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Internal Assesment Test - I

Sub: Applied Thermodynamics Code: 15ME43

Date: 14/03/2018 Duration: 90 mins Max Marks: 50 Sem: IV Branch: MECH

Answer Any 2 full Questions

Question No	Questions	Marks	OBE CO	OBE RBT
1) a)	With help of a schematic diagram and **T-S** diagram, explain the working of ideal regenerative cycle and derive an expression for its overall efficiency	[10]	CO2	L4
1) b	In a reheat cycle steam at 550°C expands in an h.p. turbine till it is saturated vapour. It is reheated at constant pressure to 400°C and then expands in a l.p. turbine to 40°C. If the moisture content at turbine exhaust is given to be 14.67%, find (a) the reheat pressure, (b) the pressure of steam at inlet to the h.p. turbine, (c) the net work output per kg, and (d) the cycle efficiency. Assume all processes to be ideal.	[10]	CO2	L3
1) c	What are the Characteristics of an ideal working Fluid in vapour power cycle	[5]	CO2	L1
2) a	With help of a flow diagram, **T-S** diagram and H S diagram explain the working of binary Vapour power cycle and derive an expression for its overall efficiency.	[10]	CO2	L4

2) b	In a reheat steam cycle, the maximum steam temperature is limited to 500°C. The condenser pressure is 0.1 bar and the quality at turbine exhaust is 0.8778. Had there been no reheat, the exhaust quality would have been 0.7592. Assuming ideal processes, determine (a) reheat pressure, (b) the boiler pressure, (c) the cycle efficiency, and (d) the steam rate.	[10]	CO2	L3
2) c	Give the classification of I C Engines.	[5]	CO1	L3
3) a	With P-θ explain combustion in C I Engines.	[8]	CO1	L4
3) b	Explain detonation and what are the factors effecting on detonation	[7]	CO1	L4
3) c	With P-θ explain combustion in S I Engines.	[10]	CO1	L4

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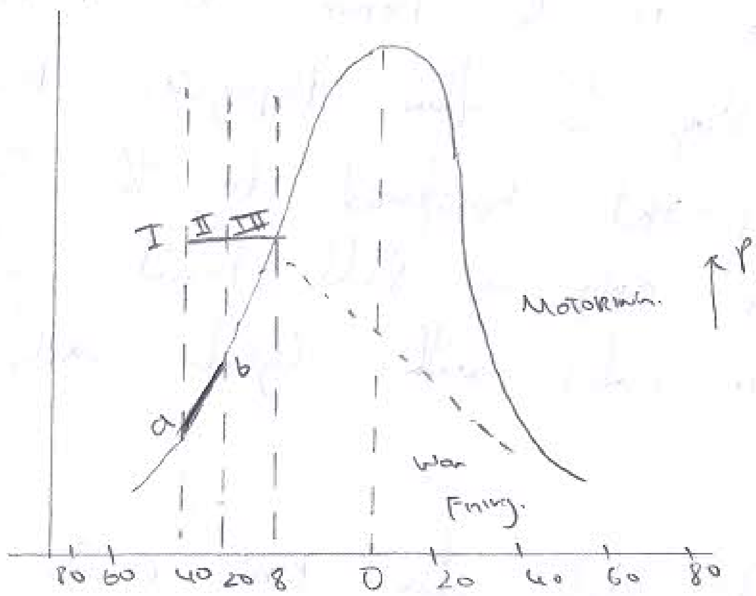
15/03/2018

3)

c) Combustion in SI Engines :



I - Ignition lag.
II - Propagation of Flame.
III - After burning.

Three Stages of Combustion are :

1) Ignition lag.

In the P-θ Diagram line A-B is referred to as the Ignition lag in which growth and Development of Self Propagation will take place. This is a Chemical

Process Depending on both temperature and Pressure. the Nature of fuel and Propagation of Exhaust Residual gases. Also Depends on the Relationship b/w temperature and Rate of Reaction.

2) Propagation of flame:-

Its a Process concerned with the Distribution of flame through out the Combustion Chamber at the starting Point of the Stage 2 One can see a measurable Rise in the Pressure at Point 'b'. During this Stage the flame Propagates Practically at a Constant Velocity. Heat transferred to the Cylinder wall is low because only a small Amount of burning mixture comes in contact with Cylinder wall.

3) After burning:

This State starts from Point c. The flame Velocity This State - Rate of Reaction becomes Decreases During this State. Rate of Reaction becomes low Due to lower flame Velocity and Reduced flame front Surface. Since the expansion Stroke Starts before the start of Combustion the Piston Moves Away from TDC

6) Detonation is Due to the Auto Ignition of the Portion of the Unburnt Charge in the Combustion Chamber. As the Normal flame front Proceeds Across the Chamber the Pressure and temp of the Unburnt

Charge increase due to the Compression by the burned Portion of the Charge. The Unburnt compressed Charge may Auto Ignite under Certain temperature conditions and Release the Energy at a Very Rapid rate Compared to Normal Combustion Process.

Factors affecting knocking:-

1) Compression ratio:-

The Pressure and temperature at the end of Compression increases with increase in Compression ratio

2) Ignition:-

a) Location of a Spark Plug:-

The Spark Plug should be located so as to reduce the length of flame travel to minimum.

b) Spark timing

The temp of Charge Increases by increasing the Spark Advance which increases the rate of burning.

c) Engine Speed:-

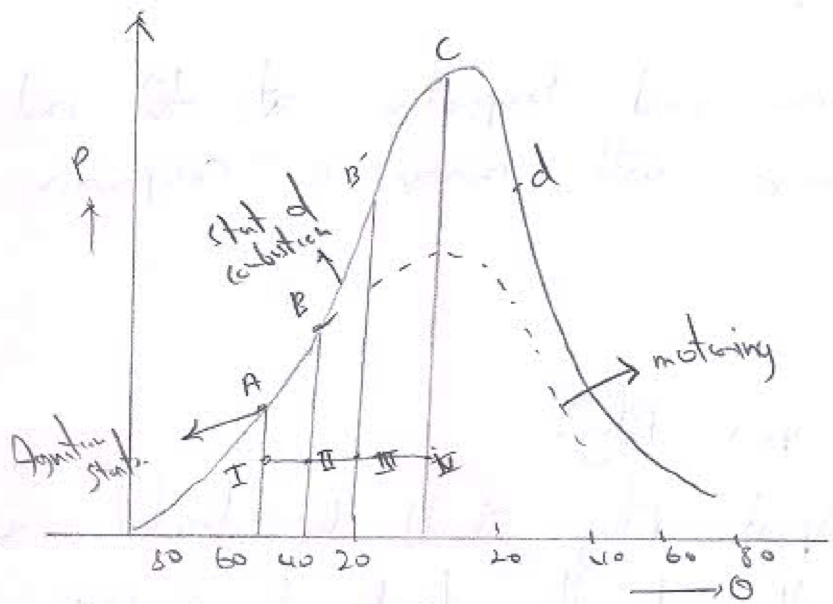
The Compression of Charge takes place rapidly in high Speed Engine and reduces the Delay Period.

3) Fuel Characteristics :-

a) Increasing the Carbon Chain increases the knocking Tendency

b) Fuels with higher Self Ignition temperatures are less Detonating.

a) Ci Engines.



I - Ignition Delay

II - Uncontrolled Combustion

III - Controlled Combustion

IV - After burning

1) Ignition Delay :-

The Delay Period is counted from the Start of injection to the Point of when P-θ Curve separates from motoring Curve. Two kind of Delays :-

Physical Delay :-

It's the time b/w the beginning of injection and to Attainment of Chemical reaction. In Physical Delay fuel is Vapourised, mixed with Air and Rise in temperature.

2) Chemical Delay

In Chemical Delay Period Reaction Starts Slowly and then the ignition takes place Randomly in the Cylinder

3) Uncontrolled Combustion :-

This Period is counted from the end of the Delay Period to the Point of maximum Pressure on P-θ.

In this Stage the Rise of Pressure is Rapid because During the Delay Period the Droplets of fuel have some time to Spread themselves over a wide Area.

4) Controlled Combustion :-

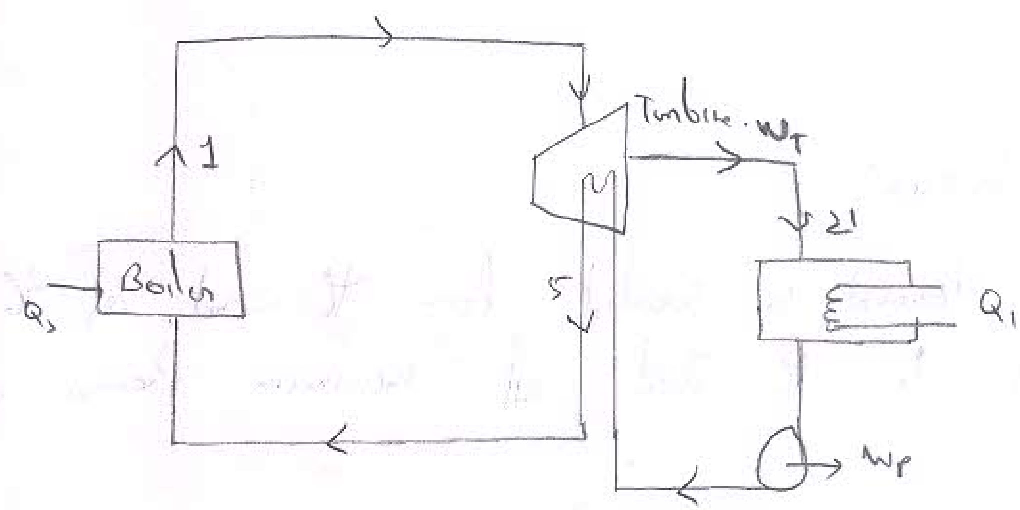
At the end of the Second Stage of Combustion the temp and Pressure are high that the fuel droplets injected in the third Stage burn almost as they enter and any further Pressure Rise Can be Controlled. by mechanical means.

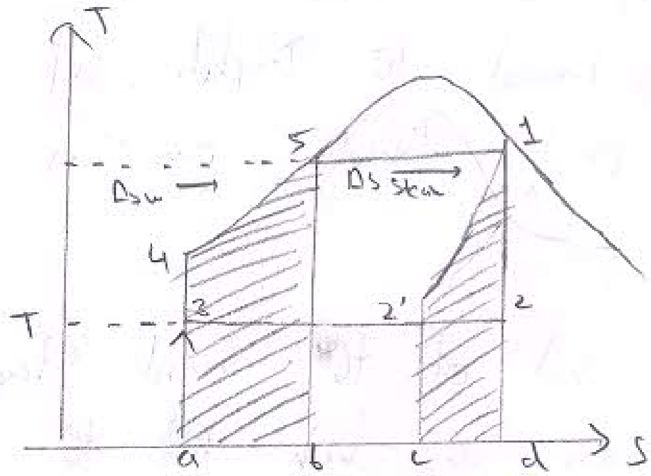
5) After burning :-

The Combustion Continues even after the injection is Over because of Poor Distribution of fuel Particles. This may go upto 70°-80° of Crank travel from TDC. This is called as the After burning.

7)

a) Ideal Regenerative Cycle :-





The unique feature of this Cycle is that the Condensate After leaving the Pump Circulates around the turbine Casing opposite to the Direction of flow.

Consider the Processes:

In the Process 1-2' it Shows the Reversible heat Rejection

Then the Slopes of lines 1-2' and 5-3 will be identical at Every temp lines will be Identical in contour. Area 4-5-6-a-4 and 2'-1-d-c-2' are not only equal but Also Congruous.

Therefore the heat Added from External Source Q_s is at the Constant temperature T_1 and heat rejected at t_2 being reversible.

$$Q_s = H_1 - H_5 = T_1 (S_1 - S_5)$$

$$Q_R = H_2' - H_3 = T_2 (S_2' - S_3)$$

$$\therefore \eta = \frac{Q_n}{Q_s} = 1 - \frac{t_2 (s_2' - s_3)}{t_1 (s_1 - s_5)}$$

$$1 - \frac{T_2}{T_1} = \eta$$

$\therefore$ the ideal regenerative Cycle efficiency = Carnot Cycle efficiency.

$$H_1 + H_4 = W_T + H_2' + H_5$$

$$W_T = (H_1 - H_2') - (H_5 - H_4).$$

$$W_P = H_4 - H_3$$

b) Given.

At 40°C

$P_4 = 0.0737$ (Steam table)

$P_4 = 0.0737$ is $x_4 = 0.85$ (Molier Chart)

$H_4 = 2220$ kJ/kg.

$H_3 = 3250$ kJ/kg. $P_2 = 20$ bar

$H_2 = 2800$ kJ/kg $P_1 = 150$ bar.

$H_1 = 3310$ kJ/kg

i) Re heat Pressure

$P_2 = 20$ bar from molier diagram.

ii) Pressure of Steam to the inlet of HP Turbine.

$P_1 = 150$ bar.

iii) Net Work Output Per kg.

$W_T = (h_1 - h_2) + (h_3 - h_4)$

$(3310 - 2800) + (3250 - 2220)$

$W_T = 1540$ kJ/kg.

$Q_s = (h_1 - h_6) + (h_3 - h_2)$

$Q_s = 3577.91$ kJ/kg.

Pump Work Supplied.

$W_p = (P_1 - P_3) v_3$

hf at 40°C using Steam table

$h_f = 167.5 \, kJ/kg$

$v_f = 0.1010078$

$W_p = 150 - 0.07375 \times 100.0010078$

$= 15.109 \, kJ/kg$.

iv) Cycle efficiency

$$\eta = \frac{W_T - W_p}{Q_s} = \frac{1540 - 15.109}{3577.91}$$

$= 0.4262$

$\therefore 42.62\%$

c) Characteristics are :-

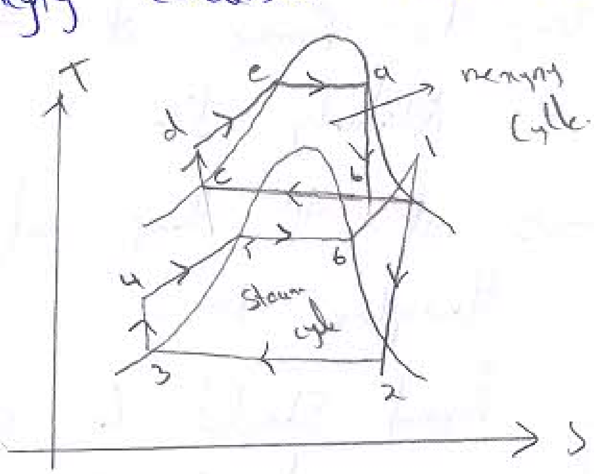
a) The fluid should have a high critical temp so that the saturation ~~temperature~~ pressure at the maximum permissible temp is relatively low.

b) The saturation pressure at the temp of heat rejection should be above atmosphere pressure

c) Specific heat of liquid should be small so that little heat transfer is required to raise the liquid to the boiling Point

d) Saturated line of the T-s Diagram Should be Steep very Close for the turbine expansion process so that excessive moisture Does not Appear During Expansion.

2)
a) The mercury Cycle is a Rankine type of Cycle which uses Saturated Vapour. Heat is supplied to the Mercury in boiler which is represented by the Process d-a. The Mercury expands in the turbine a-b. and then Condenses in (b-c). The feed pump pumps back the mercury to the boiler Process (c-d). Mercury Cycle is Completed. Saturated Vapour is heated from the hot gases of the furnace in Superheated (6-1 process). Superheated Steam Expands in the turbine (1-2) and condensed in Process (2-3). Condensated then pumped (3-4) heated till to a saturated liquid in Process (4-5) before going to mercury condenser where the latent heat is Absorbed.



Ovall efficiency.

for mercury Cycle :-

$$\eta_m = 1 - \frac{Q_2}{Q_1} = \frac{\text{Work Done}}{Q_{s_1}} \longrightarrow (1)$$

$$W_{T\,mercury} = H_a - H_b \text{ and } Q_1 = H_a - H_d.$$

for Steam Cycle :-

$$\eta_{st} = 1 - \frac{Q_3}{Q_1} = \frac{W_{T\,steam}}{Q_{s_1}} \longrightarrow (2)$$

$$W_{T\,steam} = H_1 - H_2$$

$$Q_2 = H_1 - H_4.$$

$\therefore$ Ovall efficiency

$$1 - \frac{Q_2 (1 - \eta_{st})}{Q_1}$$

$$= 1 - (1 - \eta_m)(1 - \eta_{st})$$

$$\eta = \eta_m + \eta_{st} - \eta_m \eta_{st}.$$

c) Classification of IC engines :-

1) According to Cycle of operation:-

a) otto Cycle

b) Diesel Cycle

c) Dual Combustion Cycle.

II According to No of Strokes.

a) Two Stroke Engine

b) Four Stroke engine.

III According to the Cylinder Arrangement.

a) Horizontal engine

b) Vertical engine

c) V-Type engine.

d) Radial engine.

e) Inline engine.

iv) According to Uses:-

a) Stationary engine

b) Portable engine

c) Marine engine

d) Aero engine.

v) According to fuel used

a) Petrol engine

b) Diesel engine

c) Gas engine

d) Bi fuel engine.