DEPARTMENT OF MECHANICAL & INDUSTRIAL ENGINEERING
I SEMESTER B.TECH.
Mid-term Exam
SUBJECT: BASIC MECHANICAL ENGINEERING I (MIE 1071)

Time: 8:00 – 10:00AM Date: 27/09/2023 MAX.MARKS: 30

Type: DES

Q11. The boiler is producing 30% wet steam at a temperature of 191.6°C. This steam is later heated in a superheater to produce steam with a degree of superheat equal to 65°C. Before entering the superheater, steam loses heat of the order of 12%. Find the following: (4)

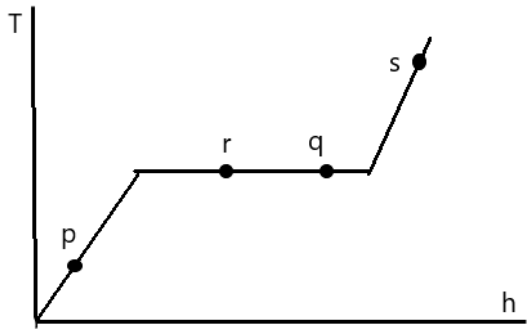
a) Total heat supplied to feed water in the boiler
b) Dryness fraction of steam at the entry of super heater
c)Total heat supplied in the super heater.

The temperature of the feedwater entering the boiler is found to be 28°C.

ANSWER:

$p = 13\ bar, T_{sat} = 191.6℃, x = 0.70, DOS = 65℃, h_f = 814.7\frac{kJ}{kg}, h_{fg} = 1970.7\frac{kJ}{kg}, h_g = 2785.4\frac{kJ}{kg}, T_1 = 28℃$

Identifying the pressure as 13 bar $-----(\mathbf{0.5\ marks})$



$a)\ Total\ heat\ supplied\ to\ feed\ water\ in\ the\ boiler: h_q - h_p -----(1)$

$$h_p = 4.187 \times 28 = 117.236\frac{kJ}{kg} -----(\mathbf{0.5\ marks})$$

$$h_q = h_f + xh_{fg}$$

$$= 814.7 + 0.70\ (1970.7)$$

$$h_q = 2194.19\frac{kJ}{kg} -----(\mathbf{0.5\ marks})$$

$Substituting\ h_p\ and\ h_q\ in\ equation\ (1)$

$$Total\ heat\ supplied\ to\ feed\ water\ in\ the\ boiler = 2194.19 - 117.236$$

$$= 2076.954\frac{kJ}{kg} ----(\mathbf{0.5\ mark})$$

Finding the value of h_p and/or h_q without finding the total heat supplied to the feed water in the boiler then award $\mathbf{0.5\ marks}$

$b)\ Dryness\ fraction\ of\ steam\ at\ the\ entry\ to\ superheater, h_r = h_f + xh_{fg}$

$$Given, h_r = 0.88 \times h_q = 0.88 \times 2194.19 = 1930.887\ kJ/kg - - - - - (\mathbf{0.5\ marks})$$

$$i.e., 1930.887 = 814.7 + x \times 1970.7$$

$$\therefore x = 0.5664 = 56.64\% - - - - - (\mathbf{0.5\ marks})$$

$$c)\ Total\ heat\ supplied\ in\ the\ superheater = h_s - h_r - - - - (2)$$

$$h_s = h_g + 2.25 \times 65 = 2785.4 + 2.25 \times 65 = 2931.65 \frac{kJ}{kg} - - - - - (\mathbf{0.5\ marks})$$

$$Substituting\ h_s\ and\ h_r\ in\ equation\ (2);$$

$$Total\ heat\ supplied\ in\ the\ superheater = 2931.65 - 1930.887 = 1000.763\ kJ/kg - - - (\mathbf{0.5\ marks})$$

Q12. A gear box for a machine tool is to be designed, the motor of which runs at 1760 rpm. Following are the gears available. Build a compound gear train and calculate out the least possible speed for the machine spindle in such a way that the driver and driven shafts are parallel to each other. The entire gear train consists of five shafts. Sketch the arrangement and list the criteria in building the gear train. (4)

Gear	Type	Module (mm)	No. of teeth
A	Spur	2	92
B	Spur	2	40
C	Helical	2	104
D	Helical	2	40
E	Bevel	2	116
F	Bevel	2	30
G	Spur	3	30
H	Spur	3	75
I	Helical	3	72
J	Helical	3	30
K	Bevel	3	20
L	Bevel	3	68

ANSWER:

Conditions used to get minimum velocity ratio.

a) For Minimum velocity ratio, driven gear should have more no. of teeth and driver gear should have less no. of teeth
b) Meshing gears should be of same type and same module
c) Different gear types can be compounded

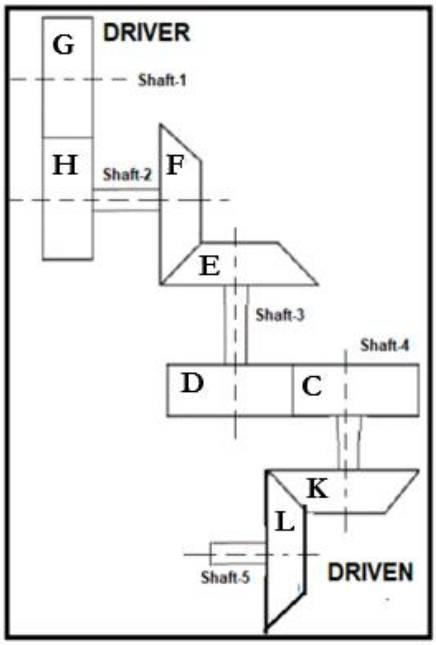
All three conditions written $(\mathbf{0.5\ mark\ each\ for\ 3\ points = 1.5\ mark})$

5 shafts and 8 gears should be used.

Sketching the arrangement with proper representation of bevel gears (1 mark)

Sketching the arrangement with improper representation of bevel gears **(0.5 mark)**

Power transmission- driver and driven shaft axes should be parallel to each other.



$$Velocity\ ratio, \frac{N_L}{N_G} = \frac{T_G}{T_H} \times \frac{T_F}{T_E} \times \frac{T_D}{T_C} \times \frac{T_K}{T_L}$$

$$Velocity\ ratio, \frac{N_H}{N_C} = \frac{30}{75} \times \frac{30}{116} \times \frac{40}{104} \times \frac{20}{68}$$

$$\boldsymbol{Velocity\ ratio} = \mathbf{0.0117}\ (\mathbf{01}\ \boldsymbol{mark})$$

$$\textit{Machine spindle speed} = 1760\ x\ 0.0117$$

$$= 20.59\ rpm\ (\mathbf{0.5}\ \boldsymbol{mark})$$

Q13. A food processing industry operating a boiler, uses 20% wet steam at a temperature of 143.6 °C. The boiler operator has a choice of wheat straw or sugarcane bagasse pellets as fuels for firing the boiler having calorific values of 18 MJ/kg and 16 MJ/kg respectively. The boiler has to be operated at an average efficiency of 85%. Compute and hence compare the fuel requirements for running the boiler with the above two fuels. The steam requirement is 375 kg/hr using the feed water at a temperature of 30°C. (3)

ANSWER:

$p = 4\ bar, T_{sat} = 143.6℃, x = 0.80,\ h_f = 604.7\ \frac{kJ}{kg}, h_{fg} = 2132.9\frac{kJ}{kg}, h_g = 2737.6\frac{kJ}{kg}, Q = 375\frac{kg}{day}, T_1 = 30℃, GCV_{wheat\ straw} = 18000\frac{kJ}{kg}, GCV_{bagasse} = 16000\frac{kJ}{kg}, \eta = 85\%$

Identifying the pressure as 4 bar $-----(\mathbf{0.5}\ \boldsymbol{marks})$

$$h_w = 4.187 \times 30 = 125.61\frac{kJ}{kg} ----- (\mathbf{0.5}\ \boldsymbol{marks})$$

$$h_s = 604.7 + 0.8 \times 2132.9 = 2311.02\ kJ/kg ----- (\mathbf{0.5}\ \boldsymbol{marks})$$

$$85 = \frac{375 \times (2311.02 - 125.61)}{m_{wheat\ straw} \times 18000} \times 100$$

$$m_{wheat\ straw} = 53.56\ kg ----- (\mathbf{0.5}\ \boldsymbol{marks})$$

$$85 = \frac{375 \times (2311.02 - 125.61)}{m_{bagasse} \times 16000} \times 100$$

$$m_{bagasse} = 60.26\ kg ----- (\mathbf{0.5}\ \boldsymbol{marks})$$

For boiler efficiency of 85%, the mass of wheat straw consumed is less than the mass of sugarcane bagasse. Hence, the fuel consumption reduces if wheat straw is used for firing the boiler instead of sugarcane bagasse. $-----(\mathbf{0.5}\ \boldsymbol{marks})$

Q14. Power is transmitted between two shafts which are 2m apart using two pulleys both rotating in counter clockwise direction with a velocity ratio of unity. The length of the belt is 5.885 m, speed of the

belt is 50 m/s and coefficient of friction is 0.3. Determine the size of the two pulleys and power transmitted, if the initial tension in the belt is 500 N. (3)

ANSWER:

Since both the shafts rotate in counter clockwise direction the drive is an open belt drive,X = 2m, L= 5.571m μ=0.3

Since $N_2 / N_1 = D_1 / D_2 = 1$; $r_1 = r_2$
Length of open belt, $L = \Pi (r_1 + r_2) + [(r_1 - r_2)^2 / X] + 2X$

5.885 = Π D + 0 + 2*2; D = 0.6 m or $r_1 = r_2 = 0.3$m (**0. 5 *mark***)
Since $r_1 = r_2$, Angle of lap = 180°

Ratio of Tensions = $T_1 / T_2 = e^{\mu\theta} = e^{0.3x180x\,\pi/180} = 2.57$ (**0. 5 *mark***)
Given, Initial tension, $T_0 = \frac{T_1+T_2}{2} \Longrightarrow 500 = \frac{T_1+T_2}{2}$
$\therefore T_1 + T_2 = 1000\ N$ (**0. 5 *mark***)

T_2 = 280.1 N (**0. 5 *mark***)
and T_1 = 719.8 N (**0. 5 *mark***)
Power Transmitted = 21.985 kW (**0. 5 *mark***)

Q15. In a manufacturing shop floor where a group drive is being used, an arrangement is required which will allow selected machines to be stopped and started at will without disturbing running of the other machines. Suggest a suitable pulley system and explain the working principle of the same with a neat sketch. (3)

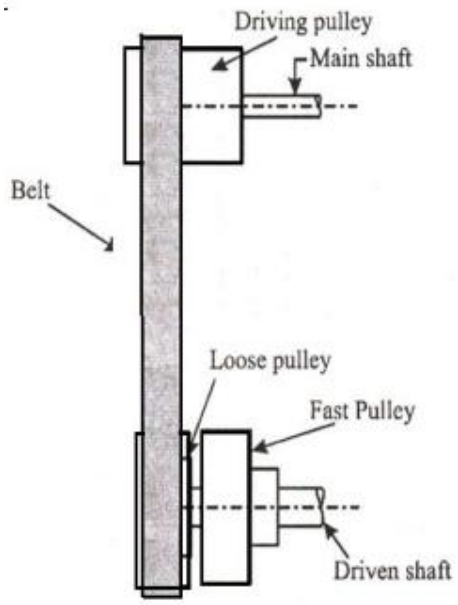
ANSWER:

Idetification of the correct pulley system as Fast and loose pulley(0. **5 *mark***)

Sketch (**1. 5 *mark***)

- Deduct 0.5 mark if the sketch fails to depict a wider driving pulley
- Deduct 0.5 mark if the sketch shows too much gap between the fast and loose pulleys.

Explanation (**1 *mark***)



Q16. Identify the following boiler parts as mounting or accessory and hence state their function.

a) Mud box

b) Steam stop valve

c) Economizer **(3)**

ANSWER:

a) Mud box: It is a boiler mounting (**0. 5 *mark***)

   Stating the function of the mud box (**0. 5 *mark***)

b) Steam stop valve: It is a boiler mounting (**0. 5 *mark***)

   Stating the function of the Steam stop valve (**0. 5 *mark***)

c) Economizer: It is a boiler accessory (**0. 5 *mark***)

   Stating the function of the Economizer (**0. 5 *mark***)

Q17. It is observed that a belt drive transmitting power to a machine tool is not able to achieve the estimated velocity ratio. Identify the possible causes and explain the same. (3)

ANSWER:

Identification of the possible cause as slip (**0. 5 *mark***)
Explanation to slip (**0**1 ***mark***)
Identification of the possible causes as creep (**0. 5 *mark***)
Explanation to creep (**0**1 ***mark***)

Q18. Give Reasons for the following:
a) Fusible plug is placed at a location above the furnace of the Babcock and Wilcox boiler.
b) Super-heated steam cannot be produced in the boiler drum (2)

ANSWER:

a) Fusible plug is a safety device which is used to extinguish the fire in the boiler furnace when the water level in the boiler falls too much below the normal level. The plug has an annulus of fusible metal having low melting point. Normally the plug is covered by water inside the boiler drum which keeps the temperature of the plug below its melting point. As the water level falls below the minimum level the plug is uncovered and the fusible metal melts as it gets exposed to steam space instead of water, which is not able to keep it cool. The plug drops down and the steam present in the boiler drum rushes out into the combustion zone and puts out the fire. Hence, It is fitted on the bottom most portion of the boiler drum just above the furnace. (**0**1 ***mark***)

b) The steam in the boiler drum will always be in contact with the water surface present inside the drum. Hence, the steam remains always wet inside the boiler drum. Thus, superheated steam cannot be generated within the boiler drum. (**0**1 ***mark***)