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| **ME8493- THERMAL ENGINEERING-I**  **UNIT-I** | | | | | | | | | | |
| **GAS AND STEAM POWER CYCLES** | | | | | | | | | | |
| **PART – A** | | | | | | | | | | |
| **1** | **Why does diesel cycle have high efficiency compared to otto cycle?** | | **AU-AM 2019** | | **Remember**  **BT-L1** | | | | **CO1** | **PI 1.3.1** |
|  | In otto cycle air –fuel mixture is taken as working fluid, where as in diesel cycle only air is taken (fuel is injected in combustion stroke). Naturally self-temperature of working fluid in diesel cycle is more. So we can increase the compression ratio in diesel cycle. So the efficiency of diesel cycle is more than the otto cycle. | | | | | | | | | |
| **2** | **What are the factors influencing the ideal Brayton cycle efficiency?** | | **AU-AM 2019** | | **Remember**  **BT-L1** | | | | **CO1** | **PI 1.2.1** |
|  | Key factors affecting the Brayton cycle efficiency includes the turbine inlet temperature, compressor and turbine adiabatic efficiencies, recuperator effectiveness and cycle fractional pressure loss. | | | | | | | | | |
| **3** | **What is cut off ratio?** | | **AU-ND 2018** | | | **Understand**  **BT-L2** | | | **CO1** | **PI 1.3.1** |
|  | The cutoff ratio is the ratio of the volume after combustion to the volume before combustion. The compression ratio is the ratio of the maximum volume to the minimum volume. Efficiency goes up with compression ratio and down with cutoff ratio | | | | | | | | | |
| **4** | **Define Air Standard efficiency.** | | **AU-ND 2018** | | **Remember**  **BT-L1** | | | | **CO1** | **PI 1.3.1** |
|  | Air standard efficiency is a measure of thermal efficiency of the internal combustion engine. It is the [thermal](http://thesciencedictionary.org/thermal/) [efficiency](http://thesciencedictionary.org/efficiency/) of the internal combustion engine while [working](http://thesciencedictionary.org/working/) under appropriate air [standard](http://thesciencedictionary.org/standard/) cycle. | | | | | | | | | |
| **5** | **Draw the p – v diagram of diesel and otto cycle.** | | | **AU- AM 2018** | | | | **Apply**  **BT-L3** | **CO1** | **PI 1.3.1** |
|  | **OTTO CYCLE DIESEL CYCLE** | | | | | | | | | |
| **6** | **Write down the air standard efficiency equation for diesel cycle.** | | | **AU- AM 2018** | | | | **Remember**  **BT-L1** | **CO1** | **PI 2.1.3** |
|  | The air standard efficiency of the diesel cycle is  Diesel cycle : η = 1-(1/r(γ-1))(( ργ-1)/(γ(ρ-1)))  Where r = compression ratio  γ=ratio of specific heats  ρ= cut-off ratio  η= Efficiency | | | | | | | | | |
| **7** | **Define mean effective pressure.** | **AU- ND 2017** | | | | | **Remember**  **BT-L1** | | **CO1** | **PI 1.2.1** |
|  | The mean effective pressure of a cycle or heat engine is the average pressure acting on the piston during the working stroke. It is also defined as the quantity relating to the operation of a reciprocating engine and is valuable measure of an engine’s capacity to do work that is independent of engine displacement. | | | | | | | | | |
| **8** | **Draw T-s and P-v diagram for Brayton cycle.** | **AU-AM 2017** | | | | | **Apply**  **BT-L3** | | **CO1** | **PI 1.3.1** |
|  |  | | | | | | | | | |
| **9** | **Write four major differences between Otto cycle and Diesel cycle.** | **AU- ND 2016** | | | | | **Understand**  **BT-L2** | | **CO1** | **PI 1.4.1** |
|  | |  |  |  | | --- | --- | --- | | **S.No** | **Otto Cycle** | **Diesel cycle** | | **1** | Heat addition takes place at constant  Volume. | Heat addition takes place at constant  Pressure. | | **2** | At constant volume, heat rejection takes place. | In diesel cycle also the heat rejection takes place at constant volume. | | **3** | Compression ratio is less. It is 7:1 to  10:1. | Compression ratio is more. It is 11:1  to 22:1. | | **4** | Efficiency is less. | Efficiency is more. | | | | | | | | | | |
| **10** | **State the assumptions made in air standard cycle analysis.** | **AU -ND 2016** | | | | | **Remember**  **BT-L1** | | **CO1** | **PI 1.2.1** |
|  | Air standard cycle assumption is given below   * The working medium is a perfect gas throughout i.e. follows the law PV= mRT. * The working medium does not undergo any chemical changes. * The compression and expansion processes are reversible adiabatic. * Kinetic and potential energy of the working fluid are neglected. * The operation of the engine is frictionless. | | | | | | | | | |
| **11** | **Define mean effective pressure.** | **AU- MJ 2016** | | | | | **Remember**  **BT-L1** | | **CO1** | **PI 1.3.1** |
|  | Mean effective pressure is defined as the constant pressure acting the piston during the working stroke. It is also defined as the ratio of work done to the stroke volume or piston displacement volume. | | | | | | | | | |
| **12** | **What is a thermodynamic cycle**? | **AU - MJ 2016** | | | | | **Remember**  **BT-L1** | | **CO1** | **PI 1.2.1** |
|  | Thermodynamic cycle is defined as the series of thermodynamic processes on the system, so that the system attains its original state and it comes to equilibrium condition. It is called thermodynamic cycle. | | | | | | | | | |

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| **13** | **What is meant by air standard cycle?** | | **AU - ND 2015** | | **Understand**  **BT-L2** | | **CO1** | **PI 1.2.1** |
|  | The air standard cycle is that we are using air as a working substance in the thermodynamic cycle it is called air standard cycles. Energy is provided by the combination of fuel and air. | | | | | | | |
| **14** | **What is the effect cut-off ratio on the efficiency of diesel cycle? When the compression ratio is kept constant?** | | **AU - ND 2015** | | **Understand**  **BT-L2** | | **CO1** | **PI 1.3.1** |
|  | The effect cut-off ratio on the efficiency of diesel cycle when cut-off ratio of diesel cycle increases, the efficiency of cycle is decreased when compression ratio is kept constant and vice versa. | | | | | | | |
| **15** | **Compare Carnot and Rankine cycles.** | | **AU - MJ 2015** | | **Understand**  **BT-L2** | | **CO1** | **PI 2.1.3** |
|  | |  |  |  | | --- | --- | --- | | **S.No** | **Carnot cycle** | **Rankine cycle** | | **1** | Lower work ratio | Higher work ratio | | **2** | Specific steam consumption is  More | Specific steam consumption is  less | | **3** | Size of the power plant for a given output is big. | Size of the power plant for a  given output is small. | | **4** | Higher thermal efficiency | Lower thermal efficiency | | | | | | | | |
| **16** | **Why reheat cycle is not used for low boiler pressure?** | | **AU - MJ 2015** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.4.1** |
|  | The reheat cycle is not used for low boiler pressure because at the low reheat pressure the heat cycle efficiency may be less than the Rankine cycle efficiency. Since the average temperature during heating will then be low. | | | | | | | |
| **17** | **Explain the terms critical point, critical temperature and critical pressure.** | | **AU - ND 2014** | | **Understand**  **BT-L2** | | **CO1** | **PI 2.1.2** |
|  | In the T-S diagram the region leftwards of the waterline, the water exists as liquid. In right of the dry steam line, the water exists as a super-heated steam. In between water and dry steam line the water exists as a wet steam. At a particular point, the water is directly converted into dry steam without formation of wet steam. The point is called **critical point**. **The critical temperature** is the temperature above which a substance cannot exist as a liquid; the critical temperature of water is 374ᵒC. The corresponding pressure is called **critical pressure**. | | | | | | | |
| **18** | **What is meant by delay period of fuel?** | | **AU - ND 2014** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.3.1** |
|  | * In IC engine combustion chamber during the mixing, the fuel should first evaporate to form a combustible mixture. The time taken for evaporation and mixing is called physical delay. * Fuel molecules are complex, Intermediate reactions are necessary before the fuel burns to form C02 and H20. The time interval between ignition and start of final reactions is called chemical delay. | | | | | | | |
| **19** | **What is the purpose of heat balance sheet in IC engine?** | | **AU - AM 2014** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.3.1** |
|  | The purpose of heat balance sheet in IC engine are   * It is the accounts of heat supplied and heat utilized in various ways in the system. * The heat balance is generally done by minute basis or percentage basis. | | | | | | | |
| **20** | **What are the assumptions made on the analysis of ideal Rankine cycle?** | | **AU - ND 2013** | | **Understand**  **BT-L2** | | **CO1** | **PI 1.3.1** |
|  | The assumptions made on the analysis of ideal Rankine cycle are   * + Each component of the working fluid is internally reversible.   + All processes of the working fluid are internally reversible.   + The pump and turbine operate adiabatically   + Condensate leaves the condenser as saturated liquid | | | | | | | |
| **21** | **What is meant by work ratio? What is the importance of work ratio in vapor cycles?** | | **AU - ND 2013** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.3.1** |
|  | **Work ratio** is defined as the ration of work delivered by actual turbine to work delivered by an isentropic turbine.  **Importance:** This raises the average temperature at which heat is added to the steam and thus raises the thermal efficiency of the cycle. | | | | | | | |
| **22** | **Name the various “gas power cycles".** | | **AU - AM 2013** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.3.1** |
|  | There are many thermodynamic gas power cycles in thermodynamic system given below.   * + Carnot cycle.   + Otto cycle.   + Diesel cycle & Brayton cycle and Duel combustion cycle & Atkinson cycle | | | | | | | |
| **23** | **Mention the various processes of diesel cycle.** | | **AU - AM 2013** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.4.1** |
|  | The processes of Diesel cycle are:   * + Isentropic compression,   + constant pressure heat addition,   + Isentropic expansion & Constant volume heat rejection | | | | | | | |
| **24** | **Mention the various processes of dual cycle.** | | **AU - ND 2012** | | **Remember**  **BT-L1** | | **CO1** | **PI 1.4.1** |
| The processes of Dual cycle are:   * Isentropic compression, * Constant volume heat addition, * Constant pressure heat addition, * Isentropic expansion & Constant volume heat rejection. | | | | | | | | |
| **25.** | **Define the following terms Compression ratio and Expansion ratio.** | |  | | **Remember**  **BT-L1** | | **CO1** | **PI 1.2.1** |
|  | **Compression ratio** : Compression ratio is defined as the ratio between total cylinder volumes to  Clearance volume.  **Expansion ratio :** Expansion ratio is the ratio of volume after the expansion to the volume before  Expansion. | | | | | | | |
| **PART – B** | | | | | | | | |
| **1** | | (i) Derive the expression for the efficiency of Diesel cycle in terms of cycle parameters. **(05)** | | **AU-AM 2019** | | **Analyze**  **BT-L4** | **CO1** | **PI 2.4.1** |
| (ii) In an air standard dual cycle, the pressure and temperature at the beginning of the compression are 1 bar and 57ᵒ C respectively. The heat supplied in the cycle is 1250 kJ/kg, two-third of this being added at constant volume and rest at constant pressure. If the compression ratio is 16, determine the maximum pressure and temperature in the cycle thermal efficiency and MEP. **(08)** | |

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| **2** | (i) Derive the expression for the efficiency of Brayton cycle in terms cycle parameters **(05)** | | | | | **AU-AM 2019** | | **Analyze**  **BT-L4** | **CO1** | **PI 2.1.3** |
| (ii) Steam power plant runs on a single regenerative heating process. The steam enters the turbine at 30 bar and 400ᵒC and steam fraction is withdrawn at 5 bar. The remaining steam exhausts at 0.10 bar, to the condenser. Calculate the efficiency and steam rate of the power plant. Neglect pump works. **(08)** | | | | |
| **3** | In an otto cycle air at 17ᵒ c and 1 bar is compressed adiabatically until the pressure is 15 bar. Heat is added at constant volume until the pressure is raises to 40 bar. Calculate the air standard efficiency, the compression ratio and the mean effective pressure of the cycle. Assume cv = 0.717kj/kg K and R= 8.314 kJ/mole k **(13)** | | | | | **AU-AM 2018** | | **Apply**  **BT-L3** | **CO1** | **PI 1.4.1** |
| **4** | The mean effective pressure of an ideal diesel cycle is 8 bar. If the initial pressure is 1.03 bar and the compression ratio is 12, determine the cut of ratio and the air standard efficiency. Assume ratio of specific heat for air to be 1.4 **(13)** | | | | | **AU-AM 2018** | | **Understand**  **BT-L2** | **CO1** | **PI 1.4.1** |
| **5** | An oil engine works on the dual cycle, the heat liberated at constant pressure being twice that liberated at constant value. The compression ratio of the engine is 8 and the expansion ratio is 5.3 but the compression an expansion processes follow the law p v1.3 = c. The pressure and temperature at beginning of compression are 1 bar and 27ᵒ c .respectively. Assuming Cp = 1.004 KJ/ kg k and Cv = 0.717 KJ/kg k for air. Fine the air standard efficiency and the mean effective pressure. **(13)** | | | | | **AU-AM 2017** | | **Apply**  **BT-L3** | **CO1** | **PI 1.2.1** |
| **6** | A gas engine operating on the ideal otto cycle has a compression ratio of 6:1. The pressure and temperature of the commencement of compression is 1 bar and 27º C. Heat added during the constant value combustion process is 1170 KJ/kg. Determine the peak pressure and temperature, work output per kg. Of air and air standard efficiency. Assume cp= 1.004 kJ/kg K and cv = 0.717 kJ/kg K., γ = 1.4 for air.  **(13)** | | | | | **AU- ND 2017** | | **Analyze**  **BT-L4** | **CO1** | **PI 2.2.3** |
| **7** | An engine with 200mm cylinder diameter and 300mm stroke works on theoretical diesel cycle. The initial pressure and temperature of air used are1bar and 27º C. The cut-off is 8% of the stroke. Determine: 1, Pressures and Temperatures at all salient points. 2, Theoretical air standard efficiency. 3, Mean Effective Pressure. Assume that compression ratio is 15 and working fluid is air. Consider all conditions to be ideal. **(13)** | | | | | **AU- AM 2017** | | **Evaluate**  **BT-L5** | **CO1** | **PI 1.2.1** |
| **8** | Derive an expression for air standard efficiency for Otto Cycle. **(13)** | | | | | **AU- AM 2017** | | **Understand**  **BT-L2** | **CO1** | **PI 2.3.2** |
|  |
| **9** | The swept volume of a diesel engine working on dual cycle is 0.0053 m3 and clearance volume is 0.00035 m3. The maximum pressure is 65 bar, fuel injection ends at 5 percent of stroke. The temperature and pressure at the start of the compression are 80ᵒ C and 0.9 bar, Determine the air standard efficiency of the cycle. Take γ for air=1.4  **(13)** | | | | | **AU -ND 2016** | | **Evaluate**  **BT-L5** | **CO1** | **PI 2.1.1** |
| **10.** | In a gas turbine plant working on the Brayton cycle the air at the inlet is at 27ᵒC, 0.1Mpa. The pressure ratio is 6.25 and the maximum temperature is 800ᵒC, the turbine and compressor efficiencies are each 80%. Find compressor work per kg of air, turbine work and the heat supplied per kg of air, cycle efficiency & turbine exhaust temperature. **(13)** | | | | | **AU- ND 2016** | | **Apply**  **BT-L3** | **CO1** | **PI 1.2.1** |
| **11.** | An air standard Diesel cycle has a compression ratio of 18. The pressure at the beginning of compression stoke is 1 bar and the temperature is 30°C. The heat supplied is 1800kJ/kg. Determine the efficiency, pressure and temperature at salient points, heat rejected and mean effective pressure. Assume the Cp, Cv, R, γ suitably. **(13)** | | | | | **AU -MJ 2016** | | **Apply**  **BT-L3** | **CO1** | **PI 1.2.1** |
| **12.** | Drive an expression for the air standard efficiency of Dual cycle.  **(13)** | | | | | **AU- ND 2015** | | **Understand**  **BT-L2** | **CO1** | **PI 2.3.2** |
| **13.** | The compression ratio and expansion ratio of an oil engine working on the dual cycle are 9 and 5 respectively. The initial pressure and temperature of the air are 1 bar and 300 C. The expansion and compression follow the law PV1.25 = constant. Determine :   * Pressure and temperatures at all salient points * Mean effective pressure of the cycle. * Efficiency of the cycle. * Power of the engine if working cycles per second are 8. Assume: cylinder bore = 250 mm and stroke length = 400 mm. **(13)** | | | | | | | **Analyze**  **BT-L4** | **CO1** | **PI 1.2.1** |
| **14.** | Consider an air standard cycle in which the air enters the compressor at10bar and 200 C. the pressure of air leaving the compressor is 3.5 bar and the temperature at turbine inlet is 6000 C. determine per kg of air:   * + - Heat supplied to air and Heat rejected in the cooler     - Work available at the shaft and the Efficiency of the cycle     - Temperature of air leaving the turbine. For air γ = 1.4 and cp =1.005 kJ/kg K   **(13)** | | | | | | | **Evaluate**  **BT-L5** | **CO1** | **PI 1.2.1** |
| **15.** | The compression ratio for a single–cylinder engine operating on dual cycle is 9. The maximum pressure in the cylinder is limited to 60 bars. The pressure and temperature of the air at the beginning of the cycle is 1 bar and 300 C. heat is added during constant pressure process up to 4 percent of the stroke. Assuming the cylinder diameter and stroke length as 250 and 300 mm respectively, Analyse :   * The air standard efficiency of the cycle. * The power developed is the number of working cycles are 3 per second.   Take for air cv = 0.71 kJ/kg K and cp = 1.0 kJ/kg K. **(13)** | | | | | | | **Analyze**  **BT-L4** | **CO1** | **PI 1.2.1** |
| **16.** | (i) Draw the P-v, T-s, h -s, diagrams and theoretical lay out for Rankine cycle and hence deduce the expression for its efficiency. **(08)** | | | | | | | **Apply**  **BT-L3** | **CO1** | **PI 2.3.2** |
| (ii) 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. **(05)** | | | | | | |
| **17.** | | Draw the P-V, T-S, h -s, diagrams and theoretical lay out for Regeneration Rankine cycle and hence deduce the expression for its efficiency. **(13)** | | | | | **Understand**  **BT-L2** | | **CO1** |  |
| **18.** | | In a single-heater regenerative cycle the steam enters the turbine at 30 bar, 400°C and the exhaust pressure is 0.10 bar. The feed water heater is a direct contact type which operates at 5 bar. Find : (i) The efficiency and the steam rate of the cycle. (ii) The increase in mean temperature of heat addition, efficiency and steam rate as compared to the Rankine cycle (without regeneration). Pump work may be neglected. **(13)** | | | | | **Evaluate**  **BT-L5** | | **CO1** |  |
| **19.** | | Draw the P-V, T-S, h -s, diagrams and theoretical lay out for Reheat Rankine cycle and hence deduce the expression for its efficiency. **(13)** | | | | | **Understand**  **BT-L2** | | **CO1** |  |
| **20.** | | A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150bar, 550 °C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550 °C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagram. Find (i) Quality of steam at turbine exhaust (ii) Cycle efficiency (iii) Steam Rate in kg/kWh. **(13)** | | | | | **Evaluate**  **BT-L5** | | **CO1** |  |
| **PART – C** | | | | | | | | | | |
| **1** | | The following data relate to both Otto and Diesel Cycles:  Condition at the start of compression : 100 kPa and 300 K  Maximum temperature : 1500K  Temperature after isentropic expansion: 700 K  Take: cp=1.005 cv=0.718, R=0.287 kJ/kg K and specific Heat ratio=1.4  Determine the pressure and temperature on the salient points, compression ratio, maximum pressure efficiency and mean effective pressure for  (i) Otto cycle and label the values on p-v and T-s diagram  (ii) Diesel cycle and label the values on p-v and T-s diagram. **(15)** | | | **AU-MJ 2019** | | **Apply**  **BT-L3** | | **CO1** | **PI 1.3.1** |
| **2** | | For an engine working on the ideal Dual cycle, the compression ratio is 10 and the maximum pressure is limited to 70 bar. If the heat supplied is 1680 kJ/kg, find the pressure and temperatures at the various salient points of the cycle and the cycle efficiency. The pressure and temperature of air at the commencement of compression are 1 bar and 100˚C respectively. Assume Cp=1.004 kJ/kg K and Cv= 0.717 kJ/kg K for air. **(15)** | | | **AU-AM 2019** | | **Analyze**  **BT-L4** | | **CO1** | **PI 1.3.1** |
| **3.** | | In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. Determine : (i) The turbine work (ii) The condenser heat flow, (iii) The pump work, (iv) Heat Supplied to the boiler, (v) Network done, (vi)The Rankine efficiency, (vii) The dryness at the end of expansion, (viii) Carnot efficiency (ix) SSC, (x)Work ratio, (xi) Turbine power output if flow rate of 9.5 kg/s. (15) | | | | | **Evaluate**  **BT-L5** | | **CO1** |  |
| **4.** | | A steam turbine is fed with steam having an enthalpy of 3100 kJ/kg. It moves out of the turbine with an enthalpy of 2100 kJ/kg. Feed heating is done at a pressure of 3.2 bar with steam enthalpy of 2500 kJ/kg. The condensate from a condenser with an enthalpy of 125 kJ/kg enters into the feed heater. The quantity of bled steam is 11200 kg/h. Find the power developed by the turbine. Assume that the water leaving the feed heater is saturated liquid at 3.2 bar and the heater is direct mixing type. Neglect pump work. **(15)** | | | | | **Evaluate**  **BT-L5** | | **CO1** |  |
| **UNIT-II**  **RECIPROCATING AIR COMPRESSORS**  **PART – A** | | | | | | | | | | |
| **1** | | **What is the purpose of intercooler in a compressor?** | **AU- ND 2018** | | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.4.1** |
|  | | It exchanges the heat to the air from the LP compressor before it enters the HP compressor. Intercooler is a cooling device .which is generally used in between high pressure and low pressure compressor in Brayton cycle .It's function is to reduce the temperature of air to initial temperature at constant pressure in order to reduce compression work. | | | | | | | | |
| **2** | | **What do you mean by Clearence volume?** | | **AU- ND 2018** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.2.1** |
|  | | The "Clearance volume" of the engine is the volume between the cylinder head and the piston when the piston is at TDC. The ratio of this volume to the swept volume determines the compression ratio of the engine. | | | | | | | | |
| **3** | | **Define isothermal & isentropic efficiency of reciprocating compressors.** | | | **AU -MJ 2018** | | **Remember**  **BT-L1** | | **CO2** | **PI 1.3.1** |
|  | | **Isentropic compression** is defined as the summation of work done during compression and wok done during delivery and subtracted work done during suction.  **Isothermal efficiency:** Isothermal efficiency of the compressor is defined as the ratio of isothermal work input to actual work input during compression. | | | | | | | | |
| **4** | | **What are the advantages of multi stage compression?** | | **AU -AM 2018** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | * Better balancing * High delivery pressure * More volumetric efficiency | | | | | | | | |
| **5** | | **What is the effect of clearance volume on work of compression?** | | **AU -ND 2017** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.4.1** |
|  | | The effect of clearance volume on work of compression is to   * Suction volume is reduced * Mass of air is reduced * Heavy compression increases mechanical loss | | | | | | | | |
| **6** | | **Explain the influence of pressure ratio on the volumetric efficiency of an air compressor.** | | **AU -AM 2017** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.3.1** |
|  | | The volumetric efficiency is high in air compressor as the clearance volume and swept volume is not applicable for air compressor. As the result the pressure ratio is high.  VS+VC/VS = 1+C-[C(P2/P1)1/n] | | | | | | | | |
| **7** | | **What do you mean by free air delivered in a Reciprocating Air Compressor?** | | **AU- AM 2017** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.3.1** |
|  | | The free air delivered is the actual volume of air delivered at the stated pressure reduced to intake pressure and temperature and expressed in m3/min. FAD is the actual quantity of compressed air converted back to the inlet conditions of the compressor. | | | | | | | | |
| **8** | | **Write the difference between centrifugal and axial compressors.** | | **AU- ND 2016** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | |  |  |  | | --- | --- | --- | | **S No** | **Centrifugal compressor** | **Axial compressor** | | **1** | Air flows radically in the compressor | Air flows parallel to the axis of the shaft. | | **2** | Low maintenance and running cost | High maintenance and running cost. | | **3** | Not suitable for Multi staging | Suitable for multistage | | **4** | Isentropic efficiency is 80% - 82% | Isentropic efficiency is 86% - 88% | | | | | | | | | |
| **9** | | **What are the merits of multistage compression?** | | **AU- ND 2016** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | * Reduces the work of compression per kg of refrigerant. * COP increases. * Temperature at the end of the compression would be less. * Volumetric efficiency of compressor increases. | | | | | | | | |
| **10** | | **Define volumetric efficiency of an air compressor.** | | **AU -MJ 2016** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.4.1** |
|  | | The volumetric efficiency is given by the ratio of actual volume of air sucked and swept volume of cylinder. Ideally the volume of air sucked should be equal to the swept volume of cylinder, but it is not so in actual case. Practically the volumetric efficiency lies between 60 to 90%. | | | | | | | | |
| **11** | | **State the condition which lowers volumetric efficiency of an air compressor.** | | **AU -MJ 2016** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | Volumetric efficiency depends on ambient pressure and temperature, suction pressure and temperature, ratio of clearance to swept volume, and pressure limits. Volumetric efficiency decreases with increase in pressure ratio in compressor. | | | | | | | | |
| **12** | | **Define volumetric efficiency of a reciprocating compressor.** | | **AU -ND 2015** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.2.1** |
|  | | The volumetric efficiency of a reciprocating compressor is given by the ratio of actual volume of air sucked and swept volume of cylinder. It is a function of cylinder clearance, compression ratio and the properties of the gas being compressed. | | | | | | | | |
| **13** | | **What is meant by single acting compressor?** | | **AU ND 2015** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.4.1** |
|  | | In single acting compressor, the suction, compression and delivery of air takes place on one side of the piston. Its reciprocating system is linear motion and is moving up and down motion and there is only one inlet valve and outlet valve in the compressor. | | | | | | | | |
| **14** | | **What is meant by double acting compressor?** | | **AU- MJ 2015** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.3.1** |
|  | | In double acting reciprocating compressor, the suction and delivery of air takes place on both sides of the piston. It is very advance system in pump. Its reciprocating system is linear motion and is moving up and down motion. | | | | | | | | |
| **15** | | **What is meant by single stage compressor?** | | **AU- MJ 2015** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | In single stage compressor, the compression of air from the initial pressure to the final pressure is carried out in one cylinder only. Its reciprocating system is linear motion and is moving up and down motion. | | | | | | | | |
| **16** | | **What is meant by multistage compressor?** | | **AU- ND 2014** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | In multistage compressor, the compression of the air from the Initial pressure to the final pressure is carried out in more than one cylinder. Its reciprocating system is linear motion and is moving up and down motion. | | | | | | | | |
| **17** | | **Define isentropic efficiency.** | | **AU -ND 2014** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
|  | | The Isentropic efficiency of a compressor is defined as the ratio of the work input to the actual process between the same inlet and exit pressures. It is the ratio of the isentropic power to the brake power to drive the compressor.  Isentropic efficiency = Isentropic power/ Actual brake power. | | | | | | | | |
| **18** | | **What is meant by free air delivered?** | | **AU- MJ 2014** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.3.1** |
|  | | The free air delivered is the actual volume delivered at the stated pressure reduced to intake pressure and temperature and expressed m3/min. Air standard is also Otto cycle system in thermal. | | | | | | | | |
| **19** | | **Explain how flow of air is controlled in a reciprocating compressor?** | | **AU -ND 2013** | | | **Understand**  **BT-L2** | | **CO2** | **PI 1.3.1** |
| The flow of air is controlled by centrifugal governor or maintaining the speed of motor constant or by providing the pocket advancement to the cylinder. Its reciprocating system is linear motion and is moving up and down motion | | | | | | | | | | |
| **20** | | **What factors limit the delivery pressure in reciprocating compressor?** | | **AU -ND 2013** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
| The factors limit the delivery pressure in reciprocating compressor   * To obtain high delivery pressure, the size of the cylinder will be large. * Temperature of air. * Its reciprocating system is linear motion and is moving up and down motion. | | | | | | | | | | |
| **21** | | **Name the method adopted for increasing isothermal efficiency of reciprocating air compressor.** | | **AU- MJ 2013** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
| The methods adopted for increasing isothermal efficiency of reciprocating air compressor**.** Isothermal efficiency is increased by perfect inter cooling. The reciprocating air compressor works in a linear motion where the piston is moved in an up and down motion | | | | | | | | | | |
| **22** | | **Why clearance is necessary and what is its effect on the performance of reciprocating compressor?** | | **AU- MJ 2013** | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
| When the piston reaches top dead center in the cylinder, there is a dead space between piston top and cylinder head. This space is known as clearance space and the volume occupied by this space is known as clearance volume. | | | | | | | | | | |
| **23** | | **Indicate the application of reciprocating compressors in industry?** | | | | | **Remember**  **BT-L1** | | **CO2** | **PI 1.2.1** |
| The applications of compressed air as follows:  1) Pneumatic brakes 6) Air Conditioning and Refrigeration System.  2) Pneumatic jakes. 7) Fuel Injection in IC engine.  3) Pneumatic drills. 8) Supercharging system in IC engine.  4) Pneumatic lifts.  5) Spray Painting | | | | | | | | | | |
| **24** | | **What are the advantages of multi stage compression with internal cooling over single stage compression for the same pressure ratio?** | | | | | **Apply**  **BT-L3** | | **CO2** | **PI 1.3.1** |
| 1. It improves the volumetric efficiency for the given pressure ratio.  2. It reduces the leakage loss considerably.  3. It gives more uniform torque and hence a smaller size flywheel is required.  4. It reduces the cost of the compressor. | | | | | | | | | | |
| **25** | | **Differentiate Positive and Non-Positive displacement Compressors.** | | | | | **Analyze**  **BT-L4** | | **CO2** | **PI 1.3.1** |
|  | | |  |  |  | | --- | --- | --- | | **S No** | **Positive displacement compressor** | **Non-Positive displacement compressor** | | In this type of compressors, air is physically trapped between to relatively moving components and forced to occupy lower volume, thereby increasing its pressure. | | In this type, a rotating component imparts its kinetic energy to the air which is eventually converted into pressure energy. | | Most notable example would be a reciprocating compressor. In which air is trapped between piston and cylinder volume and then literally pressed to increase its pressure. | | Centrifugal compressors are non-positive displacement type. Rotating impeller imparts KE to the air which is converted to PE as air passes through the diffuser. | | | | | | | | | |

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| **PART - B** | | | | | | | | | | | | |
| **1.** | Discuss the application, working and terminology of reciprocating compressors. **(13)** | | | | **AU -MJ 2018** | | **Remember**  **BT-L1** | | | **CO2** | **PI 2.1.2** | |
| **2.** | Derive the work done equation for multistage compressor with intercooler. **(13)** | | | | **AU -ND 2017** | | **Remember**  **BT-L1** | | | **CO2** | **PI 2.1.2** | |
| **3.** | A single stage single acting compressor delivers 15 m3 of free air per min from 1 bar to 8 bar. The speed of compressor is 300 rpm. Assuming that compression and expansion follow the law PV 1.3 = C and clearance is 1/16 th of swept volume, fine IP, diameter and stroke of the compressor. Take L/D = 1.5. The temperature and pressure of air at the suction are same as atm. Air. **(13)** | | | | **AU MJ 2018** | | **Evaluate**  **BT-L5** | | | **CO2** | **PI 1.4.1** | |
| **4.** | A single stage , single acting air compressor 30 cm bore and 40 cm stroke runs at 200 rpm. The suction pressure is 1 bar at 15ᵒc and the delivery pressure is 5 bar. Determine the indicated mean effective pressure and ideal power required to run it when i. compression is isothermal, ii. Compression follows the law pv 1.25 = c, iii. Compression is reversible adiabatic (γ = 1.4). Determine the isothermal; efficiency for ii, iii. Assume isentropic or reversible adiabatic index as γ = 1.4 and R = 0.287kJ/kg.k. **(13)** | | | | **AU ND 2017** | | **Evaluate**  **BT-L5** | | | **CO2** | **PI 1.3.1** | |
| **5.** | A single acting two stage compressor with complete interfolding delivers 6 kg/min of air at 16 bar. Assume an intake at 1 bar 100Kpa and 15ᵒC and compression and expansion with the law PV1.3 = C. Calculate power required to run the compressor, Isothermal Efficiency, Free air delivered per sec, If clearance ratios for LP and HP cylinder are 0.04 and 0.06, calculate the volumetric efficiency and swept volume for each cylinder. Take R = 0.287kJ/KgK CV = 0.71kJ/KgK. **(13)** | | | | **AU- MJ 2017** | | **Apply**  **BT-L3** | | | **CO2** | **PI 1.2.1** | |
| **6.** | Derive an expression for equation of work in terms of clearance factor in a single stage compressor with n as the index of expansion and compression. **(13)** | | | | **AU- MJ 2017** | | **Remember**  **BT-L1** | | | **CO2** | **PI 2.1.2** | |
| **7.** | A two-stage air compressor consists of three cylinders having the same bore and stroke. The delivery pressure is 7 bar and the free air delivery is 4.3 m3/min. Air is drawn in at 1.013 bar, 15° C and an intercooler cools the air to 38° C. The index of compression is 1.3 for all the three cylinders. Neglecting clearance calculate: i) The intermediate pressure ii) The power required to drive the compressor iii) The isothermal efficiency? **(13)** | | | | **AU-MJ 2016** | | **Apply**  **BT-L3** | | | **CO2** | **PI 1.4.1** | |
| **8.** | Explain the construction and working principle of centrifugal compressor and axial flow compressor with neat sketches. **(13)** | | | | **AU-ND 2016** | | **Understand**  **BT-L2** | | | **CO2** | **PI 1.3.1** | |
| **9.** | Drive an expression for the work done by single stage single acting reciprocating air compressor. **(13)** | | | | **AU-MJ 2016** | | **Apply**  **BT-L3** | | | **CO2** | **PI 1.4.1** | |
| **10.** | A single stage single acting reciprocating air compressor takes in 17 m3/min at suction conditions of 100 kPa and 25°C. The delivery pressure is 700 kPa. The clearance volume is 6% of swept volume. The compression and expansion follows the law pV1.3 = Constant. The speed of the compressor is 600 rpm. Stroke to bore ratio is 1. Find the power required to drive the compressor and Cylinder dimensions. | | | | **AU- ND 2015** | | **Evaluate**  **BT-L5** | | | **CO2** | **PI 1.4.1** | |
| **11.** | Explain the construction and working principle of centrifugal compressor and axial flow compressor with neat sketches. **(13)** | | | | **AU -ND 2016** | | **Understand**  **BT-L2** | | | **CO2** | **PI 1.3.1** | |
| **12.** | Explain the construction and working of a centrifugal compressor. **(13)** | | | | **AU-MJ 2015** | | **Understand**  **BT-L2** | | | **CO2** | **PI 1.3.1** | |
| **13.** | Drive an expression for volumetric efficiency of reciprocating air compressors. **(13)** | | | | **AU-ND 2015** | | **Apply**  **BT-L3** | | | **CO2** | **PI 1.4.1** | |
| **14.** | A two stage air compressor compresses air from 1 bar and 20°C to 42 bar. If the law of compression is pv1.3 = constant and the inter cooling is perfect. Find, the work done in compression, the mass of cooling water necessary for abstracting the heat in the intercooler, if the temperature rise of the cooling water is 25°C per kg of air. **(13)** | | | | **AU-ND 2012** | | **Evaluate**  **BT-L5** | | | **CO2** | **PI 1.4.1** | |
| **15.** | A three-stage air-compressor delivers 5.2 m3 of free air per minute. The suction pressure and temperature are 1 bar and 30°C. The ambient pressure and temperature are 1.03 bar and 20°C. The air is cooled to 30°C after each stage of compression. The delivery pressure of the compressor is 150 bar. The RPM of the compressor is 300. The clearances of LP, I.P and H.P cylinders are 5% of the respective strokes. The index of compression and re expansion in all stages is 1.35. Neglecting pressure losses, Calculate the B.P of the motor required to run the compressor if the mechanical efficiency is 80%. **(13)** | | | | | | **Apply**  **BT-L3** | | | **CO2** | **PI 1.4.1** | |
| **16.** | Analyze (determine) the size of the cylinder of a double acting air compressor of 32 KW I.P, in which air is drawn in at 1 bar and compressed to 16 bar according to the law pv 1.25 = constant. R.P.M. 300, Piston speed = 180 m/min, Volumetric efficiency = 0.8. **(13)** | | | | | | **Analyze**  **BT-L4** | | | **CO2** | **PI 2.4.1** | |
| **17.** | A multi stage air compressor is to be designed to evaluate the pressure from 1 bar to 120 bars. Such that the single stage pressure ratio not to exceed 4. Examine (find) (i) Number of stages, exact stage pressure ratio (iii) Inter stage pressure. **(13)** | | | | | | **Analyze**  **BT-L4** | | | **CO2** | **PI 2.4.1** | |
| **18.** | A two-stage double acting air compressor, operating at 200 r.p.m, takes in air at 1.013 bar and 27° C. The size of the L.P. cylinder is 356 x 375 mm, the stroke of H.P. cylinder is the same as that of the L.P. cylinder and the clearance of both the cylinders is 4%. The air passes through the intercooler so that it enters HP cylinder at 27C and 3.850 bar, finally it is discharged from the compressor at 15.4bar. The values of n for both cylinders are 1.25. Cp=1.0035kJ/kgK. And R=0.28kJ/kgK. Calculate: i. The heat rejected in the intercooler. ii. The diameter of HP cylinder and iii. The power required to drive HP cylinder. **(13)** | | | | | | **Remember**  **BT-L1** | | | **CO2** | **PI 2.1.2** | |
| **PART – C** | | | | | | | | | | | | |
| **1** | | A single stage reciprocating air compressor has clearance volume 5% of stroke volume of 0.05m3/s. The intake conditions are 95kN/m2 and 300K. The delivery pressure is 720kN/m2.Determine the volumetric efficiency referred to i. intake conditions ii. Atmospheric conditions of 100kN/m2 and 290K iii. FAD and iv. Power required driving the compressor, if the ratio of actual power to indicated power is 1.5. Take the index of compression and expansion as 1.3.  **(15)** | | | | | **Evaluate**  **BT-L5** | | **CO2** | | | **PI 1.4.1** |
| **2** | | A single acting tow stage-reciprocating compressor with complete inter cooling takes in air at the rate of 0.5m3/s. The intake pressure and temperature of air are 1 bar and 23oC. The air is compressed to a final pressure of 8bar. Estimate i. the intermediate pressure ii. Total volume of each cylinder, iii. The rate of heat rejection on the inter cooling. Assume compression follows the law pV1.35=C and compressor runs at 650rpm. **(15)** | | | | | **Analyze**  **BT-L4** | | **CO2** | | | **PI 2.4.1** |
| **3** | | A two cylinder single acting air compressor is to deliver 16kg of air per minute at 7 bar form suction conditions 1 bar and 15oC. The clearance may be taken as 4% of stroke volume and the index for both compression and re-expansion as 1.3. The compressor is directly coupled to a four cylinder four stroke petrol engine which runs at 2000rpm with a brake mean effective pressure of 5.5bar. Assuming a stroke-bore ration of 1.2 for both engine and compressor and a mechanical efficiency of 82% for compressor, calculate the required cylinder dimensions. **(15)** | | | | | **Evaluate**  **BT-L5** | | **CO2** | | | **PI 1.4.1** |
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| **UNIT-III**  **INTERNAL COMBUSTION ENGINE AND COMBUSTION**  **PART – A** | | | | | | | | | | | | |
| **1** | | **Mention the use of a camshaft.** | **AU-ND 2018** | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | In internal combustion engines with pistons, the camshaft is used to operate poppet valves. It consists of a cylindrical rod running the length of the cylinder bank with a number of oblong lobes protruding from it, one for each valve. | | | | | | | | | | |
| **2** | | **State the function of flywheel, connecting rod and piston.** | **AU-MJ**  **2018** | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.3.1** | |
|  | | The flywheel stores the energy. The connecting rod connects the piston and crankshaft and the piston conducts the energy to the flywheel. | | | | | | | | | | |
| **3** | | **Mention the use of a carburetor.** | **AU-ND 2018** | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | The carburetor has several uses:   * + it combines gasoline and air creating a highly combustible mixture,   + it regulates the ratio of air and fuel, and   + it controls the engine's speed | | | | | | | | | | |
| **4** | | **Draw the actual p-v diagram for a four stroke diesel engine and indicate all the processes.** | **AU-MJ**  **2018** | | | **Apply**  **BT-L3** | | **CO3** | | | **PI 1.4.1** | |
|  | |  | | | | | | | | | | |
| **5** | | **Draw an actual valve timing diagram of a four stroke diesel engine.** | | **AU ND 2017** | | **Analyze**  **BT-L4** | | **CO3** | | | **PI 1.4.1** | |
|  | | **C:\Users\Maha\Desktop\aswin2\diagram 1.png** | | | | | | | | | | |
| **6** | | **What is the purpose of a thermostat in an engine cooling system?** | | **AU ND 2017** | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.4.1** | |
|  | | A thermostat valve is used in the water-cooling system to regulate the circulation of water in system to maintain the normal working temperature of the engine parts during the different operating conditions. | | | | | | | | | | |
| **7** | | **What is a Carburetor? State any two types of Carburetor.** | | **AU MJ 2017** | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.2.1** | |
|  | | Carburetor also spelled carburetor, device for supplying a spark-ignition engine with a mixture of fuel and air. Components of carburetors usually include a storage chamber for liquid fuel, a choke, an idling (or slow-running) jet, a main jet, a venturi-shaped air-flow restriction, and an accelerator pump.  Types of Carburetor,  (i) Simple Carburetor  (ii) Solex Carburetor | | | | | | | | | | |
| **8** | | **What is the Octane number in I.C Engines?** | | **AU MJ 2017** | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.4.1** | |
|  | | |  | | --- | | An Octane number is a standard measure of the performance of an engine or aviation fuel. The higher the octane number, the more compression the fuel can withstand before ignition. | |  | | | | | | | | | | | |
| **9** | | **What are the advantages of four stroke cycle engine over two stroke cycle engines?** | | **AU ND 2016** | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | * Consumption of lubricating oil is less, because more time is allowed for removing heat from the cylinder. * Fuel cannot escape with exhaust gases. Hence fuel consumption is less * Thermal efficiency is more. * Noise is less is less. Exhaust gases are released in separate stroke. * Scavenging is better, since there is a separate exhaust stroke for the removal of exhaust gases | | | | | | | | | | |
| **10** | | **What are the effects of rich mixture in petrol engine?** | | **AU MJ 2019** | | **Understand**  **BT-L2** | | | **CO3** | | **PI 1.4.1** | |
|  | | An engine runs especially rich when accelerating, when cold, or when under a load. If there is too much fuel and not enough air, the engine is said to be “running rich”, or “has a rich mixture”. It will have a gassy or rotten egg smell from the exhaust, give off a burning effect to the eyes and will make black smoke. | | | | | | | | | | |
| **11** | | **Define the phenomenon ‘knocking’ in spark ignited engines.** | | **AU MJ**  **2016** | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.3.1** | |
|  | | The auto ignition of this large amount of fuel may cause high rate of pressure rise and high maximum pressure which may cause knocking in spark ignited engines. Knocking is simply frequently observed in CI engines. | | | | | | | | | | |
| **12** | | **Show the valve overlapping period of a typical 4-stroke engine on valve timing diagram.** | | **AU MJ**  **2016** | | **Apply**  **BT-L3** | | **CO3** | | | **PI 1.4.1** | |
|  | |  | | | | | | | | | | |
| **13** | | **What is a good air/fuel ratio?** | | | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.4.1** | |
|  | | If the ratio is too rich or too lean, the engine will not burn optimally burn the air-fuel mixture which can cause performance issues or use up too much fuel. The ideal air-fuel ratio that burns all fuel without excess air is 14.7:1. This is referred to as the “stoichiometric” mixture. | | | | | | | | | | |
| **14** | | **Classify IC engine according to cycle of lubrication system and field of application.** | | **AU ND 2015** | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | **Types of lubrication system:**   * + Wet sump lubrication system.   + Dry sump lubrication system.   **Field of application:**   * + Automobile truck, bus Locomotive engine.   + Stationary engine.   + Marine engine.   + Aircraft engine. | | | | | | | | | | |
| **15** | | **List the various components of IC engines.** | | **AU MJ 2015** | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | The various components of IC engines   * + Cylinder block.   + Cylinder head.   + Crank case & Oil sump or oil pair.   + Cylinder liners & Piston. | | | | | | | | | | |
| **16** | | **Name the basic thermodynamic cycles of the two types of internal combustion reciprocating engines.** | | **AU MJ 2015** | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.3.1** | |
|  | | The basic thermodynamic cycles of the two types of internal combustion reciprocating engines are Otto cycle in S.I engines and diesel cycle in C.I engines. These are the two basic reciprocating engines. | | | | | | | | | | |
| **17** | | **Mention the important requites of liner material.** | | **AU ND 2014** | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.3.1** | |
|  | | The important requites of liner material are abrasive wear and corrosive wear to prevent the corrosion. Because of these materials used in thermal system leads to effective resistance and improve the thermal conductivity. | | | | | | | | | | |
| **18** | | **State the purpose of providing piston in IC engines.** | | **AU ND 2014** | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | The purpose of providing piston in IC engines are:   * + It acts as a movable gas tight seal to keep the gases inside the cylinder.   + It transmits the force of explosion from the cylinder to the crankshaft through connecting rod. | | | | | | | | | | |
| **19** | | **Define the terms as applied to reciprocating I.C. engines "Mean effective pressure" and "Compression ratio".** | | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | Mean effective pressure: It is defined as the algebraic sum of the mean press acting on the piston during one complete cycle. Compression ratio: It is the ratio of volume when the piston is at BDC to the volume when the piston is at TDC. | | | | | | | | | | |
| **20** | | **What are the types of piston rings?** | | | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.4.1** | |
|  | | The types of piston rings are   * + Compression rings   + Oil rings   + The piston rings are made up of non-corrosive material, and it is used to prevent leakage in engine cylinder   . | | | | | | | | | | |
| **21** | | **Define delay period with respect to a CI engine.** | | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.4.1** | |
|  | | The physical delay period is the time between the beginning of injection and the attainment of chemical reaction conditions. During this period fuel is atomized, mixed with air and raised to its self-ignition temperature. During the chemical delay reactions start slowly add then accelerate until ignition takes place. | | | | | | | | | | |
| **22** | | **What is the purpose of providing spark plug in SI engine?** | | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** | |
|  | | The purpose of providing spark plug in SI engine is the function of a spark plug produce an electric spark for the ignition of compressed air-fuel mixture inside the engine cylinder. The spark is done in equal interval for working of engine. | | | | | | | | | | |
| **23** | | **What you mean by Scavenging in IC engine?** | | | | **Understand**  **BT-L2** | | **CO3** | | | **PI 1.4.1** | |
|  | | Scavenging is the process of replacing the exhaust gas in a cylinder of an internal combustion engine with the fresh air/fuel mixture (or fresh air, in the case of direct-injection engines) for the next cycle. ... Scavenging is equally important for both two-stroke and four-stroke engines | | | | | | | | | | |
| **24** | | **Define delay period with respect to a CI engine.** | | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.4.1** | |
| The physical delay period is the time between the beginning of injection and the attainment of chemical reaction conditions. During this period fuel is atomized, mixed with air and raised to its self-ignition temperature. During the chemical delay reactions start slowly add then accelerate until ignition takes place. | | | | | | | | | | | | |
| **25** | | **Name the stages of combustion in CI Engine.** | | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.4.1** | |
|  | | The four stages of combustion chamber in CI engine such as   * Ignition delay period, * Period of uncontrolled combustion, * Period of controlled combustion and * After burning | | | | | | | | | | |

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| **PART – B** | | | | | | |
| **1** | Explain a typical valve timing diagram and the significance of each angle. **(13)** | **AU AM 2017** | | **Understand**  **BT-L2** | **CO3** | **PI 1.4.1** |
| **2** | (i) Draw and explain the valve timing diagram of 4 stroke Diesel Engine. **(05)** | **AU-ND 2019** | | **Understand**  **BT-L2** | **CO3** | **PI 1.3.1** |
| (ii) Explain the main difference between a two stroke cycle and four stroke cycle internal combustion engine. **(08)** |
| **3** | (i) Draw the actual indicator diagram for four stroke diesel engine and list the major reason for the losses. **(05)** | **AU MJ 2019** | | **Remember**  **BT-L1** | **CO3** | **PI 1.3.1** |
| (ii) Describe the advantages and disadvantages of 2- strokes engines. (08) |
| **4** | (i) List the desirable properties of IC Engine fuels. **(05)** | **AU MJ 2019** | | **Understand**  **BT-L2** | **CO3** | **PI 1.3.1** |
| (ii)Write the combustion reaction for methane. Calculate the theoretical air to fuel ratio and composition of the products formed. **(08)** |
| **5** | Explain the construction and working principle of diesel reciprocating pump and fuel injector with neat sketch. **(13)** | **AU-ND 2017** | | **Understand**  **BT-L2** | **CO3** | **PI 1.4.1** |
| **6** | Explain a typical valve timing diagram and the significance of each angle. **(13)** | | **AU-AM 2018** | **Remember**  **BT-L1** | **CO3** | **PI 1.3.1** |
| **7** | Discuss compare between SI and CI engine. **(13)** | | | **Remember**  **BT-L1** | **CO3** | **PI 1.4.1** |
| **8** | Detailed explanation of properties and quality of fuels. **(13)** | | | **Understand**  **BT-L2** | **CO3** | **PI 1.4.1** |
| **9** | (i) With a neat sketch, explain the principle of work of diesel fuel injector.  **(05)**  (ii) A four-stroke, four-cylinder gasoline engine has a bore of 60 mm and a stroke of 100 mm. On test it develops a torque of 66.5 Nm when running at 3000 rpm. If the clearance volume in each cylinder is 60 CC, the relative efficiency with respect to brake thermal efficiency is 0.5 and the calorific value of the fuel is 42 MJ/kg, determine the fuel consumption in kg/h and the brake mean effective pressure. **(08)** | | | **Apply**  **BT-L3** | **CO3** | **PI 1.4.1** |
| **10** | Describe with sketches the following system of a modern carburetor, Main metering system, Idling system, Economizer system, Acceleration pump system, Choke. **(13)** | | | **Understand**  **BT-L2** | **CO3** | **PI 1.3.1** |
| **11** | Explain with the help of sketches ignition system for a SI. **(13)** | | | **Understand**  **BT-L2** | **CO3** | **PI 1.4.1** |
| **12** | List the various types of combustion chambers of a CI engine. Explain the principle of working of any one of the combustion chamber. **(13)** | | | **Remember**  **BT-L1** | **CO3** | **PI 1.3.1** |
| **13** | (a) Explain Normal and abnormal Combustion in SI engines. **(07)** | | | **Analyze**  **BT-L4** | **CO3** | **PI 1.4.1** |
| (b) What are the factors affecting he flame speed of the engine. **(06)** | | |
| **14** | (a) Explain four stages of combustion in CI engines. **(05)** | | | **Understand**  **BT-L2** | **CO3** | **PI 1.3.1** |
| (b) What are the factors affecting Ignition Delay and Delay Period? **(08)** | | | **Remember**  **BT-L1** |
| **15** | Analyse the effect of Octane and Cetane number on the I.C. Engine Cycle  and performance. **(13)** | | | **Analyze**  **BT-L4** | **CO3** | **PI 1.4.1** |
| **16** | What is Combustion of SI engine? Explain detail in stages of SI engine Combustion. **(13)** | | | **Understand**  **BT-L2** | **CO3** | **PI 1.3.1** |
| **17** | Compare and discuss the Knock in SI and CI Engines. **(13)** | | | **Apply**  **BT-L3** | **CO3** | **PI 1.4.1** |
| **PART-C** | | | | | | |
| **1.** | Explain knocking in CI engines. Draw the Time vs Pressure curve from SI Engine and SI engine. **(15)** | | | **Understand**  **BT-L2** | **CO3** | **PI 1.3.1** |
| **2.** | Construct the typical theoretical and actual Valve timing diagram for four stroke Otto cycle engine and the significance of each angle in the valve timing diagram. **(15)** | | | **Analyze**  **BT-L4** | **CO3** | **PI 1.4.1** |
| **3.** | Summarize the list of engine parts, material to be used and method of manufacture and its functions. **(15)** | | | **Analyze**  **BT-L4** | **CO3** | **PI 1.4.1** |

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| **UNIT-IV**  **INTERNAL COMBUSTION ENGINE PERFORMANCE AND SYSTEMS**  **PART – A** | | | | | | | | | | | | | | |
| **1** | **What do you mean by Clearence volume?** | | | **AU-ND 2018** | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.3.1** |
|  | The "Clearance volume" of the engine is the volume between the cylinder head and the piston when the piston is at tdc. The ratio of this volume to the swept volume determines the compression ratio of the engine. | | | | | | | | | | | | | |
| **2** | **What are the advantages in MPFI system?** | | | **AU MJ 2017** | | | | | **Understand**  **BT-L2** | | **CO4** | | | **PI 1.2.1** |
|  | The advantages of MPFI system are:   * + More uniform air-fuel mixture will be supplied.   + Vibrations are less.   + Mileage is high & No need to crank the engine. | | | | | | | | | | | | | |
| **3** | **Why do we feel the necessity of cooling an IC engine?** | | | **AU ND 2015** | | | | | **Understand**  **BT-L2** | | **CO4** | | | **PI 1.2.1** |
|  | The cooling system of an internal- combustion engine is very important. If the cooling system should fail, not only will the engine stop, but many of the parts are likely to be damage beyond repair. Coolant protects your engine from freezing or overheating. | | | | | | | | | | | | | |
| **4** | **What is the antifreeze solutions used in water cooling systems?** | | | **AU ND 2016** | | | | | **Remember**  **BT-L1** | | **CO3** | | | **PI 1.2.1** |
|  | The anti-free solutions used in water cooling system are:   * Denatured alcohol. * Glycerin.   Propylene Glycol & Ethylene. | | | | | | | | | | | | | |
| **5** | **What is meant by Motoring Test?** | | | | **AU ND 2016** | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.3.1** |
| In the motoring test, the engine is first run up to the desired speed by its own power and allowed to remain at the given speed and load conditions for some time so that oil, water, and engine component temperatures reach stable conditions. The fuel supply is then cut-off and by suitable electric-switching devices the dynamometer is converted to run as a motor to drive for ‘motor’ the engine at the same speed at which it was previously running is called motoring test. | | | | | | | | | | | | | | |
| **6** | **List the advantages of electronic ignition system over the conventional system.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.4.1** |
|  | * Less weight. * Compact * Spark timing can be accurately controlled. * Wiring is simple | | | | | | | | | | | | | |
| **7** | **Define the terms Mean effective pressure?** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | It is defined as the algebraic sum of the mean pressure acting on the during one complete cycle. | | | | | | | | | | | | | |
| **8** | **What is meant by highest useful compression ratio?** | | | | | | | | **Analyze**  **BT-L4** | | **CO4** | | | **PI 1.4.1** |
|  | The compression ratio which gives maximum efficiency is known as highest useful compression ratio. | | | | | | | | | | | | | |
| **9** | **Why compression ratio of petrol engines is low while diesel engines have high compression ratio?** | | | | | | | **Understand**  **BT-L2** | | | | **CO4** | | **PI 1.3.1** |
|  | Since fire point of petrol is less as compared to diesel, petrol engine has low compression ratio. | | | | | | | | | | | | | |
| **10** | **Which is better efficient two stroke or four stroke engines?** | | | | | | **Understand**  **BT-L2** | | | | **CO4** | | | **PI 1.3.1** |
|  | Two-stroke engine give always lesser efficiency than four-stroke engine due to incomplete combustion and poor scavenging. | | | | | | | | | | | | | |
| **11** | **Define Brake Power.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.4.1** |
|  | Brake power is the power output of the drive shaft of the engine without the power loss caused by gears, transmission, friction etc. it is also called as useful power or true power. | | | | | | | | | | | | | |
| **12** | **What is Specific Fuel Consumption?** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.3.1** |
|  | The mass flow rate of fuel required to produce a unit of brake power. SFC is expressed in SI units as kilograms per hour per kilowatt (kg/kW-hr). It allows engines of all different sizes to be compared to see which is the most fuel efficient. | | | | | | | | | | | | | |
| **13** | **Define the term of brake and indicated thermal efficiency of the engine.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | **Brake Thermal Efficiency** is the ratio of brake power output to power input. It is used to evaluate how efficient an engine converts the heat from a fuel to mechanical energy. It is expressed in percentage.  **Indicated thermal efficiency** is the ratio between the indicated power output of an engine and the rate of supply of energy from fuel. | | | | | | | | | | | | | |
| **14** | **What are the methods to improve efficiency of a diesel engine?** | | | | | | **Understand**  **BT-L2** | | | | **CO4** | | | **PI 1.3.1** |
|  | 1. By increasing the injection pressure 2. Increasing compression ratio 3. Increasing cut-off ratio. | | | | | | | | | | | | | |
| **15** | **What is the use of Heat balance Sheet?** | | | | | | **Understand**  **BT-L2** | | | | **CO4** | | | **PI 1.2.1** |
|  | Heat balance test is used to identify useful proportion of power output and various losses and thereby taking measures to minimize the losses for improving efficiency. | | | | | | | | | | | | | |
| **16** | **What is the use of Morse test?** | **AU-AM**  **2019** | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.4.1** |
|  | Morse test is adopted to find the indicated power of each cylinder of a high speed I C engine without using an indicator diagram. | | | | | | | | | | | | | |
| **17** | **State the methods to reduce NOx from a diesel engine.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.4.1** |
|  | * Low self-ignition temperature * Reduction of excess air * Use of catalytic converter | | | | | | | | | | | | | |
| **18** | **What are the methods to reduce NOx from a diesel engine.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | 1. Complete combustion (b) Avoiding rapid deceleration (c) Normal speed running | | | | | | | | | | | | | |
| **19** | **Define the term of “Carburation”.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.4.1** |
|  | The process of vapourizing the fuel (petrol) and mixing it with air outside the cylinder in the SI Engine is known as carburation. | | | | | | | | | | | | | |
| **20** | **What are the important requirements of the fuel injector?** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | * To inject the fuel into the engine cylinder by atomizing the fuel to the required degree. * To distribute the fuel such that there is a rapid and complete mixing of fuel and air. | | | | | | | | | | | | | |
| **21** | **Give the necessity of cooling in IC engine.** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.3.1** |
|  | 1. To avoid uneven expansion of the piston in the cylinder. 2. To reduce the temperature of piston and cylinder. 3. To avoid the overheating of the cylinder. 4. To avoid the physical and chemical changes in the lubricating oil. | | | | | | | | | | | | | |
| **22** | **What is Octane number?** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | Octane rating is a measure of a fuel's ability to resist 'knock'. The octane requirement of an engine varies with compression ratio, geometrical and mechanical considerations and operating conditions. The higher the octane number the greater the fuel's resistance to knocking or pinging during combustion | | | | | | | | | | | | | |
| **23** | **What are the main functions of Lubrication System?** | | **AU-AM**  **2019** | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.3.1** |
|  | a) It reduces friction between moving parts.  b) It reduces wear and tear of the moving parts.  c) It minimizes power boss due to friction. | | | | | | | | | | | | | |
| **24** | **What is the use of turbo charger?** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | A turbocharger consists of a compressor wheel and exhaust gas turbine wheel coupled together by a solid shaft and that is used to boost the intake air pressure of an internal combustion engine. The exhaust gas turbine extracts energy from the exhaust gas and uses it to drive the compressor and overcome friction. | | | | | | | | | | | | | |
| **25** | **What is the purpose of heat balance sheet?** | | | | | | | | **Remember**  **BT-L1** | | **CO4** | | | **PI 1.2.1** |
|  | Heat Balance Sheet is an account of heat supplied and heat utilized in various ways in the IC engine. Heat balance sheet is used to get necessary information regarding the performance of IC Engine. Heat balance sheet can be done on second basis or minute basis or hour basis | | | | | | | | | | | | | |
| **PART – B** | | | | | | | | | | | | | | |
| **1** | Explain the construction and working battery and magneto ignition system with neat sketch. **(13)** | | | | | **AU-AM 2018** | | | | **Remember**  **BT-L1** | | | **CO4** | **PI 1.4.1** |
| **2** | Explain the working of multipoint fuel injection system with block diagram. **(13)** | | | | | **AU-AM 2018** | | | | **Remember**  **BT-L1** | | | **CO4** | **PI 1.4.1** |
| **3** | (i) Explain the working of full pressure Lubrication system.  **(05)** | | | | | **AU-AM 2019** | | | | **Understand**  **BT-L2** | | | **CO4** | **PI 2.1.3** |
| (ii) Describe how turbocharging leads to high power output and the associated effects. **(08)** | | | | |
| **4** | (i) Describe the need for firing order with examples. **(05)** | | | | | **AU-AM 2019** | | | | **Remember**  **BT-L1** | | | **CO4** | **PI 2.1.3** |
| (ii)Describe the working of common rail direct injection systems.  **(08)** | | | | |
| **5** | Detailed explain the working of electronic ignition system & its types. **(13)** | | | | | | | | | **Apply**  **BT-L3** | | | **CO4** | **PI 2.1.3** |
| **6** | Detailed explanation of supercharger and turbocharger with neat sketch. **(13)** | | | | | | | | | **Apply**  **BT-L3** | | | **CO4** | **PI 2.1.2** |
| **7** | The following results refer to a test on a petrol engine,  Indicated power = 30 Kw  Brake power = 26 Kw  Engine speed = 1000 rpm  Fuel brake power/ hour = 0.35 kg, Calorific value of fuel = 43900kJ/kg  Calculate (i) The indicated Thermal efficiency,  (ii) Brake Thermal efficiency,  (iii) Mechanical efficiency. **(13)** | | | | | | | | | **Evaluate**  **BT-L5** | | | **CO4** | **PI 1.4.1** |
| **8** | A four cylinder 2 stroke cycle petrol engine develops 23.5 kW brake power at 2500 rpm. The mean effective pressure on each piston in 8.5 bar and mechanical efficiency in 85% Calculate the diameter and stroke of each cylinder assuming the length of stroke equal to 1.5 times the diameter of cylinder. **(13)** | | | | | | | | | **Analyze**  **BT-L4** | | | **CO4** | **PI 2.4.1** |
| **9** | The following data to a particular twin cylinder two stroke diesel engine. Bore 15 cm stroke. 20 cm. speed 400 rpm. Indicated mean effective pressure 4 bar, dead weight on the brake drum 650 N. spring balance reading 25 N Diameter of the brake drum 1 m .Fuel consumption 0.075 kg/min and calorific value of the fuel is 44500 kJ/kg. Determine  1. Indicated Power  2. Brake Power  3. Mechanical efficiency  4. Indicated thermal efficiency  5. Brake thermal efficiency **(13)** | | | | | | | | | **Evaluate**  **BT-L5** | | | **CO4** | **PI 2.1.1** |
| **10** | Calculate the diameter and length of the stroke of a diesel engine working on four stroke constant pressure cycle from the following data. I.P. 18.75kW, rotation per minute = 220, compression ratio = 14, Fuel cutoff = 1/20th of the stroke, Index of expansion = 1.3, index of compression = 1.35, Length/diameter = 1.5. Assume the pressure and temperature of the air at the inlet are 1 bar and 40C respectively. **(13)** | | | | | | | | | **Evaluate**  **BT-L5** | | | **CO4** | **PI 2.1.1** |
| **11** | Explain with neat sketch the splash and wet sump lubrication system. **(05)**  What are the advantages of wet sump lubrication system? **(08)** | | | | | | | | | **Understand**  **BT-L2** | | | **CO4** | **PI 1.3.1** |
| **12** | Explain the working of multipoint fuel injection system with block diagram.  **(13)** | | | | | | | | | **Remember**  **BT-L1** | | | **CO4** | **PI 2.1.3** |
| **13** | What are the emission norms followed in operating IC engine in India? **(13)** | | | | | | | | | **Remember**  **BT-L1** | | | **CO4** | **PI 1.4.1** |
| **14** | Write a note on Cooling system for an I.C. Engine in detail with relevant  Sketches of various types. **(13)** | | | | | | | | | **Understand**  **BT-L2** | | | **CO4** | **PI 1.3.1** |
| **16** | Following data relate to a 4-cylinder four stroke petrol engine. AF ratio by weight =16:1, Cv of the fuel = 45200 kJ/Kg, mechanical efficiency=82%, air standard efficiency=52%, relative efficiency=70%, volumetric efficiency=78%, Stroke/Bore ratio=1.25, suction conditions=1bar, 25ᵒC. Rpm=2400 and power at brakes = 72kW. Calculate i.)Compression ratio. ii.)Indicated thermal efficiency. iii) Brake Specific fuel consumption. **(13)** | | | | | | | | | **Evaluate**  **BT-L5** | | | **CO4** | **PI 2.1.3** |
| **17** | Air Consumption for a four stroke engine is measured by means of a circular orifice of diameter 3.5cm. The coefficient of discharge for the orifice is 0.6 and the pressure across the orifice is 14 cm of water. The barometer reads 760 mm of Hg. The temperature of air in the room is 24ᵒC. The piston displacement volume is 1800cm3. The compression ratio is 6.5. The fuel consumption is 0.13 kg/min and calorific value is 44,000 kJ/Kg. The brake power developed at 2500rpm is 28 KW. Determine, Air fuel ratio, volumetric efficiency on the basis of air alone, Brake Mean Effective pressure, Relative efficiency on brake thermal efficiency basis. **(13)** | | | | | | | | | **Apply**  **BT-L3** | | | **CO4** | **PI 2.1.3** |
| **18** | What do you mean by performance of IC engine? Discuss briefly the basic performance parameters. And also discuss with suitable sketch the brake rope dynamometer. **(13)** | | | | | | | | | **Understand**  **BT-L2** | | | **CO4** | **PI 1.3.1** |
| **PART-C** | | | | | | | | | | | | | | |
| **1.** | The following observations were made during the trail of single cylinder 4 stroke diameter 180mm and stroke of 240mm  Duration of trial =30 min  Total no of rev = 9000  Total no of explosions =4450  Gross imep= 5.35 bar  Pumping imep=0.35 bar  Net load on brake wheel=40 kg  Diameter of the brake wheel drum-0.96 m  Diameter of the rope =4 cm  Volume of gas used =2.6 m3  Pressure of gas =136mm water of gauge  Density of gas = 0.655 kg/m3  Ambient temperature=17ᵒC  Calorific value of gas at NTP=19MJ/m3  Total air used = 40m3  Pressure of air =720 mm Hg  Temperature of exhaust gas =340ᵒC  Specific heat of exhaust gas =1.1 kj/(kg K)  Cooling water circulated =80 kg  Rise in temperature of cooling water=30ᵒC  Draw up a heat balance sheet and estimate the mechanical and indicated thermal efficiencies of the engine. **(15)** | | | | | | | | | **Apply**  **BT-L3** | | | **CO4** | **PI 2.1.2** |
| **2** | Following data are available for a four stroke petrol engine: Air fuel ratio (by weight) 15:5:1  Calorific value of the fuel 45000 kJ/kg  Mechanical efficiency 80%  Air standard efficiency 53% Relative efficiency based on  Indicated thermal efficiency 70%  Volumetric efficiency 80%  Stroke/Bore ratio 1.25  Suction conditions 1 bar, 270C  Speed 2400 RPM  Power at brakes 75 kW Calculate:   * Compression ratio * Indicated thermal efficiency * Brake specific fuel consumption * Bore and stroke. **(15)** | | | | | | | | | **Analyze**  **BT-L4** | | | **CO4** | **PI 1.4.1** |
| **3.** | The following data refer to an oil engine working on Otto four-stroke cycle:  Brake power =14.7 kW  Suction pressure =0.9 bar  Mechanical efficiency =80%  Ratio of compression =5  Index of compression curve =1.35  Index of expansion curve =1.3 Maximum explosion pressure =24 bar Engine speed =1000 RPM  Ratio of stroke: bore =1.5 Find the diameter and stroke of the piston. **(15)** | | | | | | | | | **Evaluate**  **BT-L5** | | | **CO4** | **PI 1.4.1** |

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| **UNIT-V**  **GAS TURBINE**  **PART – A** | | | | | | | | | | | |
| **1** | **Distinguish between impulse and reaction turbine** | | **AU-AM 2018** | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
|  | |  |  |  | | --- | --- | --- | | **S No** | **Impulse turbine** | **Reaction turbine** | | **1** | Moving blades. | Fixed blades. | | **2** | Less Pressure drop | More Pressure drop | | **3** | High Efficiency | Low efficiency | | **4** | Slow Response | Quick Response | | | | | | | | | | | |
| **2** | **Define the term compounding in turbine** | | **AU-ND 2017** | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.4.1** |
|  | The method of absorbing the jet velocity in stages when the steam flows over the moving blades is known as compounding. To reduce the high speed more than the one set of blade are used, the steam jet velocity or steam pressures absorbed in this stages | | | | | | | | | | |
| **3** | **How does impulse work?** | | **AU-MJ 2014** | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.4.1** |
|  | The high velocity jet of steam which is obtained from the nozzle impinges on the blades fixed on a rotor. The blades change the direction of the steam flow without changing its pressure. This causes change in momentum and the force developed drives the turbine rotor. | | | | | | | | | | |
| **4** | **What fuel does a gas turbine use?** | | **AU-AM 2019** | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
|  | Combustible fuels for gas turbines encompass natural gas, process gas, low-Btu coal gas and vaporized fuel oil gas (Boyce 2002). Natural gas is the most preferred conventional fuel for propulsion of gas turbines. | | | | | | | | | | |
| **5** | **What is the effect of reheat on the Brayton cycle efficiency? And why?** | | | **AU-AM 2019** | | | **Understand**  **BT-L2** | | |  |  |
| A reheater is a heat exchanger that increase the power output without increasing the maximum operating temperature but it does not increase the efficiency of the cycle. | | | | | | | | | | | |
| **6** | **Name the three major components of a gas turbine engine.** | | | | | | | **Remember**  **BT-L1** | | **CO5** | **PI 1.4.1** |
|  | * Compressor, * Combustion system, * Gas producer turbine, and * Power turbine(Generator) | | | | | | | | | | |
| **7** | **Sketch a schematic diagram of a simple open cycle gas turbine engine** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.4.1** |
|  |  | | | | | | | | | | |
| **8** | **Sketch a schematic diagram and a T-s diagram of an open cycle gas turbine** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| C:\Users\Muninathan Kota\Desktop\Brayton.PNG C:\Users\Muninathan Kota\Desktop\Brayton1.PNG | | | | | | | | | | | |
| **9** | **Define work ratio.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| Work ratio defined as, which the work developed by the turbine is required or supplied to run the compressor, another ratio called Work Ratio is introduced in the study. Work ratio is defined as the ratio of the network (Wt – Wc) to the turbine work developed (W). | | | | | | | | | | | |
| **10** | **What are three methods of improving the part load performance of a gas turbine engine?** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| * Regeneration * Reheating * Water injection | | | | | | | | | | | |
| **11** | **Enumerate the five advantages of gas turbines over steam turbine.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.2** |
| * The mass of gas turbine per kW developed is less * It requires less space for installation * The starting of gas turbine is very easy and quick * Its control, with the changing load conditions, is easy. | | | | | | | | | | | |
| **12** | **What are the variables affecting the thermal efficiency of a gas turbine?** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.2.1** |
| * Gas turbine firing temperature * Pressure ratio * Intercooling | | | | | | | | | | | |
| **13** | **Difference between Closed and Open cycle gas turbine.** | | | | **Understand**  **BT-L2** | | | | **CO5** | | **PI 1.3.1** |
|  | | | | | | | | | | | |
| **14** | **Depict the influence of pressure ratio on the efficiency of a Brayton cycle?** | **AU-ND**  **2019** | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.2.1** |
| After the isentropic compression the pressure increase from P2 to P2ꞌ a shown in fig. the heat supplied Q1 and net work down W increases by an amount equal to the area 2-2ꞌ -3ꞌ -3- 2 whereas the heat rejection Q2 remains unchanged. Hence, the thermal efficiency of the cycle increases with increase in pressure ratio. | | | | | | | | | | | |
| **15** | **Discuss the merits of Gas Turbine over IC engines.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| * The torque produced is uniform. Thus no flywheel is required * The lubrication and ignition system are simple. * The mass of gas turbine per kW developed is less. * Its efficiency is higher. | | | | | | | | | | | |
| **16** | **What are the applications of gas turbines?** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| * It is used for electric power generation * It is used in aircrafts * It is used for supercharging for heavy duty diesel engines * It is used for locomotive propulsion and ship propulsion | | | | | | | | | | | |
| **17** | **Write down the expression for thermal efficiency of the open cycle gas turbines.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
|  | | | | | | | | | | | |
| **18** | **Classify the types of gas turbines.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.2** |
| **I. According to path of the working substance**  (a) Closed cycle gas turbines (b) Open cycle gas turbines. **II. According to process of heat obsorption.**  (a) Constant pressure gas turbines (b) Constant volume gas turbines.  **III. Thermodynamic (Gas Power) Cycle.**  (a) Brayton or Joule cycle (b) Atkinson cycle (c) Ericsson cycle | | | | | | | | | | | |
| **19** | **Name some liquid fuels used in the gas turbine.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| * Lean Methane. * Light Crude Oil (LCO) * Liquid Natural Gas (LNG) * Liquefied Propane Gas (LPG) * Medium Crude Oil. | | | | | | | | | | | |
| **20** | **What is jet propulsion? Give the classification of jet propulsion system.** | | | | **Understand**  **BT-L2** | | | | **CO5** | | **PI 1.3.1** |
| Jet Propulsion: This is done by expanding the gas which is at high temperature & pressure through the nozzle so that the gas with very high velocity leaves the nozzle giving thrust in opposite direction. - Principle is based on Newton’s Second & third law of motion. Jet propulsion – Classification (1) Atmospheric jet engines (breathing engine) -Turbojet engine - Turbo prop engines - Ram jet (2) Rocket engine (Non - breathing engine) | | | | | | | | | | | |
| **21** | **Draw constant pressure closed cycle gas turbine on P.V and T-S planes** | | | | **Understand**  **BT-L2** | | | | **CO5** | | **PI 1.3.1** |
|  | | | | | | | | | | | |
| **22** | **What is the function of regenerator in gas turbine?** | | | | **Understand**  **BT-L2** | | | | **CO5** | | **PI 1.3.1** |
| The function of regenerator is to exchange the heat from the exhaust gas to the compressed air for preheating before sending it to the combustion chamber. It increases fuel economy and thermal efficiency. | | | | | | | | | | | |
| **23** | **Why reheat is necessary in gas turbines?** | | | | **Understand**  **BT-L2** | | | | **CO5** | | **PI 1.3.1** |
| The reheater is necessary to increase the enthalpy of the exhaust gas coming from high pressure turbine. The reheater is placed between the H.P and L.P. | | | | | | | | | | | |
| **24** | **Define compressor Efficiency.** | | | | | **Remember**  **BT-L1** | | | **CO5** | | **PI 1.3.1** |
| Compressor efficiency is defined as the ratio of isentropic increase in temperature to the actual increase in temperature. | | | | | | | | | | | |
| **25** | **What is function of intercooler and where it is placed in gas turbine?** | | | | **Understand**  **BT-L2** | | | | **CO5** | | **PI 1.3.1** |
| The intercooler is placed between L.P and H.P compressor. It is used to cool the air coming out from the L.P compressor to its original temperature. | | | | | | | | | | | |

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| **PART – B** | | | | | | |
| **1** | In a closed gas turbine there is a two stage compressor and a two stage turbine. All the components are mounted on the same shaft. The pressure and temperature at the inlet of the first stage compressor are 1.5 bar and 20oC. The maximum cycle temperature and pressure are limited to 750 oC and 6 bar. A perfect intercooler is used between the two stage compressors and a reheater is used between the two turbines at 3 bar pressure. Gases are heated in the reheater to 750 oC before entering into the L.P turbine. Assuming the compressor and turbine efficiencies as 0.82. calculate, i. The efficiency of the cycle without regenerator ii. The efficiency of the cycle with a regenerator whose effectiveness is 0.70. The working fluid used in the cycle is air: for air: specific heat ratio = 1.4 and Cp=1.005 Kilo/Joule/kg K. **(13)** | **AU-AM 2019** | | **Apply**  **BT-L3** | **CO5** | **PI 2.4.1** |
| **2** | In a gas turbine the compressor takes in air at a temperature of 15oC and compresses it to four times the initial pressure with an isentropic efficiency of 82%. The air is then passed through a heat exchanger heated by the turbine exhaust before reaching the combustion chamber. In the heat exchanger 78% of the available heat is given to the air. The maximum temperature after constant pressure combustion is 600oC, and the efficiency of the turbine is 70%. Neglecting all losses except expect those mentioned, and assuming the working fluid throughout the cycle to have the characteristics of air find the efficiency of the cycle. Assume R = 0.287 kilo joule/kg K and gamma = 1.4 for air and constant specific heats throughout. **(13)** | **AU-ND 2019** | | **Analyze**  **BT-L4** | **CO5** | **PI 2.4.1** |
| **3** | Show that the optimum pressure ratio for maximum is equal to the square root of the maximum pressure ratio for the given minimum and maximum temperatures. **(13)** | **AU-AM 2019** | | **Apply**  **BT-L3** | **CO5** | **PI 2.4.1** |
| **4** | In a single impulse turbine the blade angles are equal and nozzle angle is 20ᵒ. The velocity co–efficient for the blade is 0.83. Find the maximum blade efficiency possible. If the actual blade efficiency is 90% of maximum blade efficiency, find the possible ration of blade speed to steam speed. **(13)** | | **AU ND 2017** | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.2** |
| **5** | A 50% reaction turbine (with symmetrical velocity triangles) running at 400 rpm has the exit angle of the blades as 20ᵒ and the velocity of the steam relative to the blades at the exit is 1.35 times the mean blade speed. The steam flow rate is 8.33kg/s and at a particular stage the specific volume is 1.381m3/kg. Calculate Suitable blade height, assuming the rotor mean diameter to be 12 times the blade height. **(13)** | | **AU MJ 2017** | **Evaluate**  **BT-L5** | **CO5** | **PI 2.4.1** |
| **6** | In a stage of Impulse reaction turbine operating with 50% degree of reaction, the blades are identical in shape. The outlet angle of the moving blade is 19o and the absolute discharge velocity of steam is 100 m/s in the direction 70° to the blades. If the rate of flow through the turbine is 15000 kg/hr, calculate the power developed by the turbine. **(13)** | | **AU ND 2016** | **Analyze**  **BT-L4** | **CO5** | **PI 2.1.2** |
| **7** | An impulse turbine having a set of 16 nozzles receives steam at 20 bar, 400° C. The pressure of steam at exist is 12 bar. if the total discharge Is 260 Kg/min and nozzle efficiency is 90% Find the cross sectional areas of each nozzle, if the steam has velocity of 80m/s at entry to the nozzle, find the percentage Increase In discharge. **(13)** | | **AU MJ 2016** | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.3** |
| **8** | Explain the method of governing in steam turbine. **(13)** | | **AU MJ 2015** | **Understand**  **BT-L1** | **CO5** | **PI 2.1.3** |
| **9** | Explain various type of compounding in Turbine. **(13)** | | **AU ND 2014** | **Understand**  **BT-L1** | **CO5** | **PI 2.1.3** |
| **10** | Derive the expression for work done in the open cycle gas turbine with regeneration and explain the importance of regeneration. **(13)** | | | **Remember**  **BT-L1** | **CO5** | **PI 2.1.3** |
| **11** | In a constant pressure open cycle gas turbine air enters at 1 bar and 200C and leaves the compressor at 5 bar. Using the following data: Temperature of the gas entering the turbine =6800C, the pressure loss in the compression chamber =0.1 bar, ɳcompressor = 85%, ɳturbine = 80%, ɳcombustion = 85%, γ=1.4, Cp=1.024 kJ/kg K for air and gas, Find a) The quantity of air circulation if the plants develops 1065 kW b)Heat supplied per kg of air circulation c)The thermal efficiency if the cycle, mass of the fuel may be neglected. **(13)** | | | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.2** |
| **12** | A gas turbine unit has a pressure ratio of 6:1 and maximum cycle temperature of 6100C. The isentropic efficiencies of compressor and turbine are 80% and 82% respectively. Calculate the power output in KW of an electric generator geared to the turbine when the air enters the compressor at 150C at the rate of 16kg/s. Take Cp=1.005kJ/kg K and γ=1.4 for the compression process, and take Cp=1.11kJ/kg K and γ=1.333 for the expansion process. **(13)** | | | **Analyze**  **BT-L4** | **CO5** | **PI 2.1.2** |
| **13** | A gas turbine unit receives air at 1 bar and 300K and compresses it adiabatically to 6.2 bar. The compressor efficiency is 88%.The fuel has a heating value of 44186kJ/kg and the fuel air ratio is 0.017kJ/kg of air. Take turbine internal efficiency is 90%.Calculate the work of turbine and compressor per kg of air compressed and thermal efficiency. For product of combustion, cp =1.147kJ/kg K and γ=1.333. **(13)** | | | **Apply**  **BT-L3** | **CO5** | **PI 2.4.1** |
| **14** | In an air standard regenerative gas turbine cycle the pressure ratio is 5. Air enters the compressor at 1 bar, 300 K and leaves at 490 K. The maximum temperature in the cycle is 1000K. Calculate the cycle efficiency, given that efficiency of the regenerator and adiabatic efficiency of the turbine are each 80%. Assume for air, the ratio for BT-4 Analyzing specific heats is 1.4. Also, show the cycle on T-S diagram. **(13)** | | | **Analyze**  **BT-L4** | **CO5** | **PI 2.1.1** |
| **15** | Find the required air fuel ratio in a gas turbine whose turbine and compressor efficiencies are 85% and 80% respectively. Maximum cycle temperature is 8750C. Working fluid is taken as air (Cp=1kJ/kgK and γ=1.4) which enters the compressor at 1 bar and 270C. The pressure ratio is 4. The fuel used has a calorific value of 42000kJ/kg. There is a loss of 10% of calorific value in the combustion chamber. **(13)** | | | **Apply**  **BT-L3** | **CO5** | **PI 2.4.2** |
| **16** | In a gas turbine cycle, air at atmosphere pressure is compressed adiabatically from 27º C and 1.01325bar to 5.741 bar and then the air absorbs heat from the exhaust gases at constant pressure at a rate of 84kJ per kg. The air is further expanded at constant pressure by the combustion of 0.012 kg of fuel per kg of air. The calorific value of fuel is 42000kJ/kg. The products of combustion are expanded adiabatically in the turbine to 1.01325 bar. Being exhausted with negligible velocity after yielding some of their heat to the air leaving the compressor. Cp for air = 1 kJ/kg K. **(13)** | | | **Analyze**  **BT-L4** | **CO5** | **PI 2.1.2** |
| **17** | The pressure ratio of an open cycle gas turbine power plant is 5.6. Air taken as 300C and 1 bar. The compression is carried out in two stages with perfect inter cooling in between. The maximum temperature of the cycle is limited to 7000C. Assuming the isentropic efficiency of each compressor stage as 85% and that of turbine as 90%, determine the power developed and efficiency of the power plant, if the air flow is 1.2kg/s. The mass of fuel may be neglected, and it may be assumed that Cp = 1.02kJ/kg K andγ = 1.41.**(13)** | | | **Apply**  **BT-L3** | **CO5** | **PI 2.4.1** |
| **18** | A gas turbine employs a HE with a thermal ratio of 72%. The turbine operates between the pressure of 1.01bar and 4.04 bar and the ambient temperature of 20°C. Isentropic efficiencies of the compressor and turbine are 80% and 85% respectively. The pressure drop on each side of the HE is 0.05 bar and in the combustion chamber is 0.14 bar. Assume combustion efficiency to be unity and calorific value of the fuel to be 41800 kJ/kg. Calculate the increase in efficiency due to the HE over that for simple cycle. Assume p is constant throughout and is equal to 1.024 kJ/kg K and assume γ =1.4. For simple cycle the air fuel ratio is 90:1 and for the HE cycle the turbine entry temperature is same as for simple cycle. **(13)** | | | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.2** |
| **PART-C** | | | | | | |
| **1.** | A 4500 kW gas turbine generating set operates with two compressor stages, the overall pressure ratio 9:1, a high pressure turbine is used to drive the compressor and a LP turbine drives the generator. The temperature of the gas at the entry to a HP turbine 625°C and the gases are reheated to 625°C after expansion in the first turbine. The exhaust gases leaving the LP turbine are passed through a heat exchanger to heat air leaving the HP stage compressor. The compressors have equal pressure ratio and the inter cooling is complete between the stages. The air inlet temperature to the unit is 20°C. The isentropic efficiency of each compressor stage is 0.8, and the isentropic efficiency of the each turbine stage is 0.85, and the HE thermal ratio is 0.8. A mechanical efficiency of 95% can be assumed for both the power shaft and compressor turbine shaft. Neglecting all the pressure losses and change in K.E. calculate, (i) The thermal Efficiency (ii) Work ratio of the plant (iii) Mass flow in kg/s. **(15)** | | | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.2** |
| **2.** | In a gas turbine the compressor takes in air at a temperature of 15°C and compresses it four times the initial pressure with an isentropic efficiency of 82%. The air is then passed through the HE heated by the turbine exhaust before reaching the combustion chamber. In the HE 78% of the available heat is given to the air. The maximum temperature after constant pressure combustion is 600°C and the efficiency of the turbine is 70%. Neglecting all the losses except those mentioned and assuming the working fluid throughout the cycle to have the characteristics of air and find the efficiency of the cycle. Assume R= 0.287 kJ/kg K and γ = 1.4 for air and constant specific heats throughout. **(15)** | | | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.2** |
| **3.** | In a closed cycle gas turbine there is a two stage compressor and a two stage turbine. All the components ate mounted on the same shaft. The pressure and temperature at the inlet of the first stage compressor are 1.5 bar and 20°C. The maximum cycle temperature and pressure are limited to 750°C and 6bar. A perfect intercooler is used between the two stage compressors and a re-heater is used between the two turbines. Gases are heated in the re-heater to 750°C before entering in to the L.P. turbine. Assuming the compressor and turbine efficiencies are 0.82, calculate, (i) Efficiency of the cycle without regenerator (ii) the efficiency of the cycle with regenerator whose effectiveness is 0.70. (iii) The mass of the fluid circulated if the power developed by the plant is 350 kW. The Working fluid used in the cycle is air. For air γ=1.4 and Cp=1.005 kJ/kg K. **(15)** | | | **Evaluate**  **BT-L5** | **CO5** | **PI 2.1.2** |







