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Internal Assessment Test 2 – October. 2019

Sub:	Elements of Mechanical Engineering					Sub Code:	18ME15	Branch:	ECE,EEE,ME
Date:	24/10/2019	Duration:	90 min's	Max Marks:	50	Sem / Sec:	I/ I, J, K, L, M, N & O		OBE

Answer any 5 Questions

		MARKS	CO	RBT
1.	Explain construction and working of Babcock Wilcox Boiler	[10]	CO2	L2
2.	Derive the expression for length of belt in a cross belt drive.	[10]	CO3	L1
3.	Write about extraction of energy from wind.	[10]	CO1	L1
4.	Write the differences between welding, brazing and soldering.	[10]	CO3	L1
5.	Explain construction and working of Francis Turbine with neat diagram.	[10]	CO2	L2
6.	Determine the number of teeth and speed of the driver gear if the driven gear has 60 teeth of 8mm module and rotates at 240rpm. Two spur gears has a velocity ratio of ¼. Also calculate pitch line velocity.	[10]	CO3	L3
7.	A shaft runs at 80rpm and drives another shaft at 150rpm through belt drive. The diameter of driving pulley is 600mm. Determine the diameter of driven pulley in following cases. i) t=0, ii) t = 5mm iii) t = 5mm and S_t = 4%, iv)t = 5mm, S_1 = 2%, S_2 = 2%	[10]	CO3	L3

Solution:

1.

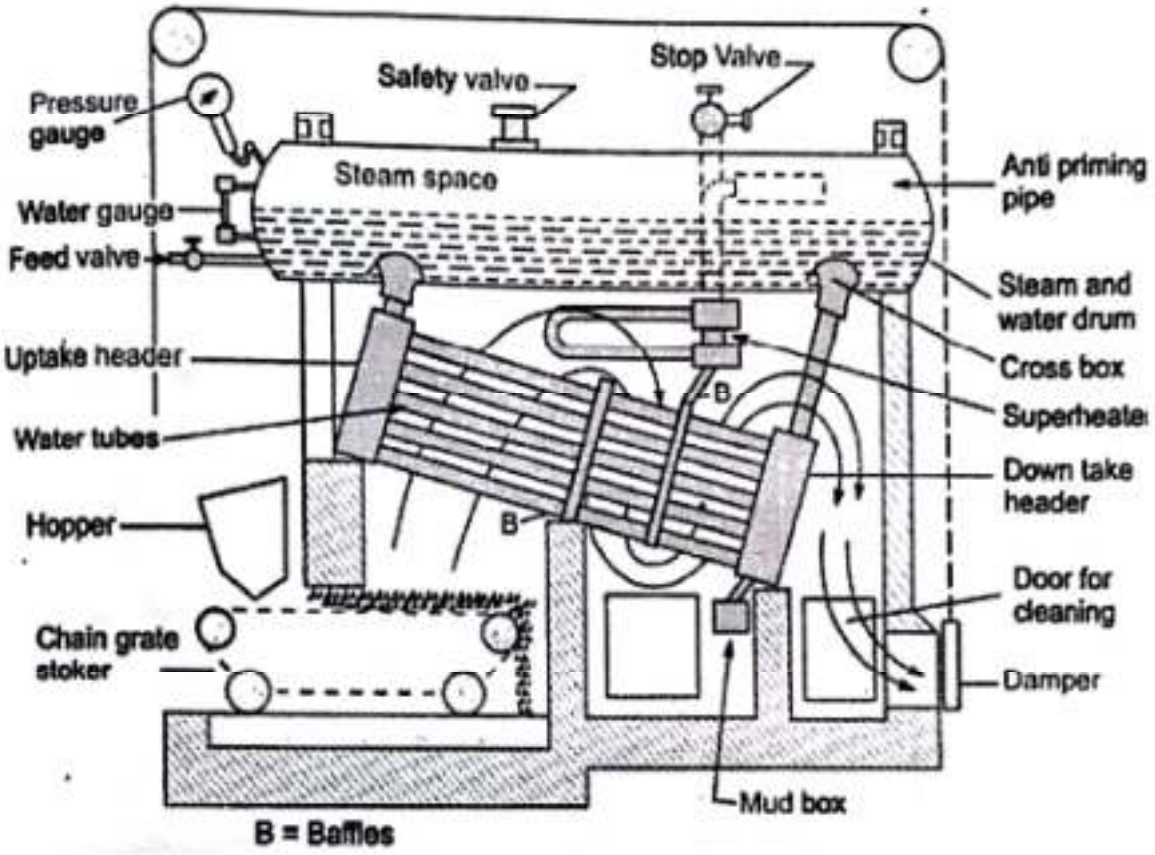
BABCOCK AND WILCOX BOILER

- It is a horizontal, externally fired water tube boiler.
- It can raise steam normally between 10 bar to 20 bar at a steam rate.
- A high capacity boiler of this type can produce steam upto a pressure of about 40 bar and steam rate as high as 4000 kg per hour.

Construction :-

- Babcock and Wilcox water tube boiler mainly consists of 4 parts :
  1. Water and Steam Drum
  2. Water tubes
  3. Chain Grate stoker
  4. Superheater tube.
- The water and steam drum is suspended from iron girders resting on iron columns.
- A number of inclined water tubes at a very low inclination of maximum upto 15° are connected at right angles to the end boxes or tubes called as headers.
- The header shown at the right end of the water tubes is called down take header and the other shown at the left end of the

water tubes is called uptake header.
- Each set of the headers are intern connected to the boiler drum.



- A mud box is provided just below the downtake header.
- Sediments in water due to its heavier specific gravity settles down in the mudbox as is taken out through a blow off pipe.

- The moving grate is provided at the front end below the uptake header.
- Boilers of higher capacity are usually provided with a chain grate stoker, which consists of slowly moving endless chain of grate bar. The coal fed at the front end of the grate is burnt on the moving grate in the furnace and the residual ash falls at the other end of the grate into the ash pit.
- Boiler is fitted with a superheater which is placed in the combustion chamber underneath the boiler drum.

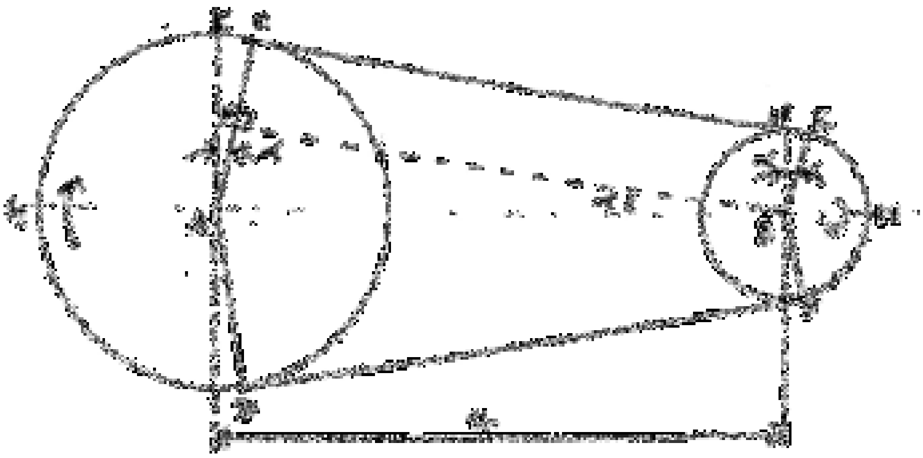
Working :→

- The water is introduced into the boiler drum through the feed valve
- A constant water level is maintained in the boiler drum.
- The water descends at the rear end into the downtake headers and then passes in the inclined water tubes, uptake headers and in the tubes connecting the uptake header and drum.
- During combustion, the hot gases from the furnace grate move upwards around the water tubes.
- There are baffle plates which guide the path of the flue gases in a particular direction as

shown in the figure in order to have maximum coverage.
- It finally passes out of the boiler through the exit door and chimney.
- During this path of hot flue gases, the hottest gases emerging directly from the grate come in contact with the hottest portions of the water tubes near the uptake header.
- The water in these positions of the water tubes get vaporized.
- The water and steam mixture ascends or moves upward through the uptake headers to the boiler drum.
- Due to this flow, a continuous rapid circulation of water is established between the drum and water tubes.
- Eventually, the steam generated gets separated from water as it is lighter than water. The steam occupies the steam space in the boiler drum.
- The wet steam is then made to flow through the anti-priming device which separates the moisture making it as a dry saturated steam.
- This dry steam is then made to flow through the superheaters present in the combustion chambers.
- There is exchange of heat and the dry saturated steam is converted into superheated steam.

- The superheated steam is then passed to its point of application through the steam stop value.

Derivation – Length of Open Belt Drive:–



Let x = Distance between centres of two pulleys (i.e. length [illegible]).
r_1 = Radius of larger pulley ; r_2 = Radius of smaller pulley.
L = Total length of belt.

From B draw BM parallel to EF. But EF is tangent at E. Hence [illegible] ⊥ [illegible] which makes ∠[illegible] = 90° or π/2 & ∠[illegible] = 90° or π/2 radians.

Let ∠[illegible] = α & ∠[illegible] = α.

$$\text{Length of Belt, } L = \text{Arc } [illegible] + CE + \text{Arc } [illegible] + FD$$

$$= 2\left[\text{Arc } [illegible] + CE + \text{Arc } EH\right]$$

$$= 2\left[r_1\left(\frac{\pi}{2}+\alpha\right) + EM + r_2\left(\frac{\pi}{2}-\alpha\right)\right]$$

In △ [illegible]

$$EM = \sqrt{([illegible])^2 - ([illegible])^2}$$

$$= \sqrt{x^2 - (r_1 - r_2)^2}$$

$$AM = AC - CM$$

$$= (r_1 - r_2)$$

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

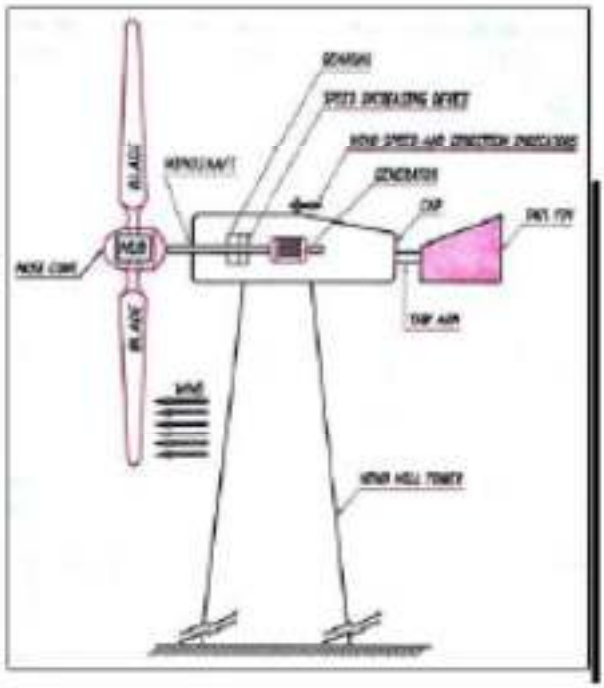
$$\boxed{L = 2\left[\frac{\pi}{2}(r_1+r_2) + \alpha(r_1-r_2) + \sqrt{x^2-(r_1-r_2)^2}\right]}$$

3.

Extraction of energy from wind

- The hub is connected to a generator through a gear drive.
- A tower (average 200 m height) helps to minimize turbulence and ground effects.
- The preferred wind speed for maximum power generation is about 40 km/h.
- Nowadays, effort is being made to improve the performance of windmills using aerodynamic and sound engineering principles.
- Winds blow across the blades in turn converting their energy in to mechanical energy due to rotation of blades. The turbine spins the generator and generates electricity.

Wind Mill- Diagram



4.

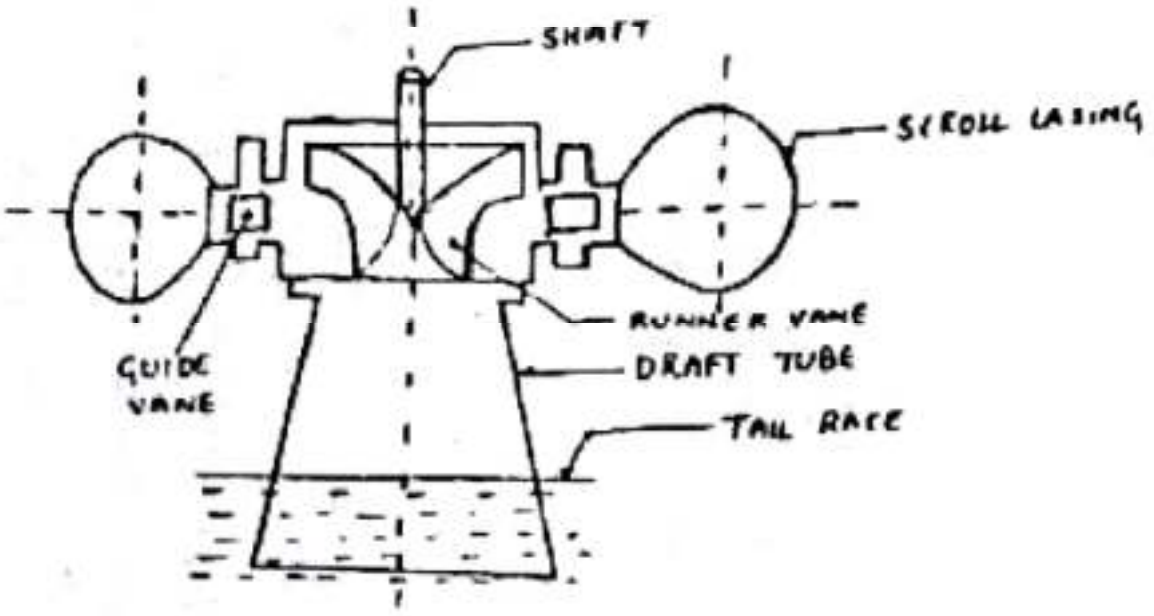
Welding	Soldering	Brazing
It is a high temp process where the base metals are heated above their melting temperature	It is a low temp process where the base materials not melted	The base metals are not melted but broadly heated to a suitable temperature
The filler material used is made of same material as that of the base metal.	filler material used is not the same as that of the base metal	filler material used is not same as that of the base metal
* joint is formed by the solidificati	* joint is obtained by diffusion	* Joint is obtained by means of diffusion
* Strength of the joint obtained in welding is much stronger than the parent metal	* Strength of the joint is obtained in soldering is very low when compared to that of brazed and welded joints.	* Strength of the joint lies in between that of welded and soldered joints
* Requires certain finishing operation like grinding, filing etc	* joints can be used as is, without any finishing operations	* Surface finish is good. In some cases, finishing operations are required
* Welding produces strongest joints. Hence this process is used for fabrication and structural applicatio	* Since the joint obtained is not much strong. this process is mostly used for joining thin sheet metals, pipes, wires, etc ..	* finds application in arts, Jewellery works and also in industries

5.

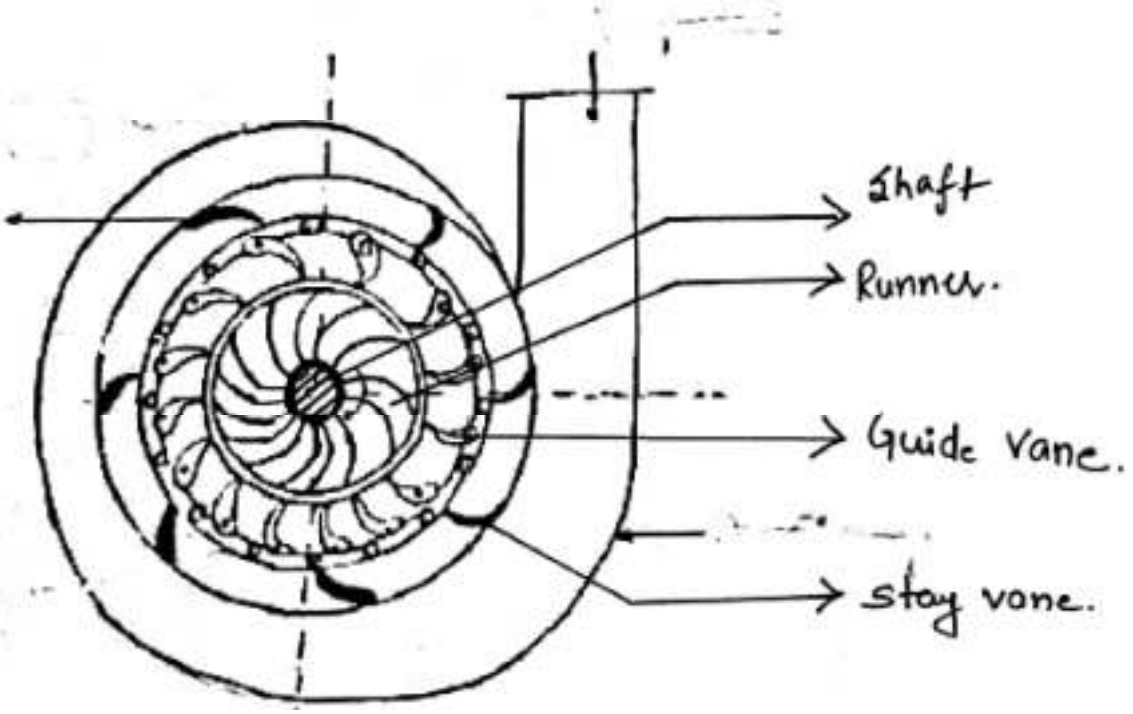
Francis Turbine (Impulse-Reaction Turbine)

- Francis turbine is a water turbine used for medium head and medium flow rate application.
- Runner, the rotating part of turbine contains set of blades over which the water glides during the flow.
- Runner is connected to the generator via a shaft for electricity production.
- In runner water enters radially and leaves axially, hence also called as a mixed flow turbine
- The cross-section of blade in the runner has a thin Air-foil shape and a bucket shape towards the outlet
- So, when water flows over it, there is a low pressure region on one side and a high pressure region on other side of blade, giving rise to a lift force. (due to air foil shape)
- The bucket shape introduces an impulse force on runner
- Hence Pressure Energy (converts to lift force) and Kinetic Energy (used up for impulse force) from the fluid and is used up to do the work on turbine
- Hence both Kinetic Energy (K.E) and Pressure Energy (P.E) drops down
- Francis turbine is not a pure reaction turbine, as some portion of force comes from impulse action also.

FRONT VIEW OF FRANCIS TURBINE



TOP VIEW OF FRANCIS TURBINE



- Water flows from reservoir through the penstock & enters spiral casing.
- The runner is positioned inside the spiral casing
- The flow rate of water (discharge, m^3/s) decreases along the length of casing, but decreasing area of casing will make sure that the water is entered in the runner region almost at uniform velocity, leading to smooth operation of runner.

$(Q = A_1V_1 = A_2V_2)$

Continuity Equation
A ⇒ Area of cross.
V ⇒ Velocity
Q ⇒ discharge.

- Stay vanes & guide vanes are fitted at the entrance of runner.
- Stay vanes (fixed) directs the water to the runner section, reducing the swirl of inlet flow. (swirl increases energy loss).
- Guide vanes (adjustable), is used to control the flowrate of water towards the runner, depending on electricity demand.
- Draft tube is fitted at the exit side of the turbine, and has increasing cross-sectional area towards the tail race. This increases the pressure of fluid above atmosphere, to maintain continous flow out of the turbine & avoid cavitation (air bubble formation - can lead blade damage).

$$F_{total} = F_{lift} + F_{impulse}$$

6.

Given data:

$T_2 = 60$

$n_1 = 8$ mm

$N_2 = 240$ rpm

$\eta_g = 98\%$

$T_1 = ?$

$D_1 = ?$

$(\eta_1 = \eta_2 = 0)$

Find T_1, D_1 if

$$V.R = \frac{N_2}{N_1} = \frac{T_2}{T_1} = 1/4$$

$$\frac{T_1}{T_2} = 1/4 \Rightarrow T_1 = \frac{T_2}{4} = \frac{60}{4} = 15.$$

$$\boxed{T_1 = 15}$$

$$\frac{N_2}{N_1} = \frac{1}{4} \Rightarrow N_1 = 4N_2 = 4 \times 240$$

$$\boxed{N_1 = 960 \text{ rpm}}$$

$$V_1 = \frac{\pi D_1 N_1}{60} = \frac{\pi D_1 \times 960}{60} \quad (\because n = \tfrac{D}{2})$$

$$= \left(\frac{\pi \times 2n \times N_1}{60}\right) = \text{[illegible]}$$

7.

Given :-

$N_1 = $ [illegible] rpm $\qquad D_1 = $ [illegible] mm

$N_2 = $ [illegible] rpm $\qquad D_2 = \,?$

(i)

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \Rightarrow D_2 = \frac{N_1}{N_2} \times D_1 = \text{[illegible]} \times \text{[illegible]} = \text{[illegible] mm}$$

$D_2 = $ [illegible] mm

(ii) $t = 5$ mm

$$\frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t} \Rightarrow \frac{\text{[illegible]}}{\text{[illegible]}} = \frac{\text{[illegible]} + 5}{(D_2 + 5)}$$

$$D_2 = (\text{[illegible]} + 5) \times \frac{\text{[illegible]}}{\text{[illegible]}} - 5$$

$D_2 = $ [illegible] mm

(iii) $t = 5$ mm, $s = 4\%$

$$\frac{N_2}{N_1} = \frac{(D_1 + t)}{(D_2 + t)}\left(1 - \frac{s}{100}\right) = \frac{\text{[illegible]}}{\text{[illegible]}} = \frac{(\text{[illegible]} + 5)}{(D_2 + 5)}\left(1 - \frac{4}{100}\right)$$

$D_2 = $ [illegible] mm

Assuming $t = 5$, $s_1 = 2\%$, $s_2 = 2\%$.

$$\frac{N_2}{N_1} = \left(\frac{D_1 + t}{D_2 + t}\right)\left(1 - \frac{s_1}{100}\right)\left(1 - \frac{s_2}{100}\right)$$

$$\frac{\text{[illegible]}}{\text{[illegible]}} = \left(\frac{\text{[illegible]} + 5}{D_2 + 5}\right)\left(1 - \frac{2}{100}\right)\left(1 - \frac{2}{100}\right)$$

$D_2 = $ [illegible] mm