MODEL ANSWER FOR ELEMENTS OF MECH.ENGG.(17413)

Q 1. a)

1) **steam boiler-** It is a closed vessel in which steam is produced from water by combustion of fuel.

2) **steam turbine-** It is a device that extract thermal energy from pressurized steam and uses it to do mechanical work on rotating output shaft.

3) **Air Compressor-** it is a machine which suck the low pressure& temp. air from atmosphere & compressed it to high pressure & temp air by reciprocating motion of piston or rotary motion of blade in casing.

Q 1.b)

Classification of Steam Turbines:

There are several ways in which the steam turbines may be classified. The most important & common division being with respect to the action of the steam, as:

(a) Impulse
(b) Reaction
(c) Combination of impulse & reaction.

(A) According to the number of pressure stages:
(i) Single stage turbines
(ii) multistage impulse & reaction turbines

(B) According to the direction of steam flow:
(i) Axial turbines
(ii) Radial turbines

(C) According to the number of cylinders:
(i) Single cylinder turbines
(ii) Double cylinder turbines
(iii) Three cylinder turbines
(iv) Four cylinder turbines

(D) According to the method of governing:
(i) Turbines with throttle governing
(ii) Turbines with nozzle governing
(iii) Turbines with by pass governing.

(E) According to heat drop process:
(i) Condensing turbines with generators
(ii) Condensing turbines with one or two intermediate stage extraction.

(iii) Back pressure turbines
(iv) Topping turbines
(v) Back pressure turbine with steam extraction from intermediate stages at specific pressure

(F) According to position of shaft axis:
(i) Horizontal axis turbine
(ii) Vertical axis turbine.

(G) According to their nature of steam supply:
(i) High pressure turbine
(ii) Low pressure turbine.

(H) According to direction of steam flow:
(i) Axial flow turbine
(ii) Radial flow turbine
(iii) Tangential flow turbine
(iv) Single flow or double flow

(I) According to exhaust steam pressure
(i) Condensing type steam turbine.
(ii) Non-condensing type steam turbine.

Q 1. C) Difference between impulse & reaction turbine.

S. No.	Particulars	Impulse turbine	Reaction turbine
1.	*Pressure drop*	Only in nozzles and not in moving blades.	In fixed blades (nozzles) as well as in moving blades.
2.	*Area of blade channels*	Constant.	Varying (converging type).
3.	*Blades*	Profile type.	Aerofoil type.
4.	*Admission of steam*	Not all round or complete.	All round or complete.
5.	*Nozzles / fixed blades*	Diaphram contains the nozzle.	Fixed blades similar to moving blades attached to the casing serve as nozzles and guide the steam.
6.	*Power*	Not much power can be developed.	Much power can be developed.
7.	*Space*	Requires less space for same power.	Requires more space for same power.
8.	*Efficiency*	Low.	High.
9.	*Suitability*	Suitable for small power requirements.	Suitable for medium and higher power requirements.
10.	*Blade manufacture*	Not difficult.	Difficult.

Q1. d) Different power losses in turbine are as follows:

1.Loss due to moisture.

2.Loss due to mechanical friction

3.loss due to radiation and convection.

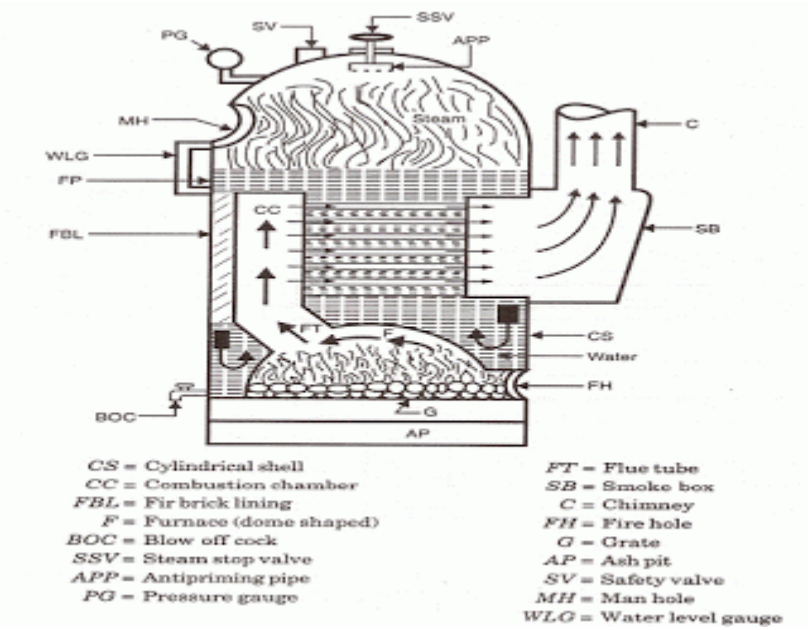
4.loss due to friction and turbulence.

5.carry over losses.

6.Wheel friction loss.

7.Residual velocity loss

Q1 . e) Fig.Cochran Boiler

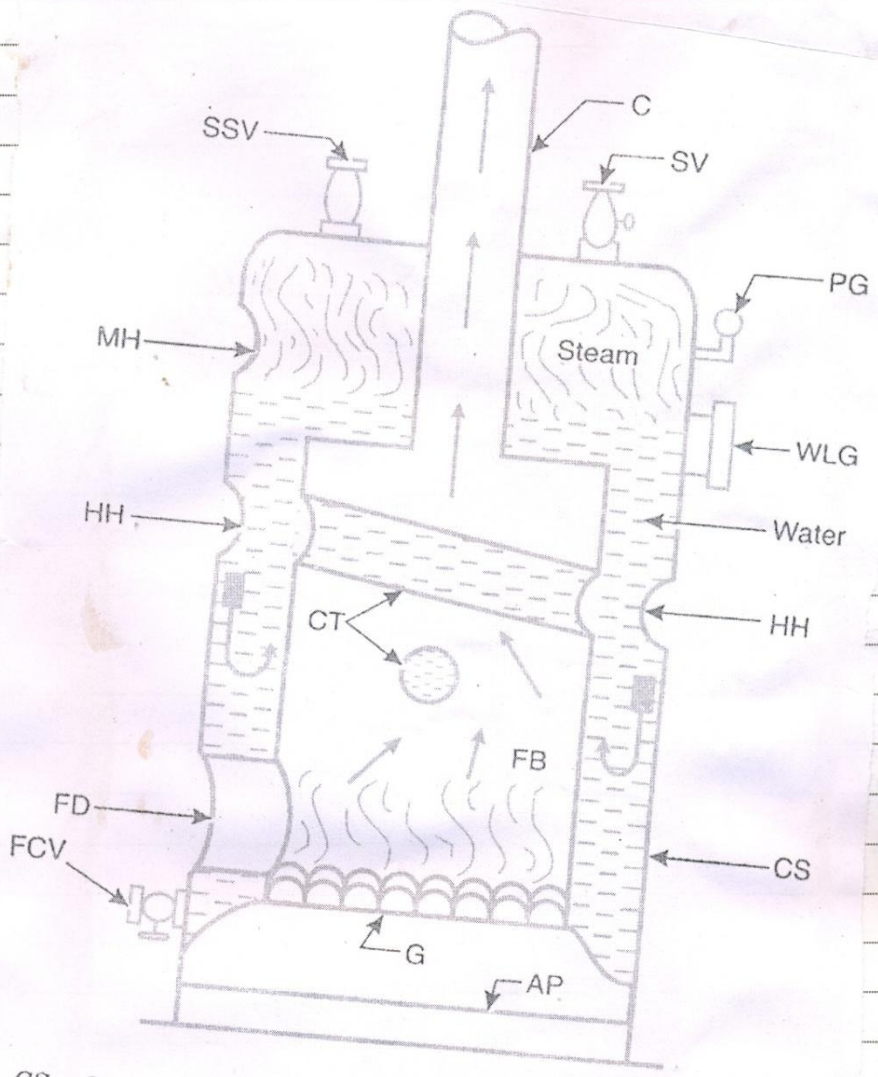


Q 2. A)

Critical Boiler:

① It consists of a cylindrical shell, the greater portion of which is full of water & remaining is the steam space.

② At the bottom of the fire box is grate on which fuel is burnt & the ash from it falls in the ash pit.



CS = Cylindrical shell
MH = Man hole
CT = Cross tubes
G = Grate
PG = Pressure gauge
SV = Safety valve
WLG = Water level gauge

C = Chimney
HH = Hand hole
FD = Fire door
FB = Fire box
AP = Ash pit
SSV = Steam stop valve
FCV = Feed check valve

Fig. 11.1. Simple vertical boiler.

③ The fire box is provided with two cross tubes. This increases the heating surface & the circulation of water.

④ The cross tubes are fitted inclined. This ensures efficient circulation of water.

⑤ At the end of each cross tube are provided hand holes to give access for cleaning these tubes. The combustion gases after heating the water & thus converting it into steam escape to the atmosphere through the chimney.

⑥ Man hole is provided to clean the interior of the boiler & exterior of the combustion chamber & chimney.

⑦ The various mountings shown in fig. are

- ⓐ Pressure gauge
- ⓑ water level gauge or indicator
- ⓒ Safety valve
- ⓓ Steam stop valve
- ⓔ Feed check valve
- ⓓ man hole.

⑧ Flow of combustion gases & circulation of water in water jackets are indicated by arrows as shown in fig.

⑨ Pressure = 7.5 to 10 bar.

Q 2.b) Impulse turbine:

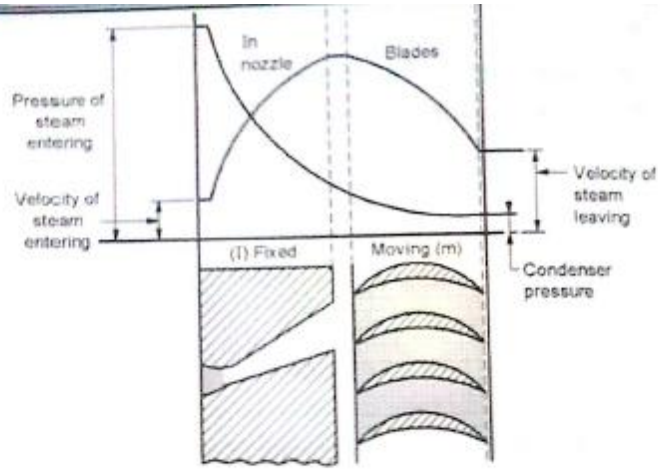


Fig. 5.4(b) : Variation of pressure and velocity of steam in simple impulse turbine

- Impulse turbine consist of one set of nozzle mounted on a stationary diaphragm which is followed by one set of moving blade ring as shown in Fig. 5.4(a) for a single stage impulse turbine.
- In impulse turbine power is developed by the impulsive force of high velocity steam jet or jets. The high velocity steam jets are obtained by complete expansion of steam in the stationary nozzles fitted in diaphragm then this high velocity steam passes through moving blade with no drop in pressure but a gradual reduction in velocity.
- Thus, in pure impulse turbine the high velocity jet from nozzle strikes on the blades mounted on the wheel attached to the shaft.
- These blades change the direction of steam and hence momentum of the jet of steam which rotate the shaft. The nozzle axis is inclined to an angle to the tangent of the rotor.

Q 2. C)

1)compression ratio: It is defined as ratio of volume of air before compression to volume of air after compression.

Rc= Vs + Vc / Vc

Vs=swept volume

Vc=clearance volume

2) Free air delivered+ it is volume of air delivered under the conditions of temp & pressure exiting at compressor intake i e volume of air delivered at surrounding temp and pressure.

Q3 a) Reciprocating Air Compressor:

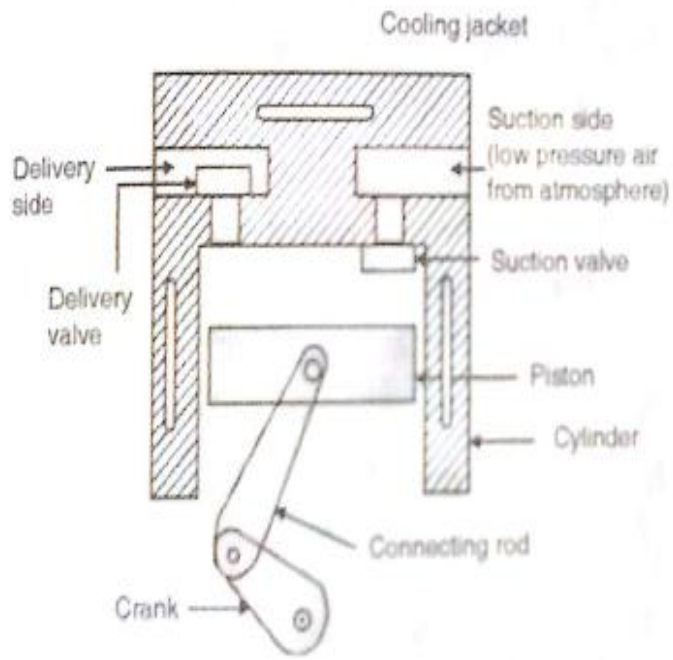


Fig. 3.1 : Single-stage single acting reciprocating air compressor

- The principal parts of a reciprocating air compressor are same as that of a engine. Fig. 3.1 shows the sectional view of an air-cooled single stage single acting reciprocating air compressor. Both suction

and delivery valves are disc type and are operated automatically.

They are open and closed by difference in the air pressure acting on their two sides and are kept closed by light springs.

During downward motion of piston, the pressure inside the cylinder falls below atmospheric, thus the suction valve opens and atmospheric air enters in cylinder.

During upward motion (during compression stroke) of piston, the air inside the cylinder is compressed which increases pressure than receiver pressure, which causes a resistance on the spring to open delivery valve and discharge takes place from cylinder to receiver. The receiver is a closed vessel acts as a storage tank.

The compressor is driven by external source (electric motor or prime mover). The prime mover will have to supply very high starting torque. To avoid this hand unloader is used for releasing pressure from the compressor cylinder when compressor is stopped.

.3.2 Indicator Diagram :

Fig. 3.2 represents indicator diagram for single stage air compressor without clearance. During the suction stroke the air is drawn into the cylinder along line 4-1 at constant pressure P_1 which is slightly below than atmosphere. At point 1, the piston complete suction stroke and start it compression stroke

At this time, all the valves are closed, the air inside cylinder is compressed along the curve 1-2. At point 2, the pressure P_2 is reached which is slightly higher than the receiver pressure. At this point discharge valve opens and the delivery of the compressed air takes place along line 2-3 at constant pressure P_2.

The piston has now reached at top of the cylinder and again starts its suction stroke and the pressure in the cylinder will be lowered again to P_1 and the cycle of operations will be repeated. The net work required is represented by the area 1-2-3-4 in Fig. 3.2.

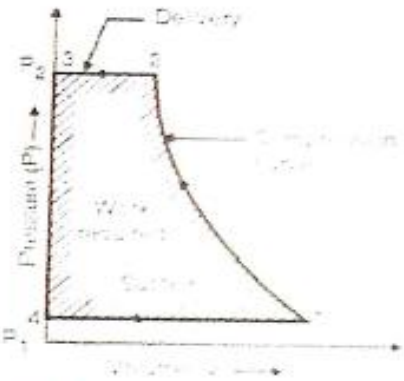


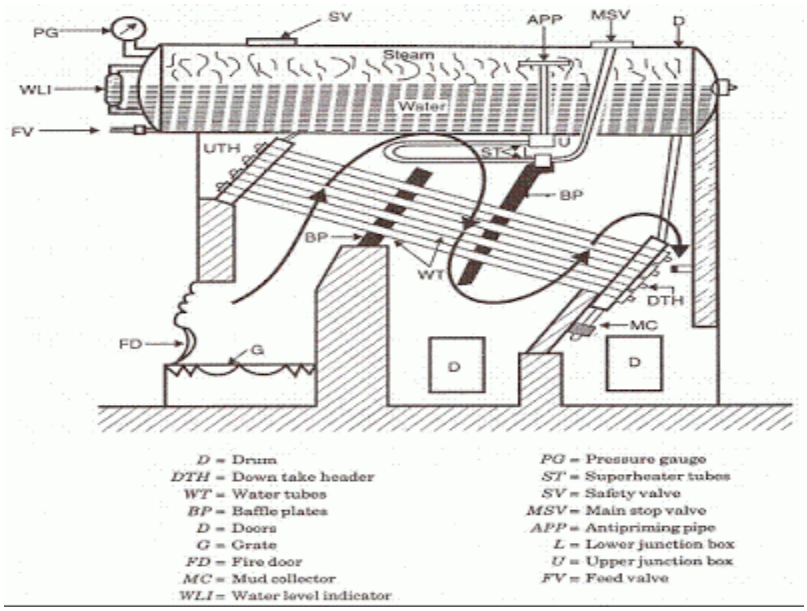
Fig. 3.2 : Theoretical indicator diagram of single-stage air compressor

The amount of work done on the air will be depend upon the nature of compression curve i.e. Isentropic or Isothermal. But in actual practice compression will be achieved in between Isentropic and Isothermal.

From Fig. 3.2 the slope of the compression curve, represented by the law $PV^n = c$, depends upon the value of index n.

Q.3. b) <u>Babcock and Wilcox Boiler:</u>

Construction of Babcock and Wilcox Boiler



The Babcock and Wilcox Boiler consists of

1. Steam and water drum (boiler shell)
2. Water tubes
3. Uptake-header and down corner
4. Grate
5. Furnace
6. Baffles
7. Super heater
8. Mud box
9. Inspection door
10. Damper

<u>Steam and water drum (boiler shell):</u>
One half of the drum which is horizontal is filled up with water and steam remains on the other half. It is about 8 meters in length and 2 meter in diameter.

<u>Water tubes:</u>
Water tubes are placed between the drum and furnace in an inclined position (at an angle of 10 to 15 degree) to promote water circulation. These tubes are connected to the uptake-header and the down-comer as shown.
<u>Uptake-header and down-corner (or downtake-header)</u>
The drum is connected at one end to the uptake-header by short tubes and at the other end to the down-corner by long tubes.

<u>Grate:</u> Coal is fed to the grate through the fire door.

<u>Furnace :</u> Furnace is kept below the uptake-header.

Baffles: The fire-brick baffles, two in number, are provided to deflect the hot flue gases.

Superheater: The boiler is fitted with a superheater tube which is placed just under the drum and above the water tubes

Mud box: Mud box is provided at the bottom end of the down comer. The mud or sediments in the water are collected in the mud box and it is blown-off time to time by means of a blow –off cock.

Inspection doors: Inspection doors are provided for cleaning and inspection of the boiler.

Working Babcock and Wilcox Boiler:

Coal is fed to the grate through the fire door and is burnt.

Flow of flue gases:

The hot flue gases rise upward and pass across the left-side portion of the water tubes. The baffles deflect the flue gases and hence the flue gases travel in the zig-zag manner (i.e., the hot gases are deflected by the baffles to move in the upward direction, then downward and again in the upward direction) over the water tubes and along the superheater. The flue gases finally escape to atmosphere through chimney.

Water circulation:

That portion of water tubes which is just above the furnace is heated comparatively at a higher temperature than the rest of it. Water, its density being decreased, rises into the drum through the uptake-header. Here the steam and water are separated in the drum. Steam being lighter is collected in the upper part of the drum. The water from the drum comes down through the down –comer into the water tubes.

A continuous circulation of water from the drum to the water tubes and water tubes to the drum is thus maintained. The circulation of water is maintained by convective currents and is known as **"natural circulation**".

A damper is fitted as shown to regulate the flue gas outlet and hence the draught.

The boiler is fitted with necessary mountings. Pressure gauge and water level indicator are mounted on the boiler at its left end. Steam safety valve and stop valve are mounted on the top of the drum. Blow-off cock is provided for the periodical removed of mud and sediments collected in the mud box.