Dr. Laximikant Yadav 5/5/2023

Roll No: 02

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NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR (HP)

DEPARTMENT OF MECHANICAL ENGINEERING

END TERM EXAMINATION MAY 2023

Thermal Power Engineering-II (ME-323)

Time: 3:00 hrs **M.M.**: 50

Note: Attempt all the questions. Make necessary assumptions wherever required.

Q 1 (a) Under what condition efficiency of an ideal regenerative gas turbine cycle equals the efficiency of an ideal simple gas turbine cycle? Justify your answer with proper reasoning. 2

(b) What are the basic requirements of compressor for aircraft applications? Do axial flow compressor meet them? Explain. 2

(c) From the point of view of actual cycle analysis how does fuel-air ratio affect the efficiency and maximum power. 2

(d) Plot the conversion efficiency of three-way catalytic convertors as a function of equivalence ratio. 2

Q 2 (a) Describe the technical features of MPFI and GDI engine. 3

(b) A four-stroke, four cylinder diesel engine running at 2000 rpm develops 60 kW. Break thermal efficiency is 30% and calorific value of fuel is 42 MJ/kg. Engine has a bore of 120 mm and stroke of 100 mm. Take $\rho_a = 1.15\ kg/m^3\ and$ air fuel ratio is 15. Calculate the air consumption (m^3/s) and volumetric efficiency. 3

(c) Explain the phenomenon of pre-ignition. How pre-ignition leads to detonation and *vice versa*? 3

Q 3 (a) Describe the Morse test as applied to multi-cylinder compression-iginition engine and explain how the results of this test may be used to find the mechanical efficiency. 4

(b) Briefly explain the working of battery-ignition system with the help of a circuit diagram. 4

Q 4 Explain the phenomenon of knock in CI engines and compare it with SI Engine knock. 5

Q 5 Explain the important observations obtained from the specific work output of simple gas turbine cycle as a function of pressure ratio using T-s diagram, and proof that net maximum specific work output, $(W_{net})_{max} = c_p\left(\sqrt{T_{max}} - \sqrt{T_{min}}\right)^2$ 6

Q 6 (a) A spark-ignition engine running at 1500 rpm has a 10 cm bore with the spark plug offset by 8 mm from the centre. The spark plug is fired at 18° bTDC. It takes 5° of engine rotation for combustion to develop and get into flame propagation mode, where the average flame speed is 20 m/s. Calculate time for flame front to reach the farthest cylinder wall and crank angle position at the end of combustion. 6

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(b) Now the engine speed is increased to 3000 rpm. The flame termination crank angle position remains the same as in part (a), flame development takes 75% of real time in comparison to part (a) and flame speed is related to engine speed by the relation $v_f \propto N^{0.85}$. Calculate flame speed at 3000 rpm, crank angle position when flame propagation starts and crank angle position when the spark plug should be fired.

Q 7 (a) Under take-off conditions (static conditions) when the ambient pressure and temperature are 1.01 bar and 288 K, the stagnation pressure and temperature at the inlet of jet pipe (nozzle) of the turbojet engine are 2.4 bar and 1000 K, and the mass flow rate is 23 kg/s. Assuming that the expansion in the converging propelling nozzle is isentropic and nozzle efficiency to be 100%. Calculate the exit area and thrust produced. 8

(b) For a new version of the engine the thrust is to be increased by the addition of an aft fan which provides a separate cold exhaust stream. The fan has a bypass ratio of 2 and a total pressure ratio of 1.75, the isentropic efficiency of the fan and fan turbine sections being 0.88 and 0.90 respectively. Calculate the thrust at sea level under static condition, assuming that expansion in the cold nozzle is also isentropic and 100% efficient, and that the hot nozzle area is adjusted so that the hot mass flow remains at 23 kg/s. Take $\gamma_{air} = 1.4, \gamma_{hot\ gas} = 1.33$