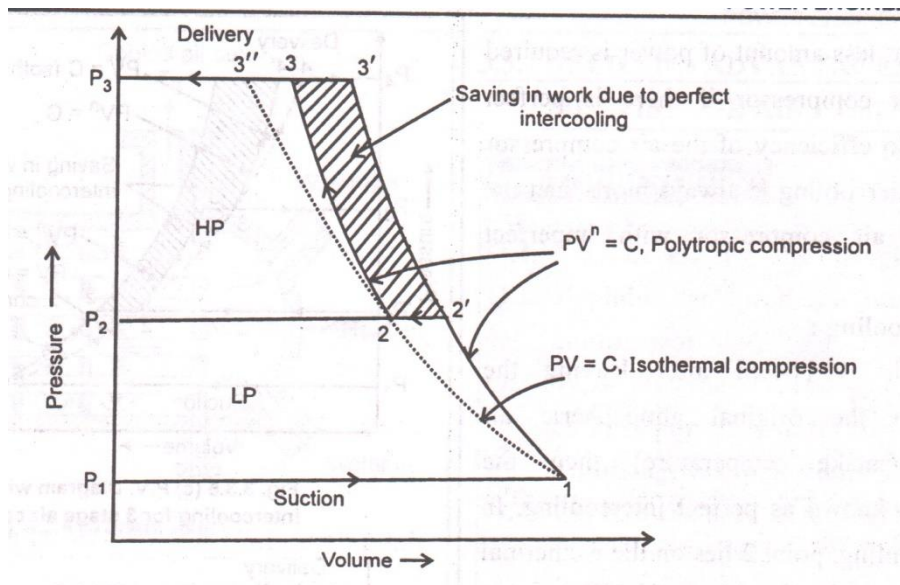
Ans:

Working of two stage air compressor-

A two stage air compressor has low pressure (LP) and high pressure (HP) cylinders (stages). Air from atmosphere is taken into LP cylinder as intake valve opens due to pressure difference. This air is compressed by movement of piston by closing both the valves. At the end of the compression, the delivery valve opens against pressure of air. This compressed air passes through intercooler where the air temperature is reduces. This air is supplied to HP cylinder as intake valve opens. The air is further compressed in HP cylinder by movement of piston. The air at high pressure opens delivery port of HP cylinder.

1 ½ mark

Representation of Work saved by two stage air compressor on P-V diagram-



1 ½ mark

- 3 e) Differentiate between single stage and multistage air compressor.

Ans:

Any 3 points of comparison like-

Sr.	Single stage air compressor	Multi stage air compressor
1	Compression of air takes place in Single stage.	Compression of air takes place in more than one stage.
2	Work required to compress air to same pressure is more as compared to multistage compressor.	Work required to compress air to same pressure is less as compared to single stage compressor.
3	Larger size of compressor is required to reach high pressure.	High pressure can be reached in overall less dimensions of compressor.
4	Resulting temperature of compressed air is high.	Resulting temperature of compressed air can be reduced by intercooling.

1 mark for each point (any 3 points)



- 3f) State purpose of casing and explain the volute casing with guide blade with neat sketch.

Ans:

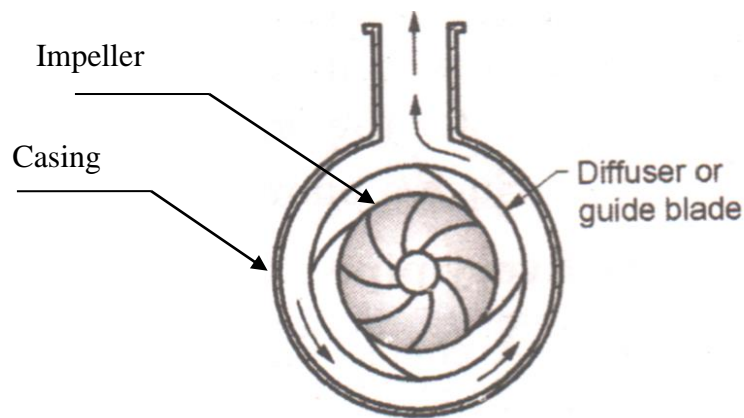
Purpose of casing-

- i) To convert velocity head into pressure head.
- ii) To provide air tight enclosure to the components of pump.

1 mark

volute casing with guide blade-

Diagram-



1 mark

Working- The impeller is surrounded by ring of guide blades. The blades are situated at an angle in such a way that water enters the casing without shock. The blades provide passage of increasing area for delivery of water.

1 mark

- 4 Attempt any four:

12

- 4 a) Differentiate between impulse reaction and reaction turbine.

Ans: Any 3 points

Sr	Impulse turbine	Reaction turbine
1	No change in pressure of steam when it passes through blades.	Steam expands partly when it passes through blades.
2	The relative velocity of steam when it passes through blades is constant.	The relative velocity of steam increases when it passes through blades.
3	Pressure on both the sides of blades is same	Differential pressure exists at sides of blade.
4	Turbine blades are symmetrical so area of flow remains constant.	Turbine blades are aerofoil shaped so area of flow changes.
5	Due to high steam velocity, speed of turbine is high.	Steam velocity is low hence speed of turbine is relatively low.
6	It requires less space	It requires more space.

1 mark for each point
(any 3 points)

- 4 b) State necessity of intercooling in multistage air compressor.

Ans:



During compression in LP stage, air temperature along with pressure increases. The intercooling reduces temperature of air hence volume of air decreases. The compression approaches to isothermal compression. So intercooling reduces work required for compression of air.

3 marks

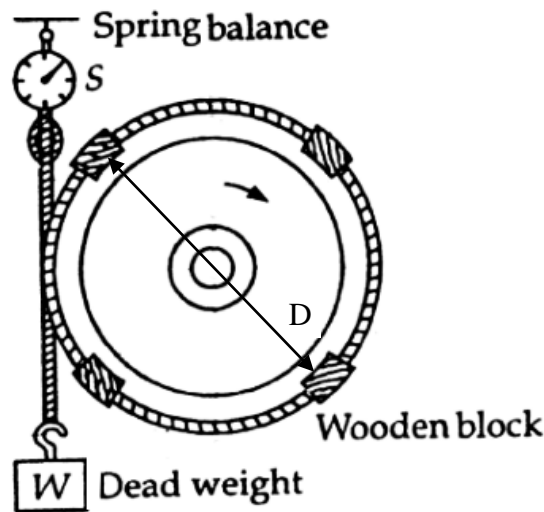
4 c) Explain any one method used to measure the brake power of engine.

Note:- Any one method of power measurement such as Rope brake dynamometer, prony brake dynamometer, eddy current dynamometer, hydraulic dynamometer etc. may be assessed. For labeled sketch 1 mark and for construction and working 2 marks may be given.

As an illustration, one method is presented here.

Rope Brake dynamometer –

As shown in figure, this dynamometer has a drum mounted on engine shaft. A rope is wound around the drum. One end of drum carries dead weight whereas another end carries spring balance.



The power of engine is absorbed by friction in between rope and drum. The brake power P in Watts is given by

$$P = \pi DN (W - S) / 60$$

where

D - Effective diameter of drum in meter.

N - Speed of rotation in rpm.

W - Dead weight in N.

S - Spring tension in N.

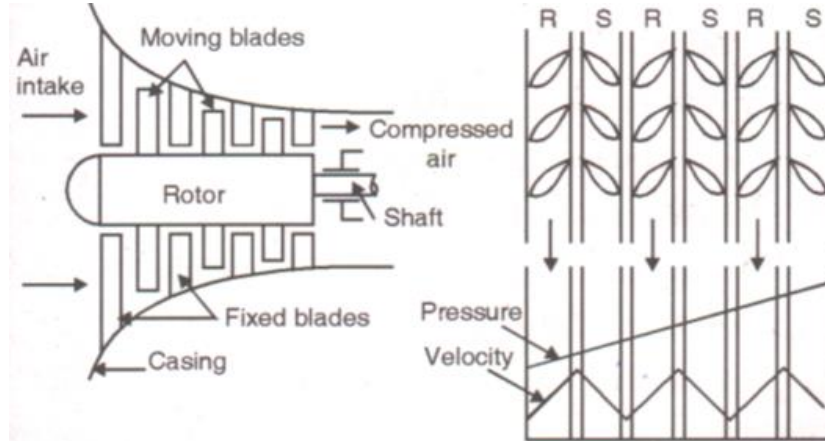
3 marks



4 d) Explain with neat sketch axial flow compressor.

Ans:

Sketch-



1 ½ marks

Axial flow compressor

Pressure-velocity diagram

Working- A shaft carries ring of moving blades which rotates in between fixed blades mounted on casing. As rotor rotates, air flowing axially through the series of moving and fixed blades. The velocity and pressure of air increases as air passes through moving blades. The fixed blades causes further rise in pressure of air. The high pressure air leaves the compressor from other end.

1 ½ marks

4 e) Give advantages and disadvantages of peristaltic pump.

Ans:

½ marks per point.

Advantages-

- It is self-priming pump.
- It can run in both directions.
- It can pump abrasive material also.
- It does not require seal or gland.

Any Three points

1 ½ marks

Disadvantages-

- Failure of tube stops working of pump.
- The pressure is limited by tube strength.
- Running Cost is relatively high.
- The flow is pulsed, particularly at low rotational speeds

Any Three points

1 ½ marks

4 f) Define pumping power? State various factors affecting the pump efficiency?

Ans:

The power imparted to the fluid by pump is called as pumping power.

1 mark

Factors-

- The density of fluid to be pumped.
- Suction and delivery head
- Flow rate of the pump
- Losses in pipes and casing of pump.
- Mechanical losses like bearings, lip seals, mechanical seals and packing

Any four points

2 marks