Code No: R1631035 **R16** SET - 1

**III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019**

# THERMAL ENGINEERING – II

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. **Use of Steam Tables and Mollier Chart is allowed.**

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## PART –A (14 Marks)

1. a) Draw diagram of 'regeneration cycle' and state the advantages and disadvantages of regeneration. [2M]
   b) Differentiate Fire tube boilers and Water tube boilers. [2M]
   c) What is super-saturation in steam nozzles? Draw the relevant enthalpy-entropy diagram. [2M]
   d) Classify Condensers. Write any three requirements of condensing plant. [3M]
   e) What Mention the various thrust augmentation techniques used in turbo-jet engine. [3M]
   f) Write working principle of turbo prop engine with a sketch. [2M]

## PART –B (56 Marks)

2. a) Draw the different processes of Basic Rankine cycle on a T-S diagram mentioning the different process operations. Also explain Modified Rankine cycle. [7M]
   b) A sample of fuel has the following percentage composition by mass. Carbon – 86%; Hydrogen – 8%; Sulphur – 3%; Oxygen – 2%; Ash – 1%. For an Air-fuel ration of 1:12, calculate: i) Mixture strength as a percentage ii) volumetric analysis of dry products of combustion. [7M]

3. a) Explain the working of a Lancashire boiler with neat sketch. [7M]
   b) Calculate the mass of flue gases flowing through the chimney when the draught is produced is equal to 1.9 cm of water. Temperature of flue gases is $290^0$ C and ambient temperature is $20^0$ C. The flue gases formed per kg of fuel burnt are 23 kg. Neglect the losses and take the diameter of chimney as 1.8 m. [7M]

4. a) Steam initially dry and saturated is expanded in a nozzle from 15 bar at $300^0$ C to 1.0 bar. If the frictional loss in the nozzle is 12 % of the total heat drop. Calculate the mass of steam discharged when exit diameter of the nozzle is 15 mm. [7M]
   b) What do you mean by compounding of steam turbine? Discuss various methods of compounding steam turbines. [7M]

5. a) Define the term ''degree of reaction'' used in reaction turbines and prove that it is given by $R_d = C_f/2C_{bl}(\cot \phi - \cot \Theta)$ when $C_{f1} = C_{f0} = C_f$. [7M]
   b) A surface condenser is required to deal with 20000 kg of steam per hour, and the air leakage is estimated at 0.3 kp per 1000 kg of steam. The steam enters the condenser dry saturated at $38^0$ C. The condensate is extracted at a temperature of $36^0$ C. The condensate loss is made up with water at $7^0$ C. It is required to find the saving in condensate and the saving in heat supplied in the boiler, by fitting a separate air extraction pump which draws air over an air cooler. Assume that air leaves the cooler at $27^0$ C. The pressure in the condenser can be assumed to remain constant. [7M]
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6. a) Explain: i) Brief about the open cycle and closed cycle turbines with block diagram sketches and also draw P-V and T-S diagrams. [4M]
   ii) What are the disadvantages of closed cycle gas turbine over open cycle gas turbine? [3M]
   b) In an open constant pressure gas turbine, air enters the compressor at 1.02 bar and $27^0$ C. The pressure of air after the compression is 4.08 bar. The isentropic efficiencies of compression and turbines are 80% and 85% respectively. The A:F ratio used is 80:1. Find the I.P and thermal efficiency of the cycle if the flow rate of air is 2.5 kg/sec. Take Cp = 1 kJ/kg-K and $\gamma$ = 1.4 for air and gases. C.V. of fuel used = 41720 kJ/kg. [7M]

7. a) i) Explain the working difference between turbo jet and turbo-prop. [7M]
   ii) State the differences between jet propulsion and rocket propulsion.
   b) The following data pertain to a turbo jet flying at an altitude of 9500 m: [7M]
   Speed of the turbo jet = 800 km/hr
   Propulsive efficiency = 55%
   Overall efficiency of turbine plant = 17%
   Density of air at 9500 altitude = 0.17 kg/$m^3$
   Drag on the plane = 6100 N
   Assuming calorific value of fuels used as 46000 kJ/kg,
   Calculate:
   i) Absolute velocity of the jet.
   ii) Volume of air compressed per min.
   iii) Diameter of the jet.
   iv) Power output of the unit.
   v) Air fuel ratio.

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Code No: R1631035 **R16** SET - 2

**III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019**

# THERMAL ENGINEERING – II

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

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4. **Use of Steam Tables and Mollier Chart is allowed.**

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## PART –A (14 Marks)

1. a) Write short note on adiabatic flame temperature. [2M]
   b) Classify of Boilers on any four accounts with example for each. [2M]
   c) Differentiate the following as related to steam turbines: [2M]
   i) Diagram efficiency ii) stage efficiency.
   d) What do you mean by vacuum efficiency and condenser efficiency? [3M]
   e) Sketch the Brayton cycle with a schematic diagram p-v and T-s diagrams. [3M]
   f) Write working principle turbo prop engine with a sketch. [2M]

## PART –B (56 Marks)

2. a) Explain the regeneration cycle and reheat cycle with the help of neat sketches of layout, P-V and T-S plots. [7M]
   b) A simple Rankine cycle works between pressures 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption. [7M]

3. a) Explain the working of any one High Pressure(HP) boiler with the help of a neat sketch. List the advantages of high pressure boilers. [7M]
   b) The following data were taken during the test on a boiler for a period of one hour: Steam generated = 5000kg; coal burnt = 700kg, calorific value of coal=31402kJ/kg, quality of steam = 0.92. If the boiler pressure is 1.2 MPa and the feed water temperature is $45^0$ C, find the boiler equivalent evaporation and the efficiency. [7M]

4. a) (i) Define the term 'steam nozzle'. Explain various types of nozzles. [3M]
   (ii) Steam having pressure of 10.5 bar and 0.95 dryness is expanded through a convergent – divergent nozzle and the pressure of steam leaving the nozzle is 0.85 bar. Find the velocity at the throat for maximum discharge conditions. Index of expansion may be assumed as 1.135. Calculate mass rate of flow of steam through the nozzle. [4M]
   b) A single stage steam turbine is supplied with steam at 5 bar, $200^0$ C at the rate of 50 kg/min. It expands into a condenser at a pressure of 0.2 bar. The blade speed is 400 m/s. The nozzles are inclined at an angle of $20^0$ C to the plane of wheel and the outlet blade angle is $30^0$ C. Neglecting friction losses determine the power developed, blade efficiency and stage efficiency. [7M]

5. a) The following data relate to a stage of a reaction turbine: [7M]
   Mean rotor diameter = 1.5 m; speed ratio = 0.72; blade outlet angle =$20^0$ ; rotor speed = 3000 r.p.m. Determine:
   i) the diagram efficiency.
   ii) the percentage increase in the diagram efficiency and rotor speed if the rotor is designed to run at the best theoretical speed, the exit angle being $20^0$.



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b) What are the components of a steam condensing plant? Write the function of each component. Discuss in brief the requirements of a good surface condenser. [7M]

6. a) What are the different types of combustion chambers in gas turbine engines? Explain them in detail with relevant sketches. [7M]

b) The pressure ratio of an open cycle constant pressure gas turbine plant is 6. The temperature range of plant is $15^0$ C and $800^0$ C. Using the following data: [7M]

$C_{pa}$ = 1kJ/kg-K
$C_{pg}$ = 1.075kJ/kg –K
$\gamma$=1.4 for air and gases , C.V. of fuel = 43000 kJ/kg
$\eta_c$= 0.85
$\eta_t$ = 0.90, $\eta_{com}$(combustion) = 0.95

Find:
i) The thermal efficiency of the plant
ii) I.P. of the plant if the circulation of the air is 5kg/sec.
iii) A:F ratio, and
iv) Specific fuel combustion.

Neglect the losses in the system.

7. a) Explain the requirements of an ideal rocket propellant. Write the expressions for thrust work, propulsive work and propulsive efficiency of rocket engines. [7M]

b) The following data pertain to a jet engine flying at an altitude of 9000 meters with speed of 215 m/s. [7M]

Thrust power developed = 750kW, Inlet pressure & temperature = 0.32 bar, $-42^0$C
Temperature of gases leaving the combustion chamber = $690^0$C
Pressure ratio = 5.2, Calorific value of fuel = 42500kJ/kg
Velocity in ducts (constants) =195m/s, Internal efficiency of turbine = 86%
Efficiency of compressor = 86%, Efficiency of jet tube = 90%
For air: $c_p$ = 1.005, $\gamma$=1.4 ,R= 0.287, For combustion gases, $c_p$ = 1.087
For gases during expansion, $\gamma$ = 1.33.
Calculate the following:
i) Overall thermal efficiency of unit.
ii) Rate of air consumption.
iii) Power developed by turbine.
iv) The outlet area of jet tube.
v) Specific fuel consumption is kg per kg of thrust.

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Code No: R1631035 **R16** SET - 3

**III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019**

# THERMAL ENGINEERING – II

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

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2. Answer **ALL** the question in **Part-A**
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4. **Use of Steam Tables and Mollier Chart is allowed.**

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## PART –A (14 Marks)

1. a) What is reheating? What the advantages of reheat Rankine cycle? [2M]
   b) Define the equivalent evaporation and boiler efficiency. [2M]
   c) Write the expression for maximum mass flow per unit area of flow through a convergent- divergent nozzle. [2M]
   d) Write short notes on Parsons reaction Turbine highlighting its features. [3M]
   e) Brief the merits and demerits of gas turbines. [3M]
   f) Mention the advantages of bipropellants used in rocket engines over monopropellants. [2M]

## PART –B (56 Marks)

2. a) What are the different thermodynamic variables affecting efficiency and output of Rankine cycle? Explain their influence on Rankine cycle. [7M]
   b) i) What are Primary and Secondary fuels? Explain with examples. [3M]
   ii) How is the analysis of exhaust and flue gases carried out? Explain the relevant apparatus used with a neat sketch. [4M]

3. a) Explain the following boiler mountings and accessories with neat sketches: [7M]
   i) Water level Indicator; ii) Feed Check valve; iii) Air pre heater; iv) Steam separator.
   b) Derive an expression for maximum discharge rate of gases through the chimney for a given height of the chimney. [7M]

4. a) Define critical pressure ratio for the nozzle of the steam turbine. Obtain analytically its value in terms of index of expansion. [7M]
   b) Write the differences between an impulse turbine and a reaction turbine. Derive the expression for maximum blade efficiency in a single stage impulse turbine. [7M]

5. a) A stage of turbine with Parsons blading delivers dry saturated steam at 2.7 bar from the fixed blades at 90 m/s. The mean blade height is 40 mm, the moving angle blade is $20^0$. The axial velocity of the blade is ¾ of the blade velocity at mean radius. Steam is supplied to the stage at the rate of 9000 kg/h. The effect of the blade tip thickness on the annulus area can be neglected. Calculate : [7M]
   i) the wheel speed in r.p.m; ii)the diagram power; iii) the diagram efficiency;
   iv) the enthalpy drop of steam at this stage.



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b) A steam condenser is equipped in a steam power plant which handles 15000 kg/hr of steam and develops 2.5 MW power. The initial condition of steam entering to turbine is 27 bar and $300^0$ C. The exhaust from the turbine is condensed in the condenser and the vacuum maintained is 72 cm of Hg while the barometer reading is 76 cm of Hg. The temperature of the circulating water is increased from $20^0$ C to $28^0$ C while the condensate is removed at a temperature of $27^0$ C. Work out the following: [7M]
(i) Dryness fraction of steam entering the condenser
(ii) Mass rate of circulating water and cooling ratio.

6. a) How are gas turbines classified? Discuss briefly the methods employed for improvement of thermal efficiency of open cycle gas turbine plant. [7M]
b) The pressure ratio of an open cycle gas turbine power plant is 5.6. Air is taken at $30^0$ C and 1 bar. The compression is carried out in two stages with perfect inter cooling in between. The maximum temperature of cycle is limited to $700^0$ C. Assuming the isentropic efficiency of each compressor stage as 85% and that of turbine is 90%; determine the power developed and efficiency of the power plant, if the air flow is 1.2 kg/s. The mass of fuel may be neglected, and it may be assumed that $C_p$= 1.02kJ/kg K and $\gamma$ = 1.41. [7M]

7. a) What is Thrust Augmentation in Jet propulsion? Explain different methods with neat sketches. [7M]
b) Define Specific Impulse of a rocket. Explain Solid and Liquid propellant rockets with sketches. [7M]

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Code No: R1631035 **R16** SET - 4

**III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019**

# THERMAL ENGINEERING – II

(Mechanical Engineering)

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## PART –A (14 Marks)

1. a) What is Stoichiometric air? Write expression for Stoichiometric Air quantity. [2M]
   b) Write the merits and de-merits of Babcock and Wilcox boiler. [2M]
   c) Distinguish various types of nozzles mentioning their features. [2M]
   d) Write the expression for blade efficiency for a single stage reaction turbine forgetting the maximum blade efficiency. [3M]
   e) What are the different types of combustion chambers in gas turbine engines? Draw sketches. [3M]
   f) Write about classification of rockets. [2M]

## PART –B (56 Marks)

2. a) Steam at a pressure of 15 bar and $250^0$ C is expanded through a turbine at first to a pressure of 4 bar. It is then reheated to a constant pressure to the initial temperature of $250^0$ C and is finally expanded to 0.1 bar. Using Mollier chart, estimate the work done per kg of steam flowing through the turbine and amount of heat supplied during the process of reheat. Compare the work output when the expansion is direct from 15 bars to 0.1 bar without any reheat. Assume all expansion processes to be isentropic. [7M]

   b) Orstat analysis of the products of combustion of a hydrocarbon fuel of unknown composition is as follows: [7M]
   Carbon dioxide ($CO_2$) = 8%
   Carbon monoxide (CO) = 0.5%
   Oxygen ($O_2$) = 6.3%
   Nitrogen ($N_2$) = 85.2%
   Determine the following:
   i) Air fuel ratio;
   ii) Percent theoretical air required for combustion.

3. a) In a boiler test 1250 kg of coal are consumed in 24 hours. The mass of water evaporated is 13000kg and the mean effective pressure is 7 bar. The feed water temperature was $40^0$ C and heating value of coal is 30000 kJ/kg. The enthalpy of 1kg of steam at 7 bar is 2570.7 kJ. Determine: [7M]
   i) Equivalent evaporation per kg of coal; ii) Efficiency of the boiler.

   b) i) Define the chimney efficiency and find out the expression for the same. [3M]
   ii) Calculate the height of the chimney required to produce a draught equivalent to 1.7 cm of water if the flue gas temperature is $270^0$ C, ambient temperature is $22^0$ C and minimum amount of air per kg of fuel is 17 kg. [4M]
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4. a) i) What do you mean by super saturated flow? Explain with the help of h-s diagram. [3M]
   ii) Air enters a convergent nozzle from a reservoir at 2200 kPa and $100^0$ C. If the exit area is 3.25 $cm^2$, what is the maximum mass flow rate that this nozzle can handle? [4M]
   Assume this process to be isentropic and that the air behaves as an ideal gas.
   b) In a De-Laval turbine steam issues from the nozzle velocity of 1200 m/s. The nozzle angle is $20^0$ C, the mean blade velocity is 400 m/s, and the inlet and the outlet angles of the blades are equal. The mass of steam flowing through the turbine per hour is 1000 kg. Calculate: [7M]
   i) Blade angles. ii) Relative velocity of steam entering the blades. iii) Tangential force on the blades. iv) Power developed. v) Blade efficiency.
   Take blade velocity co- efficient as 0.8.

5. a) In a 50% reaction turbine, the speed of rotation of a blade group is 3000 r.p.m with mean blade velocity of 120 m/s. The velocity ratio is 0.8 and the exit angle of the blade is $20^0$. If the mean blade height is 30 mm, calculate the total steam flow rate through the turbine. Neglect the effect of the blade edge thickness of the annular area but consider 10% of the total steam flow rate as the tip leakage loss. The mean condition of the steam in a blade group is found to be 2.7 bar and 0.95 dry. [7M]
   b) Classify steam condensers. What are the differences between the jet Condensers and surface condensers? Explain. [7M]

6. a) i) Draw the schematic diagram of closed cycle gas turbine and explain its working. [3M]
   ii) Explain the processes of the cycle with a schematic diagram P-V and T-S diagrams. Write the expression for the air standard efficiency of Gas turbine cycle in terms of the pressure ratio. [4M]
   b) A simple gas turbine cycle works with a pressure ratio of 6. The compressor and turbine inlet temperatures are 200 K and 600 K respectively. If the volume flow rate of air is 150 $m^3/s$, compute the power output and thermal efficiency. [7M]

7. a) A turbojet engine inducts 45 kg of air per second and propels an aircraft with a uniform speed of 880 km/hr. The isentropic enthalpy change for nozzle is 188.37 kJ/kg and its velocity co-efficient is 0.96. The fuel air ratio is 0.012, the combustion efficiency is 0.95 and the lower heating value of fuel o is 44000 kJ/kg. Calculate: [7M]
   i) The thermal efficiency of the engine. ii) The fuel flow rate in kg/h and TSFC.
   iii) The propulsion power in kW. iv) The thrust power.
   v) The propulsive efficiency. vi) The overall efficiency.
   b) Explain the working of the following with sketches and mention merits and demerits: [7M]
   i) Turbo prop engine. ii) Pulse jet engine.

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## PART –A (14 Marks)

1. a) Compare and contrast the gaseous and liquid fuels. [2M]
   b) Explain significance of boiler mountings and accessories. [2M]
   c) Define nozzle velocity coefficient and how it is related to nozzle efficiency? [2M]
   d) Draw velocity triangle for 50% reaction steam turbine. [3M]
   e) Draw the line diagram of gas turbine plant with regeneration, inter cooling and reheating system. [3M]
   f) Explain thrust power and propulsion efficiency of jet propulsion. [2M]

## PART –B (56 Marks)

2. a) Explain the significance of adiabatic flame temperature. [6M]
   b) Percentage composition of sample of liquid fuel by weight is, C=88.8% and $H_2$=15.2%, Calculate: i) the weight of air needed for combustion of 1kg of fuel, ii) the volumetric composition of product of combustion if 15% excess air supplied. [8M]

3. a) Draw the line diagram and explain the working principle of economizer and discuss the precautions to be made in usage. [7M]
   b) Calculate the height of a chimney required to produce a draught equivalent to 1.6 cm of water if the flue gas temperature is $250^0$ C and ambient temperature is $27^0$ C and minimum amount of air per kg of fuel is 20 kg. [7M]

4. a) Derive the equation for critical pressure ratio in nozzles. [6M]
   b) A simple impulse turbine has one ring of moving blades running at 120 m/s, absolute velocity of steam at exit is 75 m/s at an angle $80^0$ with the tangent of wheel, friction coefficient is 0.85, rate of steam flowing 2.5 Kg/s. Assuming the moving blades to be a symmetrical, find the i) Blade angles, ii) Nozzle angle, iii) absolute velocity of steam at entrance, and iv) power developed. [8M]

5. a) Sketch and describe the operation of central flow surface condenser. [7M]
   b) Explain the working of single stage reaction turbine. Sketch the pressure and velocity variations along the axis of the turbine. [7M]

6. a) In a gas turbine power plant, operating on Joule's cycle, air is compressed from 1.5 bar and $25^0$ C through a pressure ratio of 7. It is then heated to $697^0$ C in the combustion chamber and expanded back to 1 bar. Calculate the net work done, cycle efficiency and work ratio. Isentropic efficiency of turbine is 90% and of compressor is 85%. [7M]
   b) Draw the line diagram and explain the working of Reheat gas turbine cycle. [7M]

7. a) Showing the basic components, explain the working of turbojet engine. [7M]
   b) Explain the principle and working of liquid propellant rocket engine with neat sketch. [7M]

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## PART –A (14 Marks)

1. a) List out the methods to improve the efficiency of Rankine cycle. [2M]
   b) Write the differences between the boiler mountings and accessories. [2M]
   c) State the condition for maximum discharge through the nozzle. [2M]
   d) Define degree of reaction of a reaction turbine. [3M]
   e) Enumerate the requirements of a good combustion chamber for a gas turbine. [3M]
   f) Write the importance of specific impulse in rocket performance. [2M]

## PART –B (56 Marks)

2. a) Explain the Regenerative Rankine cycle. Write the advantages of regenerative Rankine cycle over Simple Rankine cycle. [6M]
   b) Compare the Rankine efficiency of a high pressure plant operating from 80 bar and $400^0$C and a low pressure plant operating from 40 bar and $400^0$C, if the condenser pressure in both cases is 0.07 bar. [8M]

3. a) Derive the expression for draught in mm of column of water when the discharge is maximum? [7M]
   b) Why the blow-off cock is operated periodically when the boiler is working? Explain its working with a neat sketch. [7M]

4. a) What are the different methods of compounding of steam turbine stages? Explain any one method. [6M]
   b) Dry saturated steam at 10 bar is expanded in a nozzle to 0.4 bar. The throat area is 7 cm and the inlet velocity is negligible. Estimate the mass flow and the exit area. Assume isentropic flow and take the index n=1.135 for dry saturated steam. [8M]

5. a) What are the effects of air leakage on the performance of a condenser? Explain. [6M]
   b) Show that for the maximum diagram efficiency of a reaction turbine, the blade steam speed ratio is equal to cos α, where α is the angle of absolute velocity at inlet. State the assumption made. [8M]

6. a) What are the methods in use for the improvement of thermal efficiency of an open cycle gas turbine plant? Describe them. [6M]
   b) In a simple gas turbine plant, air enters at 1 bar and $20^0$C and compressed with isentropic efficiency of 80% to 4 bar. Then it is heated in combustion chamber with A:F ratio= 90:1. The calorific value of a fuel used is 41.8 MJ/kg. If air flow is 3kg/sec, find the power developed and thermal efficiency by the plant. Take $C_p$=1kJ/kg $^0$C and $\Upsilon$=1.4 for air as well as gas. [8M]

7. a) Explain the solid propellant rocket with a neat sketch and write its applications. [7M]
   b) Derive expressions for the thrust and propulsion efficiency of rockets and compare with those of turbojet. [7M]

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Code No: R1631035 **R16** SET - 2

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(Mechanical Engineering)

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## PART –A (14 Marks)

1. a) Name any four fuels and write their calorific values. [2M]
   b) What are the differences between external fired and internal fired boilers? [2M]
   c) Write the equation for blade efficiency (or) diagram efficiency of impulse turbine. [2M]
   d) Explain velocity diagram of Parsons reaction turbine with all notations. [3M]
   e) What are the different types of combustion chambers in gas turbines? [2M]
   f) Explain liquid propellant rocket engine. [3M]

## PART –B (56 Marks)

2. a) Steam at 30 bar and $200^0$C is passed through a turbine. The steam is reheated to its original temperature by passing it through a re-heater at 12 bar. The condenser pressure is 0.07 bar. Determine net workout and thermal efficiency. [7M]
   b) Draw the line diagram and explain the flue gas analysis using Orsat apparatus. [7M]

3. a) Compare and contrast the boiler mountings and accessories. [7M]
   b) Calculate the height of chimney required to produce a draught equivalent to 1.8 cm of water if the flue gas temperature is $250^0$C and ambient temperature is $25^0$C and minimum amount of air per kg of fuel is 20 kg. [7M]

4. a) Calculate the throat and exit diameters of a convergent- divergent nozzle, which will discharge 820 kg of steam per hour at a pressure of 8 bar superheated to $220^0$C into a chamber having a pressure of 1.5 bar. The friction loss in the divergent portion of the nozzle may be taken as 0.15 of the isentropic enthalpy drop. [7M]
   b) For single stage impulse turbine steam velocity is 900 m/s. Blade speed is 400 m/s. Nozzle angle is $20^0$. Blade outlet angle is $25^0$. Steam flow rate is 30 kg/sec. Calculate the power to be developed. [7M]

5. a) Derive the condition for maximum efficiency and blade height of reaction turbine. [6M]
   b) Explain with neat line diagram the working of evaporative steam condenser. [8M]

6. A gas turbine unit has a pressure ratio of 6 and maximum cycle temperature of $610^0$C. The isentropic efficiency of the turbine and compressor are 0.82 and 0.8 respectively. Calculate the power output in kW of an electric generator, geared to the turbine, when air enters the compressors at $15^0$C at a rate of 16 kg/s. Take $C_p$=1.005kJ/kg.K and $\gamma$ = 1.4 for compression process and $C_p$ = 1.11 kJ/kg.K and $\gamma$= 1.333 for expansion process. [14M]

7. a) Explain the working of turboprop engine and write its advantages. [8M]
   b) State the fundamental difference between the jet propulsion and rocket propulsion. [6M]

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## PART –A (14 Marks)

1. a) Explain different methods to improve the efficiency of Rankine cycle. [2M]
   b) Differentiate the fire tube and water tube boiler. [2M]
   c) What is the condition for maximum discharge through the nozzle? [2M]
   d) Define vacuum efficiency and explain how it is useful in condensers? [3M]
   e) Draw the layout of an open cycle gas turbine. [3M]
   f) Why propeller engines are not recommended now a days in air craft's? [2M]

## PART –B (56 Marks)

2. a) How to calculate the minimum air required and excess air calculation in the complete combustion of gaseous fuel? [7M]
   b) A steam power plant operates on ideal Rankine cycle. The steam enters the turbine at 3 MPa, $350^0$C and is condensed in the condenser at 75 kPa, calculate thermal efficiency and work ratio of this cycle. [7M]

3. a) Why boiler mountings are installed? Explain the operation of fusible plug with the help of simple diagram. [9M]
   b) Differentiate the induced and forced draught. [5M]

4. a) Draw the line diagram and velocity triangles and explain the working details of impulse turbine. [7M]
   b) Steam leaves the nozzle of a single stage impulse turbine at 850 m/s. The nozzle angle is $18^0$ and the blade angles are $29^0$ at the inlet and outlet. The friction coefficient is 0.9. Calculate blade velocity and steam mass flow rate in kg/hr to develop 300 W power. [7M]

5. a) Steam enters a condenser at $35^0$C. The barometer reading is 760 mm of mercury. If a vacuum of 690 mm is recorded, calculate the vacuum efficiency. [7M]
   b) List the differences between impulse and reaction turbines. [7M]

6. The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1.5 bar and temperature of $25^0$C. The pressure of the air after compression is 5 bar. The isentropic efficiencies of compressor and turbine are 80% and 85% respectively. The air fuel ratio used is 85:1. If flow rate of air is 2.5 kg/sec, find: i) Power developed, and ii) Thermal efficiency of the cycle. Assume C p = 1.0 kJ.kg K and ɣ = 1.4 of air and gases, Calorific value of fuel = 41800 kJ/kg. [14M]

7. a) What are the desirable properties of a liquid propellant for a rocket engine? [8M]
   b) The jet velocity from a rocket engine is 3000 m/s. The forward velocity is 1500 m/s and propellant consumption is 80 kg/s. Calculate the thrust, thrust power and propulsive efficiency. [6M]

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Code No: R1631035 **R16** SET - 4

**III B. Tech I Semester Regular/Supplementary Examinations, March – 2021**

# THERMAL ENGINEERING – II

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**
4. Use of Steam Tables and Mollier Chart is allowed.

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## PART –A (14 Marks)

1. a) What is meant by Reheating and write its advantages? [2M]
   b) Compare boiler mountings and accessories. [2M]
   c) Explain the effect of friction on the blade diagram efficiency in steam turbines. [2M]
   d) What is the condition for maximum blade efficiency of a 50% reaction turbine? [3M]
   e) Write down different applications of gas turbine power cycles in power sector industries. [3M]
   f) Write equation for Thrust power and propulsive power. [2M]

## PART –B (56 Marks)

2. a) Explain the effect of any two operating variables on Rankine cycle performance. [6M]
   b) A steam power plant operates on the ideal reheat Rankine cycle. Steam enters the high pressure turbine at 6 MPa and $500^0$C and leaves at 4 MPa. Steam is then reheated at constant pressure to $500^0$C before it expands to 25 kPa in the low pressure turbine. Determine the turbine work output in kJ/kg and the thermal efficiency of the cycle. Also show the cycle on a T-s diagram with respect to the saturation lines. [8M]

3. a) Explain the working of any one type of water tube boiler with neat sketch. [8M]
   b) The following readings are obtained during a boiler trail of 8 hours duration. Mean steam pressure=15 bar, mass of steam generated=45000 kg, mean dryness fraction=0.87, mean feed water temperature=$30^0$C, coal used=4500 kg, calorific value of coal = 33500 kJ/kg. Determine: i) Factor of equivalent evaporation, ii) Equivalent evaporation from and at $100^0$C, iii) Efficiency of the boiler. [6M]

4. a) In a convergent-divergent nozzle, the steam enters at 20 bar and $350^0$C and leaves at a pressure of 5 bar. The inlet velocity to the nozzle is 175 m/s. Find the required throat and exit areas for a mass flow rate of 1.5 kg/s. Assume nozzle efficiency to be 90 percent and $C_{ps}$=2.4 kJ/kg.K. [7M]
   b) What is the need of compounding impulse turbines? Explain any one method in detail. [7M]

5. a) Explain the working of high level jet condenser with a neat sketch. [7M]
   b) In a Parson reaction turbine, the angles of receiving tips are $35^0$ and of discharging tips $20^0$. The blade speed is 125 m/s. Calculate the tangential force, power developed, diagram efficiency and axial thrust of the turbine, if it steam consumption is 1.5 kg/min. [7M]

6. a) A simple gas turbine cycle works with a pressure ratio of 9. The compressor and turbine inlet temperatures are 300 K and 800 K. If the volume flow rate of the air is 300 $m^3$ per sec, compute the power output and thermal efficiency. [8M]
   b) Derive the thermal efficiency of an ideal gas turbine power plant. [6M]

7. a) The effective jet velocity from a rocket is 2700 m /sec. The forward flight velocity is 1350 m/sec and the propellant consumption is 78.6 kg /sec. Calculate thrust, thrust power and propulsive efficiency. [8M]
   b) How a rocket propulsion system works? Explain. [6M]

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