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INSTITUTIONS

SASURIE
COLLEGE OF ENGINEERING
Approved by AICTE, New Delhi
Affiliated to Anna University, Chennai

Department : MECHANICAL
Subject Code & Name : ME3451 & TE
Class & Batch : II &
Semester : IV

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	Prepared By	Approved By
Sign:		
Name:	S.A.RAMESH	S.A.Ramesh
	Faculty	HoD

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CLASS TIME TABLE

Department of Mechanical Engineering

ACADEMIC 2023-2024 EVEN

YEAR / SEM : II / IV

4.3.2024

HOUR	I	II		III	IV		V	VI		VII	VIII
DAY/ TIME	9.00 AM to 9.50 AM	9.50 AM to 10.40 AM	10.40 AM to 10.55 AM	10.55 AM to 11.45 AM	11.45 AM to 12.35 PM	12.35 PM to 1.20 PM	1.20 PM TO 2.05 PM	2.05 PM TO 2.50 PM	2.50 PM TO 3.05PM	3.05 PM to 3.50 PM	3.50 PM to 4.30 PM
MONDAY	TE	TE	Break			Lunch			Break		
TUESDAY											
WEDNESDAY					TE						
THURSDAY							TE				
FRIDAY										TE	
SATURDAY											

S.No	Course Code	Course Name	Acronym	Name of the Staff & Dept.	Hours
1	ME3451	Thermal Engineering	TE	Mr.S.A.Ramesh/ AP/Mech	5
				TOTAL	48

	Prepared by	Verified by	Authorized by
Sign:			
Name:	O.D.Naveen	Mr.S.A.Ramesh	Dr.M.Vijayakumar
	TIME TABLE I/C	HOD / MECH	PRINCIPAL

ॐ

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Department of Mechanical Engineering

Students Name List

YEAR /SEM:II/IV

Academic Year :2023-2024

S.No.	Register Number	Name of the Student	H / D
1.	732422114001	Manikkavel V	H

S.A.

HOD/Mech Engg

Principal

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Department of Mechanical Engineering

Students Arrear List

YEAR /SEM:II/IV

Academic Year :2023-2024

S.No.	Register Number	Name of the Student	Number of Arrear
1.	732422114001	Manikkavel V	Nil

HOD/Mech Engg

Principal

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SUBJECT INFORMATION RECORD

Department : MECHANICAL ENGINEERING

Subject : TG

Year : II

Semester : IV

Last year handled by : S. A. Ramesh

Percentage of Result (last year) : 100%

Quality Objectives : 1. To learn the conson of T-G
2. To Evaluate perof Turbin
3. To analy working IC Eng

Reference Book :

1. P.K. NAG. Thermal Engineering

	Prepared by	Verified by
Sign:		
Name:	S A. Ramesh	S A. Ramesh
	Faculty	HOD

ME3451

THERMAL ENGINEERING

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

1 To learn the concepts and laws of thermodynamics to predict the operation of thermodynamic cycles and performance of Internal Combustion(IC) engines and Gas Turbines.
2 To analyzing the performance of steam nozzle, calculate critical pressure ratio
3 To Evaluating the performance of steam turbines through velocity triangles, understand the need for governing and compounding of turbines
4 To analyzing the working of IC engines and various auxiliary systems present in IC engines
5 To evaluating the various performance parameters of IC engines

UNIT I THERMODYNAMIC CYCLES 12

Air Standard Cycles – Carnot, Otto, Diesel, Dual, Brayton – Cycle Analysis, Performance and Comparison, Basic Rankine Cycle, modified, reheat and regenerative cycles.

UNIT II STEAM NOZZLES AND INJECTOR 12

Types and Shapes of nozzles, Flow of steam through nozzles, Critical pressure ratio, Variation of mass flow rate with pressure ratio. Effect of friction. Metastable flow.

UNIT III STEAM AND GAS TURBINES 12

Types, Impulse and reaction principles, Velocity diagrams, Work done and efficiency – optimal operating conditions. Multi-staging, compounding and governing. Gas turbine cycle analysis – open and closed cycle. Performance and its improvement - Regenerative, Intercooled, Reheated cycles and their combination.

UNIT IV INTERNAL COMBUSTION ENGINES – FEATURES AND COMBUSTION 12

IC engine – Classification, working, components and their functions. Ideal and actual : Valve and port timing diagrams, p-v diagrams- two stroke & four stroke, and SI & CI engines – comparison. Geometric, operating, and performance comparison of SI and CI engines. Desirable properties and qualities of fuels. Air-fuel ratio calculation – lean and rich mixtures. Combustion in SI & CI Engines – Knocking – phenomena and control.

UNIT V INTERNAL COMBUSTION ENGINE PERFORMANCE AND AUXILIARY SYSTEMS 12

Performance and Emission Testing, Performance parameters and calculations. Morse and Heat Balance tests. Multipoint Fuel Injection system and Common rail direct injection systems. Ignition systems – Magneto, Battery and Electronic. Lubrication and Cooling systems. Concepts of Supercharging and Turbocharging – Emission Norms

TOTAL :60 PERIODS

OUTCOMES: At the end of the course the students would be able to

1. Apply thermodynamic concepts to different air standard cycles and solve problems.
2. To solve problems in steam nozzle and calculate critical pressure ratio.
3. Explain the flow in steam turbines, draw velocity diagrams, flow in Gas turbines and solve problems.
4. Explain the functioning and features of IC engine, components and auxiliaries.
5. Calculate the various performance parameters of IC engines

TEXT BOOKS:

1. Mahesh. M. Rathore, "Thermal Engineering", 1st Edition, Tata McGraw Hill, 2010.
2. Ganesan.V, " Internal Combustion Engines" 4th Edition, Tata McGraw Hill, 2012.

REFERENCES:

1. Ballaney. P, "Thermal Engineering", 25th Edition, Khanna Publishers, 2017.
2. Domkundwar, Kothandaraman, &Domkundwar, "A Course in Thermal Engineering", 6th Edition, DhanpatRai& Sons, 2011.
3. Gupta H.N, "Fundamentals of Internal Combustion Engines", 2nd Edition Prentice Hall of India, 2013.
4. Mathur M.L and Mehta F.S., "Thermal Science and Engineering", 3rd Edition, Jain Brothers Pvt. Ltd, 2017.
5. Soman. K, "Thermal Engineering", 2nd Edition, Prentice Hall of India, 2011.

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

Department : MECHANICAL
Faculty Name : D SUVITHA
Subject Code & Title : GE3451 & Environmental science & Sustainability
Class : II

Date : 4/3/24
Semester : IV

LESSON PLAN

S.No.	Proposed		Details of Topic Covered	TA	Ref.	Actual		HOD
	Date	Period				Date	Period	
			UNIT I - ENVIRONMENT AND BIODIVERSITY					
1	4/3/24	3	Definition, scope and importance of environment, need for public awareness	1	1	4/3/24	3	
2	5/3/24	1	Concept of an ecosystem, Energy flow, ecological succession.	1	1	5/3/24	1	
3	6/3/24	8	Types of biodiversity: genetic, species and ecosystem diversity	1	1	6/3/24	8	
4	7/3/24	6	Values of biodiversity, India as a mega-diversity nation	1	1	7/3/24	6	
5	9/3/24	2	Hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man- wildlife conflicts	1	1	9/3/24	2	
6	12/3/24	1	Endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ	1	1	12/3/24	1	
			UNIT II - ENVIRONMENTAL POLLUTION					
7	13/3/24	7	Causes, effects and preventive measures of water soil pollution	1	2	13/3/24	7	
8	13/3/24	8	Causes, effects and preventive measures of air and noise pollution	1	2	13/3/24	8	
9	14/3/24	6	Solid, Hazardous waste management.	1	2	14/3/24	6	
10	14/3/24	7	E-Waste management	1	2	14/3/24	7	
11	16/3/24	2	Case studies on Occupational Health and Safety Management system (OHASMS).	1	2	16/3/24	2	
12	18/3/24	3	Environmental protection and Environmental protection acts.	1	2	19/3/24	3	
			UNIT III - RENEWABLE SOURCES OF ENERGY					
13	21/3/24	6	Energy management and conservation	1	1	21/3/24	6	
14	25/3/24	3	New Energy Sources: Need of new sources.	1	1	25/3/24	3	
15	28/3/24	6	Different types new energy sources	1	2	28/3/24	6	
16	1/4/24	3	Applications of- Hydrogen energy	1	2	1/4/24	3	
17	4/4/24	6	Ocean energy resources, Tidal energy conversion	1	2	4/4/24	6	
18	6/4/24	2	Concept, origin and power plants of geothermal energy.	1	2	6/4/24	2	

UNIT IV - SUSTAINABILITY AND MANAGEMENT								
19	8/4/24	3	Development , GDP ,Sustainability- concept, needs and challenges	1	2	8/4/24	3	
20	9/4/24	1	Economic, social and Environmental aspects of sustainability	1	2	9/4/24	1	
21	13/4/24	2	From unsustainability to sustainability- millennium development goals	1	2	13/4/24	2	
22	15/4/24	3	Sustainable protocols, Sustainable Development Goals targets,Sustainable indicators and intervention areas	1	2	15/4/24	3	
23	22/4/24	3	Climate change- Global, Regional and local environmental issues and possible solutions-case studies	1	2	22/4/24	3	
24	25/4/24	6	Concept of Carbon, Credit, Carbon Footprint, Environmental management in industry-A case study.	1	2	29/4/24	3	
UNIT V - SUSTAINABILITY PRACTICES								
25	29/4/24	4	Zero waste and R concept, Circular economy, ISO 14000 Series	1	1	29/4/24	4	
26	30/4/24	1	Material Life cycle assessment,Environmental Impact Assessment	1	2	30/4/24	1	
27	6/5/24	3	Sustainable habitat: Green buildings, Green materials,Energyefficiency, Sustainable transports.	1	2	9/5/24	6	
28	13/5/24	3	Sustainable energy: Non-conventional Sources,Energy Cycles	1	2	21/5/24	1	
29	23/5/24	6	Carbon cycle, emission and sequestration	1	2	25/5/24	2	
30	30/5/24	1	Green Engineering: Sustainable urbanization- Socio-economical and technological change	1	2	30/5/24	1	

Text Books:

1. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016
2. Gilbert M.Masters, Introduction to Environmental Engineering and Science", 2nd Edition, Pearson Education 2004.

References:

1. Dharmendra S. Sengar, „Environmental law", Prentice Hall of India PVT LTD, New Delhi, 2007.
2. Rajagopalan, R. „Environmental Studies-From Crisis to Cure", Oxford University Press, Third Edition 2015.

Teaching Aids (TA):

1 A. Black Board with Chalk
2 B. Over Head Projector
3 LCD Projector
4 Others (Field visit, Charts, Cutset Models)

	Prepared by	Verified by	Authorized by
Sign		S.A.M	
Name	D.Suvitha Faculty Incharge	S.A.RAMESH HOD	Dr.M.Vijaya Kumar Principal

TEST PLAN FOR SUBJECT

Subject : TE

Faculty: S.A.Ramesh

Semester : IV

Year: II

Department : MECHANICAL

S. No.	Description	Planned Date/Month	Actual Conducted Date / Month	Remarks
1.	UNIT TEST-1	1/4/24	1/4/24	
2.	UNIT TEST-1	24/4/24	24/4/24	
3.	UNIT TEST-3	13/5/24	13/5/24	
4.	UNIT TEST-4 MODEL Ex	27/5/24	27/5/24	

	Prepared by	Verified by
Sign:		
Name:	S.A.Ramesh	SA.Ramesh
	Faculty	HOD

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RESULT ANALYSIS OF TEST

Subject : TE

Class : II

Semester : IV

Date : 2/4/23

Department : Mechanical

Exam details & date : UNIT TEST -I 1/4/23

Faculty : S.A.Ramesh

Number of students : 01

No. of students attended : 01

No. of students absent : —

No. of students passed : 01

No. of students failed : 0

Percentage of failures : 0%

RESULT DATA:

Marks	0-25	26-50	51-75	76-90	91-100
No. of Students	—	—	—	1	—

	Prepared By	Approved By
Sign:		
Name:	S.A.Ramesh	S.A.Ramesh
	Faculty	HOD

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RESULT ANALYSIS OF TEST

Subject : TE

Date : 25/4/24

Class : II

Department : Mechanical

Semester : IV

Exam details & date : 24/4/24 UNIT TEST - III

Faculty : J.A.Ramesh

Number of students : 01

No. of students attended : 01

No. of students absent : -

No. of students passed : 01

No. of students failed : 0

Percentage of failures : 0%

RESULT DATA:

Marks	0-25	26-50	51-75	76-90	91-100
No. of Students	-	-	-	1	-

	Prepared By	Approved By
Sign:	SA	JA
Name:	J A. Ramesh	J A. Ramesh
	Faculty	HOD

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RESULT ANALYSIS OF TEST

Subject : TG

Class : II

Semester : IV

Date : 17/5/23

Department : Mechanical

Exam details & date : 13/5/23 & UNIT TEST III

Faculty : S.A.Ramesh

Number of students : 01

No. of students attended : 0

No. of students absent : 01

No. of students passed : –

No. of students failed : –

Percentage of failures : –

RESULT DATA:

Marks	0-25	26-50	51-75	76-90	91-100
No. of Students	–	–	–	–	–

	Prepared By	Approved By
Sign:	S A	S A
Name:	S.A.Ramesh	S.A.Ramesh
	Faculty	HOD

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RESULT ANALYSIS OF TEST

Subject : TE
Date : 28/5/23
Class : II
Department : Mechanical
Semester : IV
Exam details & date : MODEL EXAM - I
Faculty : S.A. Ramesh
Number of students : 01
No. of students attended : 01
No. of students absent : —
No. of students passed : —
No. of students failed : 01
Percentage of failures : 100%

RESULT DATA:

Marks	0-25	26-50	51-75	76-90	91-100
No. of Students	—	1	—	—	—

	Prepared By	Approved By
Sign:		
Name:	S.A. Ramesh	SA. RAMESH
	Faculty	HOD

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CORRECTIVE ACTION REPORT

Dept. : MECH
Year : II
Subject : TE
Semester : IV

S.No	Unit Test	Percentage of marks	Root Cause (Metrics)	Corrective Action	Deadline date	Remarks
1	UNIT TEST I	100%	–	–	–	–
2	UNIT TEST -II	100%	–	–	–	–
3	UNIT TEST -III	–	medical issue	–	–	–
4	MODEL EXAM	0%	–	motivate the student to study well	–	–

	Prepared By	Approved By
Sign:	S.A.	S A
Name:	S.A.Ramesh	S.A.Ramesh
	Faculty	HOD

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QUALITY OBJECTIVE MONITORING RECORD

Department : Mechanical Engineering

Year : II

Semester : IV

Subject : Thermal Engineering

S.No	Quality Objective	Unit Test-I		Unit Test-II		Unit Test-III		~~Unit Test-IV~~ MODEL		Unit Test-V	
		Expecting result	Obtained result	Expecting result	Obtained result	Expecting result	Obtained result	Expecting result	Obtained result	Expecting result	Obtained result
1	To learn above Turbine nozzle, SC Engines	100%	100%	100%	100%	100%	—	100%	0%	—	—

	Prepared By	Approved By
Sign:		
Name:	S.A. Ramesh	S.A. Ramesh
	Faculty	HOD

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DEPARTMENT OF MECHANICAL ENGINEERING

CONSOLIDATED MARK STATEMENT - TE

YEAR / CLASS : II MECH SEMESTER: IV

S.NO	REG.NO	NAME	Slip Test-1	Slip Test-2	INT- 1	INT- 2	INT- 3	MODEL EXAM
1	732422114001	MANIKKAVEL V	6	8	40	41	AB	42
	TOTAL NUMBER OF STUDENT		1	1	1	1	1	1
	NUMBER OF STUDENT PRESENT		1	1	1	1	0	1
	NUMBER OF STUDENT ABSENT		0	0	0	0	1	0
	NUMBER OF STUDENT PASS		0	0	1	1	0	0
	NUMBER OF STUDENT FAIL		1	1	0	0	0	1
	PASS PERCENTAGE		0	0	100	100	0	0

FACULTY HOD PRINCIPAL

Register Number: ☐☐☐☐☐☐☐☐☐☐☐☐

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Vijayamangalam, Tiruppur

Unit Test - I			**Date/Session**	**01.04.2024**	**Marks**	**50**
Course code	**ME3451**	**Course Title**	**Thermal Engineering**			
Regulation	**2021**	**Duration**	**1 Hours 30 Minutes**	**Academic Year**	**2023-2024**	
Year	**II**	**Semester**	**IV**	**Department**	**MECH**	

COURSE OUTCOMES	
CO1:	To learn the concepts and laws of thermodynamics to predict the operation of thermodynamic cycles and performance of Internal Combustion(IC) engines and Gas Turbines.
CO2:	To analyzing the performance of steam nozzle, calculate critical pressure ratio
CO3:	To Evaluating the performance of steam turbines through velocity triangles, understand the need for governing and compounding of turbines
CO4:	To analyzing the working of IC engines and various auxiliary systems present in IC engines
CO5:	To evaluating the various performance parameters of IC engines

Q.No.	**Question**	**CO**	**BTS**
	PART A **(Answer all the Questions 10 x 2 = 20 Marks)**		
1	What are the assumptions made in air standard cycle?	CO1	R
2	Define mean effective pressure and comment its application in internal combustion Engines.	CO1	U
3	What are the factors influencing the ideal Brayton cycle efficiency?	CO1	R
4	Define air standard cycle efficiency.	CO1	R
5	Define cut-off ratio	CO1	R
6	Write any four differences between Otto and Diesel cycle.	CO1	R
7	Define mean effective pressure as applied to gas power cycles	CO1	R
8	Define air standard efficiency..	CO1	U
9	What are the various types of gas power cycles?.	CO1	R
10	Draw an actual valve timing diagram of a four stroke diesel engine.	CO1	R
	PART B **(Answer all the Questions 2x 15 = 30 Marks)**		
11	A gas engine operating on the ideal cycle Otto cycle has a compression ratio of 6. The pressure and pressure and temperature at commencement of compression are 1 bar 27°C. Heat added during the constant volume combustion process is 1170kj/kg. Determine the peak pressure and Temperature, work output per kg of air and air standard efficiency assume Take for air Cv =0.717 kJ/kg K and γ=1.4forair.	CO1	R
12	Brief the working of Otto cycle with the help of p-V diagram, T-s diagram and derive the air standard efficiency of the cycle.	CO1	E

Course Faculty
(S.A.Ramesh)

HoD
(S.A.Ramesh)

Principal
(Dr.M.Vijayakumar)

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KEY HINT

Department : MECHANICAL ENGINEERING
Name of the Exam : UNIT TEST 1
Subject code/Subject's Name: ME3451 / THERMAL ENGINEERING
Date of the Exam : 01.04.2024

Part – A

1. **Assumptions Made in Air Standard Cycle:**
    - The working fluid is considered as a perfect gas, typically air, and its specific heats are assumed constant.
    - The combustion process is assumed to be replaced by heat addition from an external source, as the process is idealized.
    - All processes in the cycle are reversible.
    - There are no changes in mass in the cycle (closed cycle).
    - No losses due to friction or heat transfer with the surroundings.
2. **Define Mean Effective Pressure and Its Application in IC Engines:**
    - **Mean Effective Pressure (MEP):** It is the average pressure exerted on the piston during a cycle. MEP is used to compare engine performance and is calculated as: MEP=Work output per cycleDisplacement volume\text{MEP} = \frac{\text{Work output per cycle}}{\text{Displacement volume}}MEP=Displacement volumeWork output per cycle
    - **Application:** MEP is useful for assessing engine performance independent of the engine size and is an indicator of the engine's capacity to do work.
3. **Factors Influencing Ideal Brayton Cycle Efficiency:**
    - **Compression ratio:** Increasing the compression ratio improves the cycle efficiency.
    - **Specific heat ratio (γ):** Higher values of γ increase efficiency.
    - **Turbine and compressor efficiencies:** Ideal efficiencies assume no losses, but in practical cycles, the efficiency of these components affects the total cycle efficiency.
4. **Define Air Standard Cycle Efficiency:**
    - It is the efficiency of an idealized thermodynamic cycle assuming the working fluid is air and that processes are reversible. It represents the theoretical maximum efficiency of cycles like Otto, Diesel, and Brayton cycles.
5. **Define Cut-Off Ratio:**
    - In a Diesel cycle, the cut-off ratio rcr_crc is the ratio of the cylinder volume after combustion to the volume before combustion (i.e., when fuel injection stops): rc=V3V2r_c = \frac{V_3}{V_2}rc =V2V3 where V3V_3V3 and V2V_2V2 are the volumes at the end and start of combustion, respectively.
6. **Four Differences Between Otto and Diesel Cycles:**
    - **Compression Process:** Otto uses constant volume heat addition; Diesel uses constant pressure.
    - **Compression Ratio:** Otto cycle has a lower compression ratio than Diesel.
    - **Efficiency:** Otto is more efficient at lower compression ratios, while Diesel becomes more efficient at higher ratios.
    - **Applications:** Otto cycle is used in gasoline engines; Diesel is used in diesel engines, typically in heavier vehicles.
7. **Define Mean Effective Pressure for Gas Power Cycles:**
    - MEP in gas power cycles is defined similarly as in IC engines, representing the average pressure that would produce the same work output over the cycle as the actual varying pressures in the

- Air standard efficiency is the theoretical efficiency of a heat engine operating on an air standard cycle, representing the maximum achievable efficiency under idealized conditions.

9. **Types of Gas Power Cycles:**
   - Otto Cycle
   - Diesel Cycle
   - Dual Cycle (Combination of Otto and Diesel)
   - Brayton Cycle

10. **Valve Timing Diagram of a Four-Stroke Diesel Engine:**

- Drawing is necessary here, but in summary, it shows the timing of intake, compression, power, and exhaust strokes in a Diesel engine. The timing diagram illustrates when the valves open and close relative to piston position and crank angle.

Part – B

Question 11

For the Otto cycle with the following parameters:

- **Compression Ratio (r)** = 6
- **Initial Pressure (P1)** = 1 bar
- **Initial Temperature (T1)** = 27°C (or 300K)
- **Heat Added (Qin)** = 1170 kJ/kg
- **Specific Heat (Cv)** = 0.717 kJ/kg K
- **Specific Heat Ratio (γ)** = 1.4

Solution Outline:

- **Step 1:** Use T2=T1×r(γ−1)T_2 = T_1 \times r^{(\gamma - 1)}T2=T1×r(γ−1) to find T2T_2T2.
- **Step 2:** Calculate T3T_3T3 using Qin=m·Cv·(T3−T2)Q_{\text{in}} = m \cdot Cv \cdot (T_3 - T_2)Qin =m·Cv·(T3−T2).
- **Step 3:** Use ideal gas relations to find pressures P2P_2P2 and P3P_3P3.
- **Step 4:** Calculate work done per cycle and efficiency.

Question 12

Explanation of the Otto Cycle:

- The Otto cycle consists of two adiabatic (isentropic) and two constant volume processes.
- **Process 1-2:** Adiabatic compression (from intake to compressed state).
- **Process 2-3:** Heat addition at constant volume (combustion).
- **Process 3-4:** Adiabatic expansion (power stroke).
- **Process 4-1:** Heat rejection at constant volume (exhaust).

p-V Diagram: Illustrates the pressure-volume changes throughout the cycle.
T-s Diagram: Illustrates the temperature-entropy changes, showing heat addition and rejection.
Air Standard Efficiency:

- Derived as: η=1−1r(γ−1)\eta = 1 - \frac{1}{r^{(\gamma - 1)}}η=1−r(γ−1)1

where rrr is the compression ratio, and γ\gammaγ is the specific heat ratio.

Course Faculty
(S.A.Ramesh)

HoD
(S.A.Ramesh)

Principal
(Dr.M.Vijayakumar)

Register Number: ☐☐☐☐☐☐☐☐☐☐☐☐

SASURIE INSTITUTIONS

SASURIE
COLLEGE OF ENGINEERING
Vijayamangalam, Tiruppur

Unit Test - 2

Course code	ME3451		Date/Session	01.04.2024	Marks	50
		Course Title	Thermal Engineering			
Regulation	2021	Duration	1 Hours 30 Minutes	Academic Year	2023-2024	
Year	II	Semester	IV	Department	MECH	

COURSE OUTCOMES

CO1:	To learn the concepts and laws of thermodynamics to predict the operation of thermodynamic cycles and performance of Internal Combustion(IC) engines and Gas Turbines.
CO2:	To analyzing the performance of steam nozzle, calculate critical pressure ratio
CO3:	To Evaluating the performance of steam turbines through velocity triangles, understand the need for governing and compounding of turbines
CO4:	To analyzing the working of IC engines and various auxiliary systems present in IC engines
CO5:	To evaluating the various performance parameters of IC engines

Q.No.	Question	CO	BTS
	PART A **(Answer all the Questions 10 x 2 = 20 Marks)**		
1	What is steam nozzle?	CO2	A
2	Write about the function of nozzle	CO2	U
3	List the types of nozzle.	CO2	R
4	Define Convergent nozzle.	CO2	R
5	Define divergent nozzle.	CO2	R
6	Define Convergent-Divergent nozzle.	CO2	A
7	Draw the shape of supersonic nozzle.	CO2	R
8	List the effects of friction in nozzle	CO2	U
9	Define critical pressure ratio. Give its expression.	CO2	R
10	Define nozzle efficiency or coefficient of nozzle.	CO2	R
	PART B **(Answer all the Questions 2x 15 = 30 Marks)**		
11	Derive the condition for maximum flow rate in steam nozzle	CO2	R
12	Steam expands isentropic ally in a nozzle from 1 MPa, 250° C to 10 Kpa. The flow rate of the steam is 1 kg/s. Find the following when the inlet velocity is neglected, (i) Quality of steam, (ii) Velocity of steam at the exit of the nozzle, (iii) Exit area of the nozzle..	CO2	A

Course Faculty (S.A.Ramesh)	HoD (S.A.Ramesh)	Principal (Dr.M.Vijayakumar)

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SASURIE INSTITUTIONS

KEY HINT

Department : MECHANICAL ENGINEERING
Name of the Exam : UNIT TEST 2
Subject code/Subject's Name: ME3451 / THERMAL ENGINEERING
Date of the Exam : 22.04.2024

Part – A

1. **What is a Steam Nozzle?**
    - A steam nozzle is a passage of varying cross-sectional area through which steam expands, converting thermal energy into kinetic energy to produce high-velocity steam jets. This process is typically used in steam turbines and other applications where high-speed steam is required.
2. **Function of a Nozzle:**
    - The primary function of a nozzle is to convert the thermal energy of steam (or any gas) into kinetic energy. This increases the steam's velocity, making it useful for applications such as driving turbine blades, where the kinetic energy of the steam is converted into mechanical energy.
3. **Types of Nozzles:**
    - **Convergent Nozzle:** Decreases in cross-sectional area along the flow direction.
    - **Divergent Nozzle:** Increases in cross-sectional area along the flow direction.
    - **Convergent-Divergent Nozzle (C-D Nozzle):** First converges, then diverges, allowing supersonic flow at the outlet under specific conditions.
4. **Define Convergent Nozzle:**
    - A nozzle that decreases in cross-sectional area along the direction of flow. It accelerates subsonic fluid flow but cannot achieve supersonic speeds on its own.
5. **Define Divergent Nozzle:**
    - A nozzle that increases in cross-sectional area along the direction of flow. It is used primarily for supersonic flow conditions as it allows further expansion and acceleration of a supersonic fluid.
6. **Define Convergent-Divergent (C-D) Nozzle:**
    - A nozzle that first converges to a throat, where the flow reaches sonic speed, and then diverges to further accelerate the flow to supersonic speeds. This type of nozzle is commonly used in applications like rocket engines.
7. **Draw the Shape of a Supersonic Nozzle:**
    - The shape of a supersonic nozzle is a **convergent-divergent** shape, where the nozzle narrows down to a minimum cross-section (the throat) and then widens afterward. At the throat, the flow reaches Mach 1, and the divergent section further accelerates the flow to supersonic speeds.
8. **List the Effects of Friction in a Nozzle:**
    - Friction in a nozzle can lead to:
        - Loss of kinetic energy and lower exit velocity.
        - Increased entropy due to irreversibilities, reducing isentropic efficiency.
        - Decrease in overall nozzle efficiency.
        - Possible pressure losses, causing deviation from ideal expansion.
9. **Define Critical Pressure Ratio and Its Expression:**
    - The critical pressure ratio is the ratio of the downstream pressure to the upstream pressure at which the flow reaches the speed of sound (Mach 1) at the throat of a convergent-divergent nozzle.
    - For a perfect gas, the critical pressure ratio (PcriticalPinlet\frac{P_{\text{critical}}}{P_{\text{inlet}}}PinletPcritical) can be given by: PcriticalPinlet=(2γ+1)γγ−1\frac{P_{\text{critical}}}{P_{\text{inlet}}} = \left(\frac{2}{\gamma + 1} \right)^{\frac{\gamma}{\gamma - 1}}PinletPcritical=(γ+12)γ−1γ

10. Define Nozzle Efficiency or Coefficient of Nozzle:

- Nozzle efficiency (η_nozzle) measures how effectively the nozzle converts thermal energy into kinetic energy. It is defined as the ratio of actual kinetic energy obtained to the ideal kinetic energy without losses:
  ηnozzle=Actual kinetic energy at exitIdeal kinetic energy at exit\eta_{\text{nozzle}} = \frac{\text{Actual kinetic energy at exit}}{\text{Ideal kinetic energy at exit}}ηnozzle =Ideal kinetic energy at exitActual kinetic energy at exit

Part – B

Question 11: Derive the Condition for Maximum Flow Rate in a Steam Nozzle

Outline for Derivation:

- **Step 1:** For a convergent-divergent nozzle, derive the mass flow rate m˙=ρ·A·V\dot{m} = \rho \cdot A \cdot Vm˙=ρ·A·V at the throat where V=cV = cV=c, the speed of sound.
- **Step 2:** Use the isentropic flow relation to express the critical pressure ratio and establish the condition for maximum mass flow rate at the throat.
- **Step 3:** Show that the maximum mass flow rate is achieved when the pressure ratio between the inlet and the throat reaches the critical pressure ratio.

The key result to derive:

m˙max=Athroat·ρcritical·k·R·Tinlet\dot{m}_{\text{max}} = A_{\text{throat}} \cdot \sqrt{\rho_{\text{critical}} \cdot k \cdot R \cdot T_{\text{inlet}}}m˙max=Athroat·ρcritical·k·R·Tinlet

where ρcritical\rho_{\text{critical}}ρcritical is the density at critical conditions, and AthroatA_{\text{throat}}Athroat is the area at the throat.

Question 12

Given data:

- **Inlet Pressure (P1)** = 1 MPa
- **Inlet Temperature (T1)** = 250°C (or 523 K)
- **Exit Pressure (P2)** = 10 kPa
- **Mass Flow Rate** = 1 kg/s
- **Neglect Inlet Velocity**

Solution Outline:

- **Step 1:** Determine the quality of steam at the nozzle exit by calculating the enthalpy drop from inlet to exit (using steam tables or Mollier chart).
- **Step 2:** Calculate the velocity at the nozzle exit using the energy equation: h1=h2+V222h_1 = h_2 + \frac{V_2^2}{2}h1=h2+2V22 where h1h_1h1 and h2h_2h2 are the specific enthalpies at inlet and exit, and V2V_2V2 is the exit velocity.
- **Step 3:** Compute the exit area using the continuity equation: A2=m˙ρ2·V2A_2 = \frac{\dot{m}}{\rho_2 \cdot V_2}A2=ρ2·V2m˙ where ρ2\rho_2ρ2 can be calculated from the specific volume or steam tables for the given conditions.

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SASURIE COLLEGE OF ENGINEERING

Unit Test - 3

Course code	ME3451		**Date/Session**	14.05.2024	**Marks**	50
Regulation	2021	**Course Title**	**Thermal Engineering**			
Year	II	**Duration**	**1 Hours 30 Minutes**		**Academic Year**	**2023-2024**
		Semester	**IV**		**Department**	**MECH**

COURSE OUTCOMES

CO1:	To learn the concepts and laws of thermodynamics to predict the operation of thermodynamic cycles and performance of Internal Combustion(IC) engines and Gas Turbines.
CO2:	To analyzing the performance of steam nozzle, calculate critical pressure ratio
CO3:	To Evaluating the performance of steam turbines through velocity triangles, understand the need for governing and compounding of turbines
CO4:	To analyzing the working of IC engines and various auxiliary systems present in IC engines
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Q.No.	**Question**	**CO**	**BTS**
	PART A **(Answer all the Questions 10 x 2 = 20 Marks)**		
1	Define Steam turbine.		
2	Advantage of steam turbine over reciprocating steam engines.	CO2	A
3	Classify steam turbine according to the classification of flow.	CO2	U
4	Classification of steam Turbine	CO2	R
5	Define Impulse turbine.	CO2	R
6	How impulse turbine is classified?	CO2	R
7	What is meant by carry over loss?	CO2	A
8	What are the methods adopted to prevent erosion in steam turbines?	CO2	R
9	What is the purpose of compounding?	CO2	U
10	Distinguish between impulse and reaction turbine	CO2	R
	PART B **(Answer all the Questions 2x 15 = 30 Marks)**	CO2	R
11	Explain the pressure and velocity compounding diagram of multistage turbinewith neat sketch.	CO2	R
12	In a single stage impulse turbine, nozzle angle is 20° and blade angles are equal. The velocity coefficient for blade is 0.85. Find maximum blade efficiency possible. If the actual blade efficiency is 92% of the maximum blade efficiency, find the possible ratio of blade speed to steam speed.	CO2	A

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KEY HINT

PART A

INTERNAL TEST - III

1. **Define Steam Turbine:**
   - A steam turbine is a mechanical device that extracts thermal energy from pressurized steam and converts it into mechanical work. This work is typically used to drive a generator for electricity production.
2. **Advantages of Steam Turbine over Reciprocating Steam Engines:**
   - **Higher Efficiency:** Steam turbines operate with higher efficiency, especially in large-scale power generation.
   - **Smooth Operation:** They provide continuous rotary motion, reducing vibrations and wear compared to the reciprocating motion of steam engines.
   - **Higher Speed:** Turbines can operate at higher speeds, making them more suitable for power generation.
   - **Less Maintenance:** Due to fewer moving parts, steam turbines require less maintenance.
3. **Classify Steam Turbine According to the Classification of Flow:**
   - Based on the flow direction of steam, steam turbines are classified as:
     - **Axial Flow Turbine:** Steam flows parallel to the axis of rotation.
     - **Radial Flow Turbine:** Steam flows radially relative to the axis.
     - **Tangential Flow Turbine:** Steam enters tangentially to the blades.
4. **Classification of Steam Turbine:**
   - Steam turbines are classified as:
     - **Impulse Turbines:** Use the kinetic energy of steam jets directed onto blades to generate rotation (e.g., De Laval turbine).
     - **Reaction Turbines:** Utilize both the kinetic energy and pressure energy of steam as it expands across the rotor blades (e.g., Parsons turbine).
     - **Compounded Turbines:** Use combinations of impulse and reaction stages to manage speed and power (e.g., Curtis turbine).
5. **Define Impulse Turbine:**
   - An impulse turbine is a type of steam turbine where the steam expands and converts to kinetic energy in stationary nozzles before it impinges on the moving blades. The blades then redirect the steam flow, changing its direction to generate rotational motion.
6. **How is Impulse Turbine Classified?:**
   - Impulse turbines can be classified based on the arrangement of the stages:
     - **Single-stage Impulse Turbine:** Only one set of nozzles and blades.
     - **Multi-stage Impulse Turbine:** Multiple sets of nozzles and blades, often with compounding methods like pressure or velocity compounding.
7. **What is Meant by Carry-Over Loss?:**
   - Carry-over loss refers to the loss of kinetic energy when steam exiting one stage of a turbine enters the next stage at a speed higher than necessary, resulting in inefficiency.
8. **Methods Adopted to Prevent Erosion in Steam Turbines:**
   - **Use of erosion-resistant materials** on blades.
   - **Steam conditioning** to remove moisture and impurities before entering the turbine.
   - **Blade coating** or protective surface treatments to enhance blade durability.
   - **Flow control** to minimize areas of high-speed droplet impingement.
9. **Purpose of Compounding:**
   - Compounding reduces excessive rotor speed in turbines by dividing the steam expansion across multiple stages. This allows for controlled speed and improved efficiency, particularly in high-

    - **Impulse Turbine:** All pressure drop occurs in stationary nozzles, creating high-velocity steam jets. The moving blades change the steam's direction without a further pressure drop.
    - **Reaction Turbine:** Both the stationary and moving blades cause steam expansion and pressure drop, with the blades themselves shaped like small nozzles, allowing both kinetic and pressure energy to drive rotation.

Part B

Question 1: Pressure and Velocity Compounding in Multistage Turbines

Explanation:

- **Pressure Compounding:** In pressure compounding, the total pressure drop is divided among multiple stages of nozzles and blades. Each nozzle creates high-velocity steam jets by dropping the pressure, but only a portion of the total pressure drop. This helps control the velocity at each stage and reduces rotor speeds.
- **Velocity Compounding:** In velocity compounding, a single pressure drop is achieved in one stage, but multiple sets of moving and fixed blades reduce the velocity in steps. This method is often used for small turbines and helps manage high inlet velocities.

Diagram:

- Draw separate sketches for pressure and velocity compounding, showing how pressure and velocity vary across each stage.

Question 2: Efficiency and Blade Speed Ratio in a Single-Stage Impulse Turbine

Given data:

- Nozzle angle α=20∘\alpha = 20^\circα=20∘,
- Blade angles are equal,
- Blade velocity coefficient K=0.85K = 0.85K=0.85,
- Actual blade efficiency is 92% of maximum blade efficiency.

1. **Finding Maximum Blade Efficiency:**
    - The maximum blade efficiency (ηb\eta_bηb) for an impulse turbine is given by: ηb,max=2·cos 2α1+cos α\eta_{b,\text{max}} = \frac{2 \cdot \cos^2 \alpha}{1 + \cos \alpha}ηb,max=1+cosα2·cos2α
    - Substituting α=20∘\alpha = 20^\circα=20∘: ηb,max=2·cos 2(20∘)1+cos (20∘)\eta_{b,\text{max}} = \frac{2 \cdot \cos^2(20^\circ)}{1 + \cos(20^\circ)}ηb,max=1+cos(20∘)2·cos2(20∘)
        - Calculate cos (20∘)\cos(20^\circ)cos(20∘), plug into the formula to find ηb,max\eta_{b,\text{max}}ηb,max.
2. **Actual Blade Efficiency:**
    - Since the actual blade efficiency is 92% of the maximum, it can be calculated as: ηb,actual=0.92×ηb,max\eta_{b,\text{actual}} = 0.92 \times \eta_{b,\text{max}}ηb,actual =0.92×ηb,max
3. **Finding Blade Speed to Steam Speed Ratio:**
    - Blade speed uuu to steam speed VVV ratio can be found as: uV=K×ηb,actual2\frac{u}{V} = K \times \sqrt{\frac{\eta_{b,\text{actual}}}{2}}Vu=K×2ηb,actual
        - Substitute K=0.85K = 0.85K=0.85 and ηb,actual\eta_{b,\text{actual}}ηb,actual from the previous step to find the value of uV\frac{u}{V}Vu.

Course Faculty	**HoD**	**Principal**
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Register Number:

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MODEL EXAM			Date/Session	27.05.2024	Marks	100
Course code	ME3451	**Course Title**	**Thermal Engineering**			
Regulation	2021	**Duration**	3 Hours	**Academic Year**	2023-2024	
Year	II	**Semester**	IV	**Department**	MECH	

COURSE OUTCOMES

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Q.No.	Question	CO	BTS
	PART A **(Answer all the Questions 10 x 2 = 20 Marks)**		
1	Define the term stream nozzle.	CO1	R
2	What is the effect of friction on the flow through a stream nozzle?	CO2	U
3	Define boiler thermal efficiency.	CO1	R
4	What is safety valve? And define safety valve.	CO2	A
5	What is meant by Pressure Compounding?	CO1	R
6	Define stage efficiency & Diagram efficiency.	CO2	E
7	Explain how cogeneration is advantageous over conventional power plant.	CO3	R
8	Explain the principle of metallic recuperator & explain the term heat-to-power ratio.	CO3	E
9	Estimate the effect of super heat and sub cooling on the vapour compression cycle.	CO3	R
10	Compare RSHF, GSHF and ESHF.	CO3	U
	PART B **(Answer all the Questions 6x 13 = 65 Marks)**		
11a	. i. In a steam nozzle, the steam expands from 4 bar to 1 bar. The initial velocity is 60 m/s and the initial temperature is 200oC. Determine the exit velocity if the nozzle efficiency is 92%. ii. Describe (Derive) the expression for critical pressure ratio in terms of index of expansion.	CO1	R
	OR		
11b	Dry saturated steam at a pressure of 11 bar enters a convergent- divergent nozzle and leaves at a pressure of 2 bar. If the flow is adiabatic and frictionless, determine: (i) The exit velocity of steam. (ii) Ratio of cross section at exit and that at throat. Assume the index of adiabatic expansion to be 1.135.	CO1	U
12a	Explain the function of boiler mountings. Can a boiler work without mountings.	CO1	u
	OR		
12b	A boiler generates 13000 kg of steam at 7 bars during a period of 24 hrs and consume 1250 kg of coal whose CV. = 30000 kJ/kg. Taking the enthalpy of steam coming out of boiler = 2507.7 kJ/kg and water is supplied to the boiler at 40°C. Find: (a) efficiency of the boiler (b) Equivalent evaporation per kg of coal.	CO1	A
13a	A single stage impulse turbine rotor has a diameter of 1.2 m running at 3000 rpm. The nozzle angle is 18°. Blade speed ratio is 0.42. The ratio of the relative velocity at outlet to relative velocity at inlet in The outlet angle of the blade is 3° smaller than the inlet angle. The steam flow rate is 5 kg/s. Draw the velocity diagram and find the following	CO2	E

<table>
<tr><td colspan="4">OR</td></tr>
<tr><td>13b</td><td>A 50 % reaction turbine (with symmetrical velocity triangles) running at 400 rpm has the exit angle of the blades as 20° C and the velocity of steam relative to the blades at the exit is 1.35 times the mean speed of the blade. The steam flow rate is 8.33 Kg/s and at a particular stage the specific volume is 1.381 m^3/Kg. Evaluate for this stage. (i) A suitable blade height, assuming the rotor mean diameter 12 times the blade height and (ii) the diagram work</td><td>CO2</td><td>E</td></tr>
<tr><td>14a</td><td>i. Explain any three types of recuperators.
ii. What are waste heat recovery boilers? Explain the need and benefits?</td><td>CO2</td><td>U</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>14b</td><td>Explain in detail about low temperature Energy Recovery Options and Technologies.</td><td>CO3</td><td>A</td></tr>
<tr><td>15a</td><td>A refrigerating machine using R-12 as refrigerant operates between the pressures 2.5 bar and 9.0 bar. The compression is isentropic and there is not under cooling in the condenser. The vapour is dry and saturated condition at the beginning of the compression. Estimate the theoretical COP. If the actual COP is 0.65 of theoretical COP, calculate the net cooling produced per hour. The refrigerant flow is 5 Kg/min. The Properties of Refrigerant are:
<table>
<tr><td rowspan="2">Pressure (Bar)</td><td rowspan="2">Satu. temp. (C)</td><td colspan="2">Enthalpy (kJ/kg)</td><td>Entropy(kJ/kg K)</td></tr>
<tr><td>Liquid</td><td>Vapour</td><td>Vapour</td></tr>
<tr><td>9.0</td><td>36</td><td>70.55</td><td>201.8</td><td>0.6836</td></tr>
<tr><td>2.5</td><td>-7</td><td>29.62</td><td>184.5</td><td>0.7001</td></tr>
</table>
Take specific heat of superheated vapour at 9 bar as 0.64 kJ/kg K.</td><td>CO3</td><td>E</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>15b</td><td>Air at 25 °C WBT 25% RH is to be conditioned to 22 ° C. DBT and 11 gm / kg d.a. specific humidity. Determine heat transfer per kg of dry air referring the psychrometric chart. Represent the process on chart by sketch.</td><td>CO3</td><td>E</td></tr>
<tr><td colspan="4">PART C
(Answer all the Questions 1x 15 = 15 Marks)</td></tr>
<tr><td>16a</td><td>In an installation 5 kg/s of steam at 30 bar and 300°C is supplied to group of six nozzles in a wheel chamber maintained at 7.5 bar. Determine the dimensions of the nozzles of rectangular cross- sectional flow area with aspect ratio 3: 1. The expansion may be considered meta-stable and friction is neglected.Also calculate: degree of under-cooling and super-saturation ;loss in available drop due to irreversibility;, increases in entropy Ratio of mass flow rate with meta-stable expansion to that if expansion is in thermal equilibrium.</td><td>CO3</td><td>R</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>16b</td><td>In a boiler, the following observations were made: Pressure of steam= 10 bar
Steam condensed = 540 kg/h
Fuel used = 65 kg/h
Moisture in fuel = 2% by mass
Mass of dry flue gases = 9 kg/kg of fuel
Lower calorific value of fuel = 32000 kJ/kg
Temperature of the flue gases = 325°C
Temperature of boiler house = 28°C
Feed water temperature = 50°C
Mean specific heat of flue gases = 1 kJ/kg K
Dryness fraction of steam = 0.95 Draw up a heat balance sheet for the boiler.</td><td>CO3</td><td>U</td></tr>
</table>

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KEY HINT

Department : MECHANICAL ENGINEERING
Name of the Exam : Model Exam 1
Subject code/Subject's Name: ME3451 / THERMAL ENGINEERING
Date of the Exam : 27.05.2024

Part – A

1. **Define the Term Steam Nozzle:**
   - A steam nozzle is a device that allows steam to expand from high to low pressure, converting thermal energy into kinetic energy and increasing steam velocity. It is used in steam turbines to drive the blades.
2. **Effect of Friction on Flow Through a Steam Nozzle:**
   - Friction causes energy losses in a nozzle, reducing the exit velocity and the kinetic energy of the steam. It also increases entropy, reducing the efficiency of the nozzle.
3. **Define Boiler Thermal Efficiency:**
   - Boiler thermal efficiency is the ratio of the useful heat output in the steam to the energy input from the fuel. It is a measure of how effectively the boiler converts fuel energy into steam.
4. **What is a Safety Valve? Define Safety Valve:**
   - A safety valve is a device on a boiler that automatically releases steam when the pressure exceeds a certain limit, preventing overpressure and potential explosions.
5. **Define Pressure Compounding:**
   - Pressure compounding is a method used in steam turbines where the total pressure drop of steam is divided across multiple stages, allowing gradual expansion and reducing velocity at each stage.
6. **Define Stage Efficiency and Diagram Efficiency:**
   - **Stage Efficiency**: The ratio of actual work done in a turbine stage to the isentropic work.
   - **Diagram Efficiency**: The ratio of actual work output to the work represented on a velocity diagram, taking account of the losses in the stage.
7. **Advantages of Cogeneration Over Conventional Power Plants:**
   - Cogeneration systems produce both electricity and useful heat, increasing overall efficiency and reducing fuel consumption compared to conventional power plants, which only produce electricity.
8. **Principle of Metallic Recuperator and Define Heat-to-Power Ratio:**
   - A metallic recuperator transfers waste heat from exhaust gases to incoming air, enhancing thermal efficiency. **Heat-to-Power Ratio** is the ratio of the heat recovered to the electrical power output in cogeneration.
9. **Effect of Superheat and Subcooling on the Vapour Compression Cycle:**
   - **Superheating** increases the refrigerant's specific volume, raising refrigeration capacity but potentially reducing efficiency. **Subcooling** increases the cooling effect without increasing compressor work, thereby enhancing cycle efficiency.
10. **Compare RSHF, GSHF, and ESHF:**

- **RSHF (Room Sensible Heat Factor)**, **GSHF (Gross Sensible Heat Factor)**, and **ESHF (Effective Sensible Heat Factor)** are ratios that represent the balance between sensible and latent heat loads in air conditioning systems, reflecting different operational requirements and load distributions.

Part – B

Question 11(a)

1. **Exit Velocity in a Steam Nozzle:**
   - Given data: P1=4P_1 = 4P1=4 bar, P2=1P_2 = 1P2=1 bar, initial velocity V1=60V_1 = 60V1=60 m/s, T1=200∘CT_1 = 200^\circ CT1=200∘C, and nozzle efficiency η=92%\eta = 92\%η=92%.
   - Approach:
     - Find initial enthalpy, h1h_1h1, at 4 bar and 200°C (using steam tables).
     - Calculate enthalpy at 1 bar, h2h_2h2, considering isentropic expansion.
     - Use nozzle efficiency: V2=V12+2η(h1−h2)V_2 = \sqrt{V_1^2 + 2 \eta (h_1 - h_2)} V2 =V12+2η(h1−h2)
     - Substitute values to find V2V_2V2.
2. **Derivation for Critical Pressure Ratio:**
   - For a nozzle, critical pressure ratio PcriticalPinlet\frac{P_{\text{critical}}}{P_{\text{inlet}}}PinletPcritical can be derived as: (PcriticalPinlet)=(2γ+1)γγ−1\left(\frac{P_{\text{critical}}}{P_{\text{inlet}}} \right) = \left(\frac{2}{\gamma + 1} \right)^{\frac{\gamma}{\gamma - 1}}(PinletPcritical)=(γ+12)γ−1γ

where γ\gammaγ is the specific heat ratio, reflecting the sonic condition at the throat.

Question 11(b)

1. **Exit Velocity of Steam:**
   - For dry saturated steam, calculate the enthalpy drop using steam tables at 11 bar and 2 bar.
   - Use the energy equation to find Vexit=2(h1−h2)V_{\text{exit}} = \sqrt{2(h_1 - h_2)} Vexit=2(h1 −h2).
2. **Cross-Section Ratio (Exit/Throat):**
   - Use the continuity and energy equations with adiabatic expansion and properties at critical pressure to find the area ratio A2Athroat\frac{A_2}{A_{\text{throat}}}AthroatA2.

Question 12(a)

- **Boiler Mountings:** Explain mountings such as safety valves, water level indicators, and pressure gauges, which are essential for safe operation. A boiler cannot work safely without these mountings, as they provide necessary controls.

Question 12(b)

1. **Boiler Efficiency:**
   - Boiler Efficiency =Total Heat OutputTotal Heat Input×100%= \frac{\text{Total Heat Output}}{\text{Total Heat Input}} \times 100\%=Total Heat InputTotal Heat Output×100%.
   - Total heat output = mass of steam ×\times× enthalpy of steam.
   - Total heat input = mass of coal ×\times× calorific value.
2. **Equivalent Evaporation:**
   - Calculate equivalent evaporation per kg of coal based on the boiler's performance at standard conditions.

Question 13(a) and 13(b)

- In both questions, draw and analyze the velocity diagrams based on the given data for turbine rotor or reaction turbine parameters to find required blade angles, velocities, and power.

Question 14(a) and 14(b)

- **Recuperators:** Explain types such as shell and tube, plate, and rotary recuperators, along with benefits of waste heat recovery.

- **Low Temperature Energy Recovery**: Describe techniques such as absorption chillers and organic Rankine cycles.

Question 15(a)

1. **Theoretical COP:**
   - COP for an ideal refrigeration cycle =hevaphcomp−hevap= \frac{h_{\text{evap}}}{h_{\text{comp}} - h_{\text{evap}}}=hcomp−hevaphevap.
   - Use enthalpies from given data for compression and evaporation.
2. **Actual COP and Net Cooling:**
   - Adjust theoretical COP by actual performance, and calculate total cooling using refrigerant flow rate.

Part – C

Question 16(a)

1. **Nozzle Dimensions:**
   - Use mass flow, pressure, temperature, and meta-stable expansion principles to estimate nozzle area.
2. **Degree of Super-saturation and Under-cooling:**
   - Calculate based on the deviation from thermal equilibrium, and analyze entropy changes due to irreversibility.

Question 16(b)

- **Heat Balance Sheet:**
  - Include boiler output and losses in areas like flue gas, unburnt fuel, and moisture, calculating energy contributions based on specific fuel and operational data.

Course Faculty
(S.A.Ramesh)

HoD
(S.A.Ramesh)

Principal
(Dr.M.Vijayakumar)

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Internal Assessment Test Answer Book

Name	V.Manikkavel			**Year/ Semester/Section**	II/IV
Register Number	732420114001	**Date/Session**	22.04.2024	**Department**	BE MECH
Course code	ME3451	**Course Title**	Thermal Engineering		
Internal Assessment Test		**IAT 1** ☒	**IAT 2** ☑	**IAT 3** ☐	**Model** ☐
Name and Signature of the Invigilator with date					

Instruction to the Student: Put tick mark to the question attended in the column against question.

Part A			**Part B/ Part C**					**Total Marks**
Q. No.	✓	**Marks**	**Q. NO.**	✓	**a** **Marks**	✓	**b** **Marks**	
1	✓	2	11	✓	12			12
2	✓	2	12	✓	12			12
3	✓	2	13					
4	✓	2	14					
5	✓	2	15					
6	✓	2	16					
7	✓	2	**Grand Total**					24
8	✓	2	41 **Grand Total**			S.A. Ramesh S.A. Ramesh **Name and Signature of the Examiner with date**		
9	✓	01						
10		—						
Total		17						

To be filled by the examiner

Course Outcomes	1	2	3	4	5	6	Total
Marks allotted		50					50
Marks Obtained		41					41

IQAC Audit - Remarks

Name and Signature of the IQAC member

Name: V. Manikavavel Sub: Thermal Engineering

Reg No: 722422114001 Date: 22.04.2024

Dept: BE. MECH. Test: UNIT TEST-II

Part. B

$\frac{41}{50}$

(1) Given data:

$\alpha = 20^\circ$, $D = 3m$

$P = 50kW$, $N = 2500$ rpm

$n = 5$, $d = 10mm$

$P_1 = 15$ bar, $t_1 = 25^\circ C$

$P_2 = 0.5$ bar, $\delta y = 3N$

Sollution:

Blade velocity, $C_b = \frac{\pi DN}{60} = \frac{\pi \times 3 \times 2500}{60}$

$= 392.7 m/s$

From mollier diagram, corresponding to 15 bar and 25°C, read enthalpy of steam.

$h_1 = 2920$ kJ/kg

$h_2 = 2330$ kJ/kg

$x_2 = 0.86$

Heat drop $\Delta h = h_1 - h_2 = 2920 - 2330$

$\Delta h = 590$ kJ/kg

velocity of steam at inlet to the blade

$C_1 = \sqrt{2000 \times \Delta h} = \sqrt{2000 \times 590} = 1086.2$ m/s

$v_g = 2.24$ m³/kg

Area of each nozele.

$A = \frac{\pi}{4} d^2 = \frac{\pi}{4} (0.01)^2 = 7.85 \times 10^{-5}$ m²

Mass of steam discharged through the nozzle.

$$m = \frac{n A C_1}{x V_g}$$

$$= \frac{5 \times 7.85 \times 10^{-5} \times 1086.28}{0.86 \times 3.24} = 0.1531 \text{ kg/s}$$

$$\tan\theta = \frac{C_{f1}}{C_{w1} - C_b} = \frac{371.53}{1020.77 - 392.7}$$

$$\therefore \theta = 30^\circ 36'$$

$$C_{r1} = \sqrt{C_{f1}^2 + (C_{w1} - C_b)^2}$$

$$C_{r1} = \sqrt{371.53^2 + (1020.77 - 392.69)^2}$$

$$= 729.73 \text{ m/s}$$

Axial thrust $F_y = m(C_{f1} - C_{f2})$

$3 = 0.152\,(371.53 - C_{f2})$

$\therefore C_{f2} = 351.79\ m/s$

$$\tan\phi = \frac{C_{f2}}{C_b + C_{w2}}$$

$$= \frac{351.79}{3927 - 183.11}$$

$\therefore \phi = 59^\circ\ 12'$

$$C_{r2} = \sqrt{C_{f2}^2 + (C_b - C_{w2})^2}$$

$$= \sqrt{351.79^2 + (392.7 - 183.11)^2}$$

$= 409.49\ m/s$

Power lost due to friction.

$$= \frac{m(C_{r1}^2 - C_{r2}^2)}{2000}$$

12

$$= \frac{0.152\,(729.73^2 - 409.49^2)}{2000}$$

$\Rightarrow 27.73\ kW$

(2) **Given data:**

$P_1 = 2.8$ bar , $x = 0.976$

$C_1 = 125$ m/s , $\alpha_1 = \phi = 20^\circ$

$h = 22$ mm $= 0.022$ m , $m = 4.2$ kg/s

Tip leakage $= 5\%$

$\frac{C_{f1}}{C_b} = 0.72$, $\frac{C_{f2}}{C_b} = 0.77$

Solution:

$C_{f1} = C_1 \sin\alpha_1 = 125 \times \sin 20^\circ$

$= 42.75$ m/s

$$\frac{C_{f1}}{C_b} = 0.72$$

$$C_b = \frac{C_{f1}}{0.72} = \frac{42.75}{0.72} = 59.38 \text{ m/s}$$

$$\frac{C_{f2}}{C_b} = 0.77$$

$$\therefore C_{f2} = 0.77 \times C_b = 0.77 \times 59.38$$

$$= 45.72 \text{ m/s}$$

$$m = 4.2 - (4.2 \times 0.05) = 3.99 \text{ m/s}$$

from steam table at $p_1 = 2.00$ bar

$$V_g = v_s = 0646 \text{ m}^3/\text{kg}$$

we know that

$$m = \frac{\pi D_m h C_{f2}}{x v_s}$$

$$3.99 = \frac{\pi \times D_m \times 0.022 \times 45.72}{0.976 \times 0.646}$$

$$D_m = 0.7961 \text{ m} = 79.61 \text{ cm}$$

$C_{w1} = C_1 \cos \alpha = 125 \times \cos 20° = 117.46$

$$\tan \phi = \frac{C_{f2}}{C_b + C_{w2}}$$

$$C_b + C_{w2} = \frac{C_{f2}}{\tan \phi} = \frac{45.72}{\tan 20°} = 125.62 \text{ m/s}$$

$\therefore C_{w2} = 125.62 - 59.38 = 66.24$ m/s

$P = m(C_{w1} + C_{w2})C_b$

$= 3.99 \times (117.46 + 66.24) \times 59.38$

$= 43532$ W $= 43.52$ kW

Part - A

1) Types of nozzle:

1) convergent nozzle
2) Divergent nozzle
3) convergent - divergent nozzle.

2) Nozzle efficiency:

Nozzle efficiency = $\frac{\text{Actual enthalp}}{\text{Isentropic enthalpy drop}}$

3) Steam turbine:

~~for~~ Steam turbine is a device which is used to convert kinetic energy of steam into mechanical energy

4) Carryover loss:

They velocity of steam at exit is sufficiently high thereby resulting the kinetic energy loss called carryover loss.

5) The function of fixed blades is to guide the steam as well as to allow it for expansion to a larger velocity

6) Compounding is a method of absorbing the jet velocity in stages when the steam flows over moving blades.

7) 1) velocity compounding

(ii) 2) pressure compounding

3) pressure . velocity compounding

8)

the pressure is reduced in each stage or nozelo rings and hence the efficiency is low

9)

$$\eta_b = \frac{\text{work done on the blade}}{\text{Energy supplied to the blade}}$$

$$= \frac{2 C_b (C_{w_1} + C_{w_2})}{C_1^2}$$

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Internal Assessment Test Answer Book

Name	V.Manikkavel			**Year/ Semester/Section**	II | IV
Register Number	73242211100[illegible]	**Date/Session**	01/04.24	**Department**	BE.MECH
Course code	ME3451	**Course Title**	Thermal Engineering		
Internal Assessment Test		**IAT 1** ☑	**IAT 2** ☐	**IAT 3** ☐	**Model** ☐
Name and Signature of the Invigilator with date					

Instruction to the Student: Put tick mark to the question attended in the column against question.

Part A			**Part B/ Part C**					**Total Marks**
Q. No.	✓	**Marks**	**Q. NO.**	✓	**a** **Marks**	✓	**b** **Marks**	
1	✓	2	**11**	✓	11			11
2	✓	2	**12**	✓	12			12
3	✓	2	**13**					
4	✓	2	**14**					
5	✓	1	**15**					
6	✓	2	**16**					
7	✓	2					**Grand Total**	23
8	✓	1	40		S.A.Ramesh			
9	✓	1						
10	✓	2						
Total		17	**Grand Total**		**Name and Signature of the Examiner with date**			

To be filled by the examiner

Course Outcomes	1	2	3	4	5	6	Total
Marks allotted	50						50
Marks Obtained	40						40

IQAC Audit - Remarks

Name and Signature of the IQAC member

Name : V. Manikkavel
Reg No : 732422111001
Dept : BE.MECH

Sub : Thermal Engineering
Date : 01.04.2024
Test : UNIT - I

40/50

80%

Part - A

1)

=> The working medium is a perfect gas throughout. PV = mRT.

=> The operation of the engine is frictionless

=> Heat is supplied and rejected in a reversible manner.

=> Kinetic and potential energies of the working fluid are neglected.

2)

Mean effective pressure P_m = $\frac{\text{Work done}}{\text{Stroke volume (or) piston displacement volume.}}$

Mean effective pressure is defined as the constant pressure acting on the piston during working stroke.

3) 1) Isentropic compression

2) Constant volume heat addition

3) Constant pressure heat addition

4) Isentropic expansion

5) Constant volume heat rejection

2

4) Air standard cycle efficiency is defined as the series is of operations or process es performed on a system so that the system attains its original state.

2

5)

Cut - of ratio is defined as the ratio of volume after heat addition to the volume before ~~that~~ heat addition.

1

6) Otto cycle	Diesel cycle
1) Heat addition takes place at constant volume	1) Heat addition takes place at constant pressure.
2) compression ratio is equal to expansion ratio	2) Compression ratio greater than expansion ratio

2

7)

$$P_m = \frac{p_1 r^{\gamma}\left[\gamma(\rho-1) - r^{1-\gamma}(\rho^{r}-1)\right]}{(\gamma-1)(r-1)}$$

$$P_m = \frac{p_1 r^{\gamma}\left[k\gamma(\rho-1)+(k-1) - r^{1-\gamma}(k\rho^{\gamma}-1)\right]}{(\gamma-1)(r-1)}$$

8) Air standard efficiency is defined as the ratio of work done by the cycle to the heat supplied to the cycle.

9)

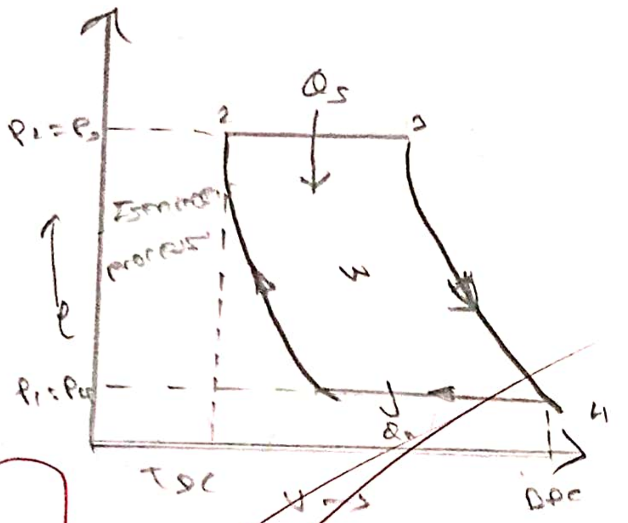
i) Heat supply is increased

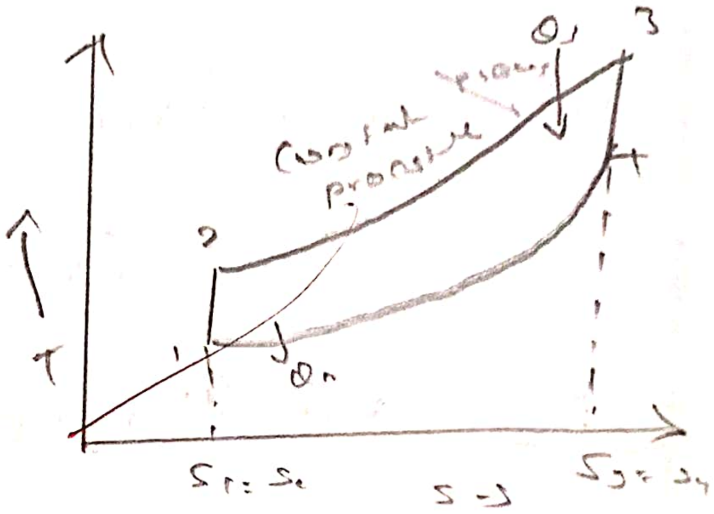
ii) It decreases the thermal efficiency

iii) work ratio will be increased

iv) Specific volume of air is reduced.

10)





Part-B

12) Otto cycle!

1) Reversible adiabatic (or) Isentropic compression process

2) constant volume heat addition process

3) Reversible adiabatic (or) isentropic expansion process

4) constant volume heat rejection process.

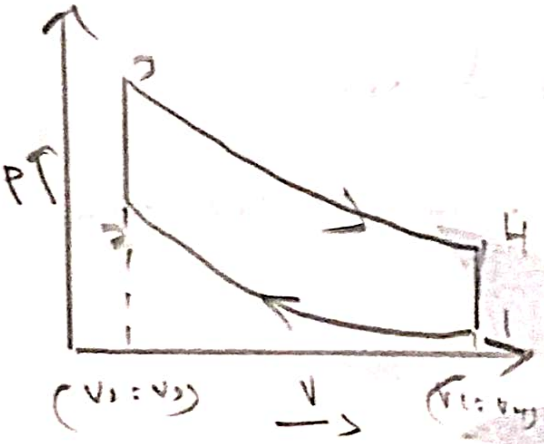
Process

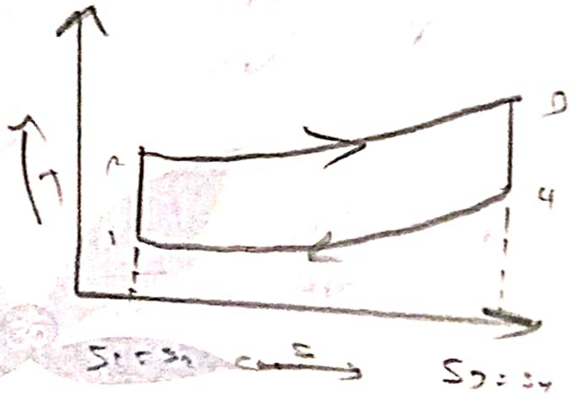
1-2 : Isentropic compression process

2-3 = Constant volume heat addition

3-4 = Isentropic expansion

4-1 = Constant volume heat rejection.





Process 1-2 :

$S_1 = S_2$

Process 3-4 :

$S_3 - S_4$

Process 2-3 :

$Q_s = mC_v (T_3 - T_2)$

Process 4-1 :

$Q_R = mC_v(T_4 - T_1)$

$W = Q_s - Q_R$

$= mc_v (T_3 - T_2) - mC_v (T_4 - T_1)$

$$\eta_{otto} = \frac{W}{Q_s} = \frac{mc_v [(T_3 - T_2) - (T_4 - T_1)]}{mC_v (T_3 - T_2)}$$

$$= \frac{(T_3 - T_2) - (T_4 - T_1)}{(T_3 - T_2)} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

Total volume $= V_1 = V_4$

Clearance volume $= V_c = V_2 = V_3$

Stroke volume $= V_s = V_1 - V_2 = V_4 - V_3$

Compression ration:

$$r = \frac{V_1}{V_2} = \frac{\text{Total volume}}{\text{Clearance volume}}$$

$$r = \frac{V_1}{V_2} = \frac{V_4}{V_3}$$

process 1-2:

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1} = (r)^{\gamma - 1}$$

$$T_2 = T_1 (r)^{\gamma - 1}$$

process 3-4:

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma - 1} = (r)^{P - 1}$$

$$T_3 = T_4 (r)^{\gamma - 1}$$

$$\eta_{otto} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

$$= 1 - \frac{T_4 - T_1}{T_4 (r)^{\gamma-1} - T_1 (r)^{\gamma-1}}$$

$$= 1 - \frac{1}{r^{(\gamma-1)}} \left(\frac{T_4 - T_1}{T_4 - T_1} \right)$$

$$\eta_{otto} = 1 - \frac{1}{(r)^{\gamma-1}}$$

Gas equation

$$Pv = mRT$$

$$P_1 V_1 = mRT_1 \qquad V_1 = \frac{mRT_1}{P_1}$$

Mean effective pressure:

$$P_m = \frac{\text{work done}}{\text{swept volume}}$$

$$= \frac{W}{V_1 - V_2}$$

Stroke (or) swept $= V_1 - V_2$

$$= V_1\left(1 - \frac{V_2}{V_1}\right) = V_1\left(1 - \frac{1}{r}\right)$$

$$= \frac{mRT_1}{P_1}\left(\frac{r-1}{r}\right) \qquad R = C_v(\gamma - 1)$$

$$= \frac{m C_v(\gamma-1) T_1}{P_1}\left(\frac{\gamma-1}{r}\right)$$

$$\frac{W}{V_1 - V_2} = \frac{mc_v(T_3 - T_2) - mC_v(T_4 - T_1)}{\frac{mc_v(\gamma-1)T_1}{P_1}\left(\frac{r-1}{r}\right)}$$

$$= \frac{P_1 r\left[mC_v(T_3 - T_2) - mC_v(T_4 - T_1)\right]}{mc_v(\gamma-1)T_1(r-1)}$$

$$= \frac{P_1 r\left[(T_3 - T_2) - (T_4 - T_1)\right]}{(\gamma-1)T_1(r-1)}$$

Process 1-2 $\quad T_2 = T_1(r)^{\gamma-1}$

2-3 : pressure ratio.

$$k = \frac{P_4}{P_1} = k\frac{P_3}{P_2}$$

$$\frac{T_3}{T_2} = \frac{P_3}{P_2} = k$$

$$T_3 = kT_2 \Rightarrow T_3 = kT_1 (r)^{(\gamma-1)}$$

process 4-1 $= T_4 = T_1 k$

$$P_m = P_1 r \left[\frac{(kT_2 - T_2) - (kT_1 - T_1)}{(\gamma-1)\, T_1 (r-1)} \right]$$

$$= P_1 r \left[\frac{(kT_1 (r)^{\gamma-1} - T_1 (r)^{\gamma-1} - (kT_1 - T_1)}{(\gamma-1)\, T_1 (r-1)} \right]$$

$$= P_1 r \left[\frac{T_1 (r)^{\gamma-1} [k-1] - T_1 (k-1)}{(\gamma-1)\, T_1 (r-1)} \right]$$

12

$$= P_1 \frac{r(k-1)}{\gamma-1} \left[\frac{(r)^{\gamma-1} - 1}{r-1} \right]$$

$$= P_1 r \left[\frac{k-1}{\gamma-1}\right]\left[\frac{(r)^{\gamma-1}-1}{r-1}\right]$$

iii)

Given data:

Cylinder diameter, $d = 20cm, 0.2m$

Stroke length, $l = 30cm, 0.3m$

Clearance volume, $V_c = 1600$ cu cm $= 1600cm$

$= 1600 \times 10^{-6} m^3 = 0.0016 m^3$

$P_1 = 1 bar = 100 kN/m^2$

$T_1 = 60°C$ ~~C~~ $= 333 K$

$P_3 = 24 bar = 2400 kN/m^2$

Solution:

Stroke volume, $V_s = \frac{\pi d^2}{4} \times l = \frac{\pi}{4} \times (0.2)^2 \times 0.3$

$= 0.00943 m^3$

Compression ratio, $r = \frac{V_1}{V_2} = \frac{V_c + V_s}{V_c} = \frac{0.0016 + 0.009}{0.0016}$

$= 6.89$

Air standard efficiency, $\eta = 1 - \frac{1}{(r)^{\gamma - 1}}$

$= 1 - \frac{1}{(6.89)^{1.4-1}} = 53.79\%$

Consider process 1-2 : adiabatic compression

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma}$$

$\therefore P_2 = P_1 \times \left(\frac{V_1}{V_2}\right)^{\gamma} = 100 \times (6.89)^{1.4}$

$= 1491.1 \text{ kN/m}^2$

$k = \frac{P_3}{P_2} = \frac{2400}{1491.1} = 1.61$

Mean effective pressure;

$$P_m = P_1 r \left(\frac{k-1}{\gamma-1}\right)\left(\frac{(r)^{\gamma-1} - 1}{r-1}\right)$$

$$= 100 \times 6.89 \times \left(\frac{1.61-1}{1.4-1}\right)\left(\frac{(6.89)^{1.4-1} - 1}{6.89-1}\right)$$

$$p_m = 207.68 \text{ kN/m}^2$$

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Internal Assessment Test Answer Book

Name	V.Manikavel			**Year/ Semester/Section**	II/IV		
Register Number	73242011400[illegible]	**Date/Session**	2705.2024	**Department**	BE.MECH		
Course code	ME3451	**Course Title**	Thermal Engineering				
Internal Assessment Test		**IAT 1** ☐	**IAT 2** ☐	**IAT 3** ☐	**Model** ☑		
Name and Signature of the Invigilator with date							

Instruction to the Student: Put tick mark to the question attended in the column against question.

Part A			**Part B/ Part C**					**Total Marks**
Q. No.	✓	**Marks**	**Q. NO.**	✓	**a** **Marks**	✓	**b** **Marks**	
1	✓	2	11	✓	11			11
2	✓	2	12					
3	✓	2	13					
4	✓	2	14					
5	✓	2	15					
6	✓	2	16	✓	14			14
7	✓	2	**Grand Total**					25
8	✓	2	42			**Name and Signature of the Examiner with date**		
9		—						
10	✓	1						
Total		17	**Grand Total**					

To be filled by the examiner							
Course Outcomes	1	2	3	4	5	6	Total
Marks allotted	32	32	36	-	-	-	100
Marks Obtained	17	06	19	-	-	-	42

IQAC Audit - Remarks

Name and Signature of the IQAC member

D.P 27/5/24

PAGE NO.
DATE : / /

MODEL EXAM-I

Name: V. ManiKKavel
Reg No: 732422114001
Dept: BE. Mech / II
Sub: Thermal Engineering
Sub code: ME3451
Date: 27.05.2024
Exam: Model exam-I

42/100

S.A.

Part-A

1) Assumptions of air standard cycle:

=> working of cycle is a perfect a gas

=> It is follows a law of Pv = mRT

=> The process of compression and expansion is a reversible adiabatic process.

2

=> The air standard cycle is a eiror of a the process is neglected.

2) Mean effective pressure:

Mean effective pressure is defined as a pressure the position during the working stroke. ~~It~~ is determined the work done to the stroke volume (or) piston constant volume

Mean effective pressure

$$P_m = \frac{\text{work done}}{\text{stroke volume (or) piston constant volume}}$$

2

3) Critical pressure ratio:

Critical pressure ratio is defined as the pressure ratio which will accelerate the velocity of the motion to the local velocity of's sound in the steam. It is the ratio is flow through the nozzle is critical pressure.

2

4) Nozzle efficiency:

Nozzle efficiency is defined as the coefficient of the nozzle obtained the actual enthalpy drop to the isentropic enthalpy drom between the same pressure.

2

$$\text{Nozzle efficiency} = \frac{\text{actual enthalpy drop}}{\text{Isentropic enthalpy drop.}}$$

5) Steam Turbine:

Steam Turbine is defined as the which the rotary motion of the ~~co~~ coefficient in the nozzle steam. It is entered the coefficient ~~a~~ friction in the steam volume.

6)

S.No	Particulars	Impulse turbine	Reaction Turbine
1)	Blades	Profile Type	Aerofoil Type
2)	Actual blade channel	Constant	Varying
3)	Admission of blades	Not all round	All round (or) Complete
4)	~~Steam~~ power	Not will can be devdoped	will can be developed
5)	Efficiency	low	high

2

7) Uses of carburetor:

The carburetor will help to the air and fuel mixture of consumption. It is used to air and fuel mixture for the engines.

2

8) Homogeneous mixtures:

Homogenous mixture is literal to the air and fuel is correct mixture in the consumption.

Hetero geneous mixtures:

Heterogeogeous mixtures is literal so the air and fuel is ~~not~~ in crorect or ~~in~~ in property mixture in the consumption.

2

10) Swept volume:

Swept volume is defined as the standard efficiency equal to the volumetric efficiency less swep volume.

Standard efficiency = volumetric efficiency
− Swept volume.

Part-B

(1)
a) Given:

$Q_{s2} = Q_{s1} \times 2$

$r = 8$

$P_1 = 5.3$

$T_1 = 27^\circ = T_1 = 27 + 273 = 300K$

$P_1 = 1$ bar

$C_p = 1.004$ kJ/kgK

$C_v = 0.717$ kJ/kgK

Solution:

$$V_1 = \frac{RT_1}{P_1} = \frac{283 \times 300}{0.9}$$

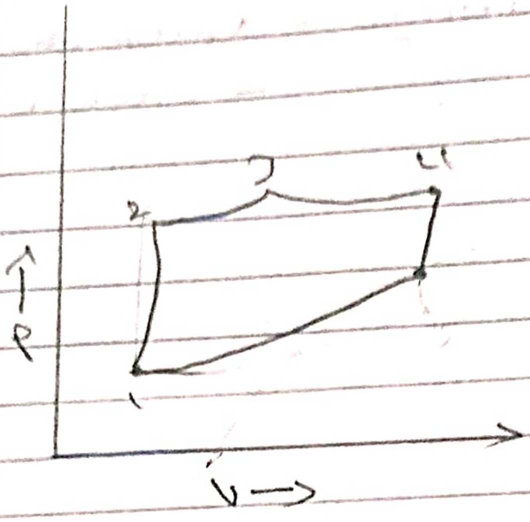
$$= 0.93 \text{ m}^3/\text{kg}$$

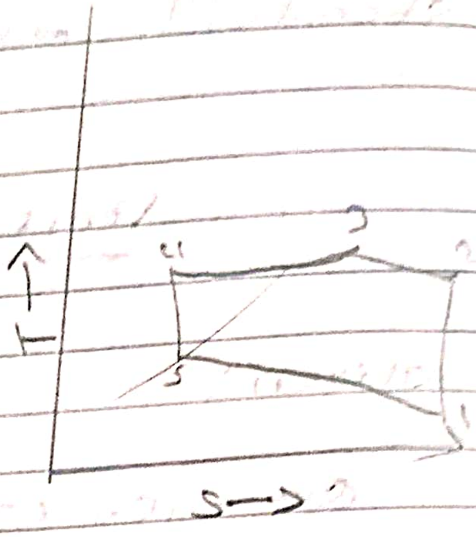
$$V_2 = \frac{V_1}{r} = \frac{0.93}{8}$$

$V_2 = 0.12 \text{ m}^3/\text{kg}$

$V_3 = V_2 = 0.12 \text{ m}^3/\text{kg}$

I, ued





Process 1-2 ⇒ Isentropic Compression

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = (r)^{\gamma}$$

$$P_2 = (r)^{\gamma} \times P_1 .$$

$$P_2 = (8)^{1.4} \times 0.9$$

$$P_2 = 17.2 \text{ bar}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1} = (r)^{\gamma - 1}$$

$$T_2 = (r)^{\gamma - 1} \times T_1$$

$$= (8)^{1.4-1} \times 300$$

$$= (8)^{0.4} \times 300$$

$$T_2 = 689.22 \quad K$$

Process 4-5 ⇒ Isentropic expansion.

$$\frac{V_3}{V_4} = 5.3$$

$V_4 = ~~4~~ \cdot 5.3 \times V_3$

$V_4 = 0.18 \, m^3/kg$

$T_4 \left(\frac{V_4}{V_3}\right) \times 2 = 1.527$

$Q_{s2} = 2 \times Q_{s1}$

$C_p(T_4 - T_3) = 2 \times C_v(T_3 - T_2)$

$1.005(1.5 \times T_3 - T_3) = 2 \times 0.717 (T_3 - 689.22)$

$T_3 = 1060.23 \, K$

$W = \eta \times Q_s = 430 \times 1.56$

$W = 0.5382$

Mean effective pressure:

$$P_m = \frac{W}{V_1 - V_2} = \frac{0.5382}{0.93 - 0.12}$$

$P_m = 5.3$ bar.

Part-C

16)

a) Types Gaseoline injection System:

The injection system is the petrol fuel in the air mixture in a Gaseoline System.

They are two type of injection system

~~Multi~~ ~~Point~~ fuel ~~injecti~~

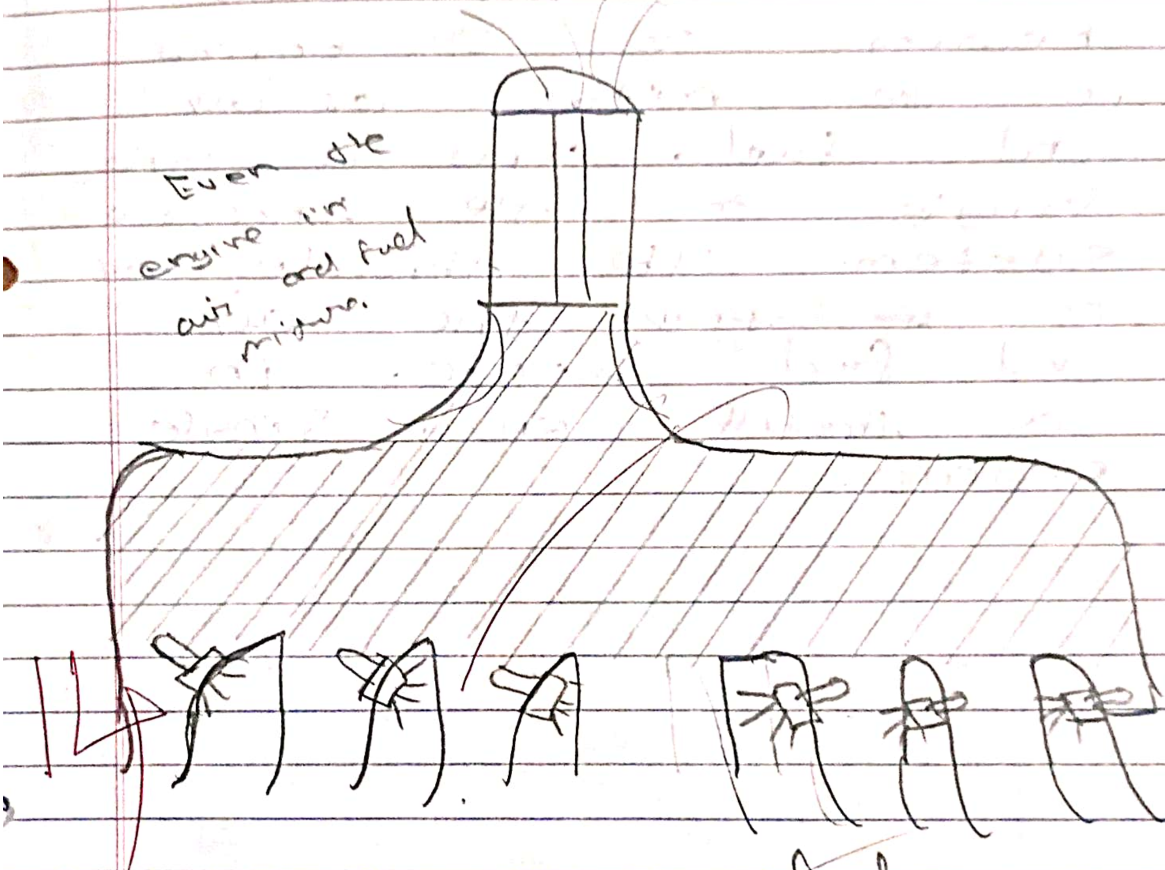
1) Multi point fuel injection System

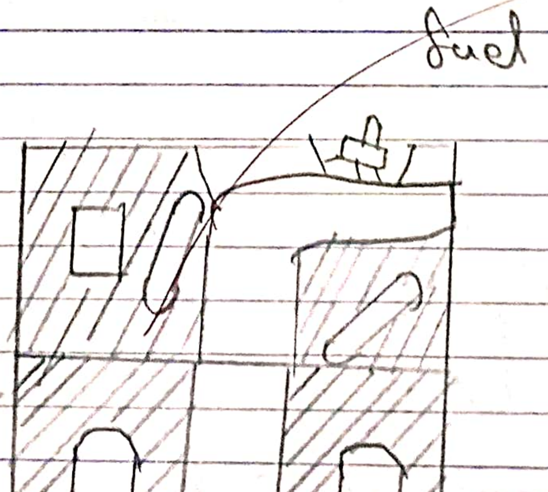
2) Mono point (or) Single point fuel, injection system.

1) Multi point fuel injection system.

Multi point fuel injection system is port injection system. It is a even engine in air and fuel suply is even to the engines. the air and fuel mixtures are even the engines.

The main advantages or mult fuel injection system is air and fuel is properly mixture in to the even engines.

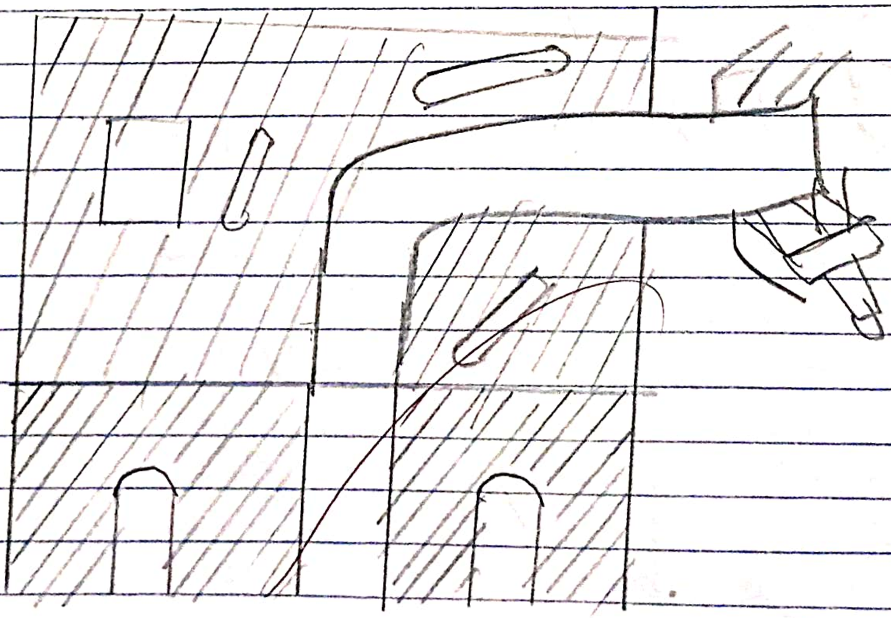




Multi port

2) Mono point (or) Single point fuel injection system:

Mono point fuel injection system is a throttle point injection system. The throttle is nearing to the engine in the mixture of air and fuel. This a single single to the throttle system. The throttle point is ~~gip~~ spray the air and fuel mixture. in a throttle ~~engi~~ single engine.



Mono point fuel injector system.

Name: V.Manikkavel Sub: Thermal Engineering
RegNO: 732422114001 Subcode: ME3451
Dept: BE.MECH / II

06/25

S.A.

Slip test - 1

1) Air Standard cycle efficiency:-

It is the efficiency of an idealized thermodynamic cycle assuming the working fluid is air and that process are reversible.

2) Cut-off Ratio:-

In a Diesel cycle, the cut-off ratio rcr ..erc is ratio of the cylinder volume after combustion to the volume before combustion. The volumes at the end and start of combustion respectively.

3) Mean effective Pressure:-

MEP in gas power cycle is defined similarly as in IC engine representing the average pressure that would produce the same work output over the cycles.

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Slip test - II

1) Types of Gas power cycles :-

=> otto cycle

=> Diesel cycle

=> Dual cycle

=> Brayton cycle.

2)

=> compression ratio :

=> specific heat ratio

=> turbine and compressor efficiencies.

=> All processes in the cycle are reversible

=> there are no changes in mass in the cycle.

=> No losses due to friction (or) heat transfer with the
2 Surroundings.

4) Application of MEP:-

MEP is useful for assensing engine performance independent of the engine size and is an indicator of the engine's capacity to do work.

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Department of Mechanical Engineering

ASSIGNMENT SCHEDULE

S.No	Particulars	Target Date
1	ASSIGNMENT - I	22/4/24
2	ASSIGNMENT - II	27/5/24
3		

	Prepared by	Verified by
Sign		
Name	S.A. Ramesh	S.A. Ramesh
	Faculty	HOD

ॐ

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DEPARTMENT OF MECHANICAL ENGINEERING

Assignment Question Paper

Assignment – 01			Date of Issue:	01/04/2024	Marks	10
Course code	ME3451	Course Title	Thermal Engineering			
Year	II YEAR	Semester/Section	04	Date of Submission:	22/04/2024	

Q.No	Questions	CO
1	Steam turbine develops 185 kW with a consumption of 16.5 kg/kW/h. The Pressure and temperature of the steam entering the nozzle are 12 bar and 220º C. The steam leaves the nozzle at 1.2 bar. The diameter of the nozzle at throat is 7mm, Find the number of nozzles. If 8% of the total enthalpy drop is lost in friction in the diverging part of the nozzle, determine the diameter at the exit ofthe nozzle and the exit velocity of the leaving steam. Sketch the skeleton Mollier diagram and show on it the values of pressure, temperature or dryness fraction, enthalpy and specific volume at inlet, throat and exit.	CO1
2	Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300K, and a turbine temperature of 1000K. Determine the required mass flow rate of air for a net power output of 70MW, assuming both the compressor and the turbine have an isentropic efficiency of 85%.	CO2

Name and Signature of the Faculty Incharge

S.A.Ramesh

HoD/MECH

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DEPARTMENT OF MECHANICAL ENGINEERING

Assignment Question Paper

Assignment – 02			**Date of Issue:**	22/04/2024	**Marks**	10
Course code	ME3451	**Course Title**	Thermal Engineering			
Year	II YEAR	**Semester/Section**	04	**Date of Submission:**	27/05/2024	

Q.No	Questions	CO
1	A gas turbine plant of 800 kW capacities takes the air at 1.01 bar and 15°C. The pressure ratio of the cycle is 6 and maximum temperature is limited to 700°C. A regenerator of 75% effectiveness is added in the plant to increase the overall efficiency of the plant. The pressure drop in the combustion chamber is 0.15 bars as well as in the regenerator is also 0.15 bars. Assuming the isentropic efficiency of the compressor 80% and of the turbine 85%, determine the plant thermal efficiency. Neglect the mass of the fuel.	CO3
2	The blade speed of a single ring of an impulse turbine is 300 m/s and the nozzle angle is 20°. The isentropic heat drop is 473 kJ/kg and the nozzle efficiency is 0.85. Given that the blade velocity coefficient is 0.7 and the blades are symmetrical, draw the vector diagrams and calculate for a mass flow of 1 kg/s. (i) Axial thrust on the blading (ii) Steam consumption per B.P hour if the mechanical efficiency is 90% (iii) Blade efficiency, stage efficiency and maximum blade efficiency (iv) Heat equivalent of the friction of blading.	CO4

Name and Signature of the Faculty Incharge

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DEPARTMENT OF MECHANICAL ENGINEERING

Assignment Answer Sheet

Name of the Student: V. Manickavel
AU Register Number: 730422114001

Assignment – 01			**Date of Issue:**	01/04/2024	**Marks**	10
Course code	ME3451	**Course Title**	Thermal Engineering			
Year	II YEAR	**Semester/Section**	04	**Date of Submission:**	22/04/2024	

Q.No	Questions	CO
1	Steam turbine develops 185 kW with a consumption of 16.5 kg/kW/h. The Pressure and temperature of the steam entering the nozzle are 12 bar and 220º C. The steam leaves the nozzle at 1.2 bar. The diameter of the nozzle at throat is 7mm, Find the number of nozzles. If 8% of the total enthalpy drop is lost in friction in the diverging part of the nozzle, determine the diameter at the exit ofthe nozzle and the exit velocity of the leaving steam. Sketch the skeleton Mollier diagram and show on it the values of pressure, temperature or dryness fraction, enthalpy and specific volume at inlet, throat and exit.	CO1
2	Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300K, and a turbine temperature of 1000K. Determine the required mass flow rate of air for a net power output of 70MW, assuming both the compressor and the turbine have an isentropic efficiency of 85%.	CO2

Mark Allocation

Rubrics	Marks Allocated	Marks obtained
Content Quality	6	05
Presentation Quality	2	02
Timely submission	2	02
Total marks	10	09

Name and Signature of the Faculty Incharge
(S.A. Ramesh)

HoD/MECH

umber of pipes of 5km long and
5mm diameter each laid parallel
e used for power transmission. The
ressure at discharge and is maintained
onstant are used for 7mpa, Determine
e minimum number of pipes.

iven data :

$L = 5km = 5000m$

$D = 125 mm = 0.125m$

$Discharge = 7mpa = 7 \times 10^6 N/m^2$

$\eta = 80\% = 0.8$

$P = 400kw$

Sol

$h = H - h_f$

$= 7 \times 10^6 N/m^2 - \frac{7 \times 10^6}{9810} = 713.56$

$\eta = \frac{H - h_f}{H}$

$$0.8 = \frac{713.56}{H}$$

$$\therefore H = 891.95 m$$

$$h_f = H - h = 891.95 - 713.56 = 178.$$

$$P = wQ(H - h_f)$$

$$400 = 9.81 \times Q \times 713.56$$

$$\therefore Q = 0.0571 m^3/s$$

$$V = \frac{q}{A} = \frac{q}{\frac{\pi}{4}(D^2)} = \frac{4q}{\pi D^2}$$

$$h_f = \frac{4fLV^2}{2gD}$$

$$h_f = \frac{4fL\left(\frac{4q}{\pi D^2}\right)^2}{2gD} = \frac{32fLq^2}{2g\pi^2 D^5}$$

$$178.39 = \frac{32 \times 0.0068 \times 5000 \times q^2}{2 \times 9.81 \times \pi^2 \times 0.125^5}$$

$q = 0.0311\ m^3/S$

$$\frac{0.0511}{0.0311} = 1.64$$

The number of pipe required = 2

hree pipes of Same length L,
iameter D, and friction factor f are
nnected in parallel. Determine
e diameter of the pipe of length
and friction factor f that

$$_f = \frac{fLV^2}{2gD}$$

Given data:

Length of each pipe = L

Diameter of each pipe = D

friction factor of each pipe = f

$$h_f = \frac{fLV^2}{2gD}$$

Sol

$$h_f = h_{f_1} + h_{f_2}$$

$$Q = Q_1 + Q_2 + Q_3$$

$$\therefore Q = 3Q_1 \Rightarrow A_1 v_1 = 3 \times \frac{\pi}{4} D^2 \times v$$

v = velocity through

$$Q = A \times V = \frac{\pi}{4} d^2 \times V$$

$$3 \times \frac{\pi}{4} D^2 \times v = \frac{\pi}{4} d^2 \times V$$

$$3 \times \frac{D^2}{d^2} = \frac{v}{V}$$

$$h_f = \frac{f L v^2}{2gd}$$

$$h_f = \frac{f L v^2}{2gD}$$

$$\frac{f L v^2}{2gd} = \frac{f L V^2}{2gD}$$

$$\frac{V^2}{d} = \frac{v^2}{D}$$

$$\frac{d}{D} = \left(\frac{v}{V}\right)^2$$

$$\frac{v}{V} = \left(\frac{d}{D}\right)^{1/2}$$

$$3 + \frac{D^2}{d^2} = \left(\frac{d}{D}\right)^{1/2}$$

$$3 = \left(\frac{d}{D}\right)^{\frac{1}{2}} \times \left(\frac{d}{D}\right)^2 = \left(\frac{d}{D}\right)^{5/2}$$

$$\frac{d}{D} = (3)^{2/5}$$

$$d = 1.55\,D$$

Determine the length of an equivalent pipe of diameter 20cm and friction factor 0.02 for a given pipe system discharging 0.1 m³/s.

i) A 10m line of 20cm diamet

ii) three 90°. bend, $K = 0.5$

iii) Expansion or diameter 20 to

iv) A 15m line of 30cm $f = 0.$

v) A global , $K = 10$

<u>Given data:</u>

$d = 20cm = 0.2m$

$f = 0.02$

$Q = 0.1 m^3/s$

<u>Soln</u>

$Q = A_1 V_1$

$$V_1 = \frac{Q}{A_1} = \frac{0.1}{\frac{\pi}{4} \times (0.2)^2} = 3.18 m/s$$

$$h_{f_1} = \frac{4fLV^2}{2gD} = \frac{4 \times 0.02 \times 10 \times 3.18^2}{2 \times 9.81 \times 0.2}$$

$$= 3.092 m$$

$$\frac{694}{T} = \frac{200}{Q_2}$$

$$Q_3 = 0.288 T$$

$$W_A = 200 - 0.288 T$$

$$W_B = 100 - 0.144 T$$

$$W_D = Q_3 - Q_4$$

$$= 0.288 T - Q_4$$

$$100 - 0.144 T = 0.288 T - Q_4$$

$$Q_4 = 0.432 T - 100$$

$$\frac{T}{T_4} = \frac{Q_3}{Q_4}$$

$$= \frac{0.288 T}{Q_4}$$

$$\frac{T}{277.4} = \frac{0.288 T}{0.432 T - 100}$$

$$T(0.432 T - 100) = 277.4 \times 0.288 T$$

$$0.432 T^2 - 100 T - 79.97 = 0$$

$0.432T^2 = 179.9T$

$T = 416.43K = 143.43°C$

$Q_2 = 0.288 \times 416.43 = 119.93k$

$Q_4 = 0.433 \times 416.43 - 100 = 79.8$

$\eta_A = 1 - \frac{Q_2}{Q_1}$ ~~$=$~~

$1 - \frac{119.93}{200} = 40.04\%$

$\eta_o = 1 - \frac{Q_4}{Q_3}$

$1 - \frac{79.89}{119.93}$

$= 33.39\%$

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DEPARTMENT OF MECHANICAL ENGINEERING

Assignment Answer Sheet

Name of the Student: V. Monikkandel
AU Register Number: 733422114001

Assignment – 02			**Date of Issue:** 22/04/2024	**Marks**	10
Course code	ME3451	**Course Title**	Thermal Engineering		
Year	II YEAR	**Semester/Section**	04	**Date of Submission:**	27/05/2024

Q.No	Questions	CO
1	A gas turbine plant of 800 kW capacities takes the air at 1.01 bar and 15°C. The pressure ratio of the cycle is 6 and maximum temperature is limited to 700°C. A regenerator of 75% effectiveness is added in the plant to increase the overall efficiency of the plant. The pressure drop in the combustion chamber is 0.15 bars as well as in the regenerator is also 0.15 bars. Assuming the isentropic efficiency of the compressor 80% and of the turbine 85%, determine the plant thermal efficiency. Neglect the mass of the fuel.	CO3
2	The blade speed of a single ring of an impulse turbine is 300 m/s and the nozzle angle is 20°. The isentropic heat drop is 473 kJ/kg and the nozzle efficiency is 0.85. Given that the blade velocity coefficient is 0.7 and the blades are symmetrical, draw the vector diagrams and calculate for a mass flow of 1 kg/s. (i) Axial thrust on the blading (ii) Steam consumption per B.P hour if the mechanical efficiency is 90% (iii) Blade efficiency, stage efficiency and maximum blade efficiency (iv) Heat equivalent of the friction of blading.	CO4

Mark Allocation

Rubrics	Marks Allocated	Marks obtained
Content Quality	6	06
Presentation Quality	2	01
Timely submission	2	02
Total marks	10	09

S. A.

Name and Signature of the Faculty Incharge

S. ARanesh

S. A.

HoD/MECH

A gas occupies $0.3 m^3$ at 2 bar It executes a cycle consisting of a process. (i) 1.2 : constant pressure with work interaction as 15 kJ (2) 2.3 : Compression process which follows the law pv = constant and $U_3 = U_2$ (3) 3.1 : Constant volume process and change internal energy is 40 kJ . Neglect Change in KE and PE . Draw pv diagram for the process and determine network transfer for the cycle. Also show that first law is obeyed by the cycle.

Given data:

$V_1 = 0.3 m^3$

$P_1 = 2$ bar $= 200 kN/m^2 = P_2$

$W_{1.2} = 15 kJ$

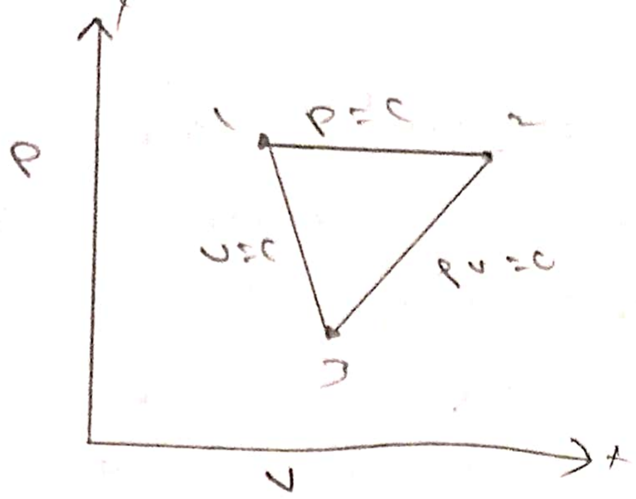
PV = Isothermal

$U_3 = U_2$

3.1 Constant volume process change in internal energy $= U_1 - U_3 = 40$ kg

To find

$\oint w$



Sollution:

Process 1-2

$W = P_2V_2 - P_1V_1 = P_1(V_2 - V_1)$

$15 = 200(V_2 - 0.3)$

$15 = 200V_2 - 60$

$200V_2 = 75$

$\boxed{V_2 = 0.375 \text{ m}^3}$

Process 2-3

$P_1V_1 \ln\left(\frac{V_2}{V_1}\right)$

$W_{2-3} = P_2 V_2 \ln\left(\frac{V_3}{V_2}\right)$

$W_{2-3} = 200(0.375) \ln\left(\frac{0.3}{0.375}\right)$

$W_{2-3} = 75 \ln(0.8)$

$W_{2-3} = -16.74$ kJ

Process 3-1

$\boxed{W_{3-1} = 0}$

Network transformer

$W_{net} = W_{1-2} + W_{2-3} + W_{3-1}$

$= 15 - 16.74 + 0$

$W_{net} = -1.74$ kJ

$Q_{1-2} = W_{1-2} + U_{1-2}$

$U_{1-2} = U_2 - U_1$

$U_3 = U_2$

$U_1 - U_2 = 40$

$U_2 - U_1 = -40$

$\boxed{U_{1-2} = -40}$

$Q_{1-2} = 15 - 40$

$Q_{1-2} = -25$ kJ

$Q_{net} = Q_{1-2} + Q_{2-3} + Q_{3-1}$

$= -25 - 16.74 + 40$

$\boxed{Q_{net} = -1.74 \text{ kJ}}$

First law thermodynamic is proc

2) An insulated rigid tank with a heat capacity contains 15 kg of at 8 bar and 50°C It is fille with air from a large reservoir at 10 bar and 60°C. Find the final state of air in the tank and mass added. Assume $C_p = 1.00$ $C_v = 0.71$ kJ/kgK

Given:

$Q = 0$

$V_1 = V_2$

$m_1 = 15$

$P_1 = 20$ bar

$T_1 = 50°C = 50 + 273 = 323K$

$P_2 = 10 \text{ bar}$

$T_r = 60°C = 6 + 273 = 333K$

$C_p = 1.03 \text{ KJ/kgK}$

$C_v = 0.71 \text{ KJ/kgK}$

<u>To find:</u>

T_2 and $m_2 - m_1$

<u>Sollution:</u>

$$m_1 = \frac{P_1 V_1}{RT_1} \qquad \frac{m_2}{m_1} = \frac{\frac{P_2 V_2}{RT_2}}{\frac{P_1 V_1}{RT_1}}$$

$$m_2 = \frac{P_2 V_2}{RT_2} \qquad = \frac{P_2 V_2 T_1}{P_1 V_1 T_2}$$

$$\frac{m_2}{15} = \frac{10 \times 325}{2T_2} = \frac{24225}{T_2}$$

$Q - W = m_2 u_2 - m_1 u_1 - (m_2 - m_1) h_i$

$Q = W = 0$

$m_2 u_2 - m_1 u_1 - (m_2 - m_1) h_i = 0$

$u = CT$

$m_2 C_v T_2 \; m_1 C_v T_1 - (m_2 - m_1) C_p T_v = 0$

$\frac{24225}{T_2}(0.71) T_2 - 15(0.71)(323) - \Big(\frac{24}{T_2}$

$(1.03)(333).$

$17199.75 - 3439.95 - \Big(\frac{8308932.75}{T_2} - 51$

$8614.95 = \frac{8308932.75}{T_2}$

$T_2 = \frac{964.75}{T_2}$

$m_2 = \frac{24225}{T_2}$

$m_2 = 25.14 \text{ kg}$

$m_2 - m_1 = 25.14 - 15$

$\boxed{m_2 - m_1 = 10.14 \text{ kg}}$

An insulated rigid tank with zero one litre of hydrogen at 273K is adiabatically compressed to one half of its initial volume. find the change in temprature of the gas if the ration of two specific heat for hydrogen is 1.4.

Given:

$V_1 = 1\, l = 0.001 m^3$

$T_1 = 273K$

$V = 1/2$ litre $= 0.0005 m^3$

$\gamma = 1.4$

To find : $T_2 - T_1$

Soll:

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\frac{T_2}{273} = \left(\frac{1}{0.5}\right)^{1.4-1} = (2)^{0.4}$$

$$\frac{T_2}{273} = 1.3195$$

$$T_2 = 360.23$$

$$\boxed{T_2 - T_1 = 87.23K}$$

ME3451 Thermal Engineering Important questions

Unit 1

PART A

1. What is meant by cut-off ratio?

2. Draw the P-V and T-S diagram for otto cycle.

3. What are the assumptions made for air standard cycle analysis?

4. Define mean effective pressure as applied to gas power cycles.

5. What is the effect of compression ratio on efficiency of otto cycle?

6. Draw the actual and theoretical P-V diagram for four stroke cycle SI engine.

7. Mention the various processes of dual cycle.

8. For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, diesel and dual cycle.

9. What are the effects of reheat cycle?

10. What is thermodynamic cycle?

11. What is a thermodynamic cycle?

12. What is meant by air standard cycle?

13. Name the various "gas power cycles".

14. What are the assumptions made for air standard cycle analysis

15. Mention the various processes of the Otto cycle.

16. Mention the various processes of diesel cycle.

17. Mention the various processes of dual cycle.

18. Define air standard cycle efficiency.

19. Define mean effective pressure as applied to gas power cycles. How it is related to indicate power of an I.C engine.

20. Define the following terms. (i) Compression ratio (ii) Cut off ratio, (iii) .Expansion ratio

PART B

1. Drive and expression for the air standard efficiency of Otto cycle in terms of volume ratio.
2. Drive an expression for the air standard efficiency of Diesel cycle.

3. Drive an expression for the air standard efficiency of Dual cycle.

4. Explain the working of 4 stroke cycle Diesel engine. Draw the theoretical and actual PV diagram.

5. Drive the expression for air standard efficiency of Brayton cycle in terms of pressure ratio.

6. A Dual combustion air standard cycle has a compression ratio of 10. The constant pressure part of combustion takes place at 40 bar. The highest and the lowest temperature of the cycle are 1725degree C and 27 0 C respectively. The pressure at the beginning of compression is 1 bar. Calculate (i) the pressure and temperature at' key points of the cycle. (ii) The heat supplied at constant volume, (iii) the heat supplied at constant pressure. (iv) The heat rejected. (v) The work output. (vi) The efficiency and (vii) mep.

7. An Engine-working on Otto cycle has a volume of 0.45 m3 , pressure 1 bar and temperature 30o, Cat the beginning of compression stroke. At the end of compression stroke, the pressure is 11 barand 210 KJ of heat is added at constant volume. Determine (i) Pressure, temperature and volumes at salient points in the cycle.' (ii) Efficiency.

8. Explain the working of 4-stroke cycle Diesel engine. Draw the theoretical and actual valve- timing diagram for the engine. Explain the reasons for the difference.

9. Air enters the compressor of a gas turbine at 100 KPa and 25 o C. For a pressure ratio of 5 and a maximum temperature of 850°C. Determine the thermal efficiency using the Brayton cycle.

10. The following data in referred for an air standard diesel cycle compression ratio = 15 heat added= 200 Kj/Kg- minimum temperature in the cycle = 25°C Suction pressure = 1 bar Calculate 1. Pressure and temperature at the Salient point. 2. Thermal efficiency 3. Mean effective pressure, 4. Power output of the cycle, if flow rate 'of air is 2 Kg/s

11. A Dual combustion air standard cycle has a compression ratio of 10. The constant pressure part of combustion takes place at 40 bar. The highest and the lowest temperature of the cycle are 1727° C and 27° C respectivety.The pressure at the beginning of compression is 1 bar. Calculate- (i) The pressure and temperature at key points of the cycle. (ii) The heat supplied at constant volume, (iii) The heat supplied at constant pressure (iv) The heat rejected *(v)* The Work output, (vi) The efficiency and (vii) Mean effective pressure.

12. An Engine working on Otto cycle has a volume of 0.45 m3, pressure 1 bar and Temperature 30Oc, at the beginning of compression stroke. At the end of Compression stroke, the pressure is 11 bar and 210 KJ of heat is added at constant Volume. Determine i. Pressure, temperature and volumes at salient points in the cycle. ii. Efficiency.

Unit 3 & 4

PART A

1. Classify IC engine according to cycle of lubrication system and field of application.
2. Types of lubrication system
3. List the various components of IC engines.
4. Name the basic thermodynamic cycles of the two types of internal combustion reciprocating engines.
5. Mention the important requites of liner material.
6. State the purpose of providing piston in IC engines.
7. Define the terms as applied to reciprocating I.C. engines "Mean effective pressure" and "Compression ratio".
8. What is meant by highest useful compression ratio?
9. What are the types of piston rings?
10. What is the use of connecting rod?
11. What is the use of flywheel?
12. Which factor increases detonation in IC engines?
13. Which factor do not have much influence in detonation?
14. For maximum power, air-fuel ratio should be?
15. For maximum economy, air-fuel ratio should be?
16. For maximum power we need is?
17. Cold starting required?
18. Knock in SI engine can be reduced by
19. In 2-stroke engines wich two strokes are eliminated?
20. Which efficiency will reduce if fresh charge filled is reduced?
21. SFC decreases as power capacity of engine?
22. What about the NOx emission when the compression ratio decreases?
23. Methods used for preparing bio-diesel?
24. Nox, Sox, HC can be determined by ?
25. What is blending of fuel?
26. Is hydrogen fuel is storable?

PART B

1. Explain full pressure lubrication system I.C Engine.

2. Explain the water cooling system in I.C Engine.

3. Explain the 2 types of Ignition system In S.I Engine.

4. Draw and explain the valve timing diagram of 4 strokes Diesel Engine.

5. Draw and explain the port timing diagram of 2stroke Petrol Engine.

6. Explain with neat sketch the exhaust gas analysis.

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 the indicated Thermal efficiency, the brake Thermal efficiency and Mechanical efficiency

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%

Reg. No. : E N G G T R E E . C O M

Question Paper Code : 30257

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Fourth Semester

Mechanical Engineering

ME 3451 – THERMAL ENGINEERING

(Common to: Mechanical Engineering (Sandwich))

(Regulations 2021)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Discuss the effect of cut-off ratio on diesel cycle in thermal efficiency values.

2. List out all cold air assumption of air standard cycles?

3. Define metastable state and degree of super saturation in steam nozzles.

4. What is the significance of the critical pressure ratio on discharge through the steam nozzle?

5. Compare the open cycle gas turbine and closed cycle gas turbine

6. List out the methods of improving the performance of gas turbine power plant.

7. What do understand by stoichiometric, rich and lean mixture?

8. Represent the various stages of combustion of CI engine in pressure and crank angle diagram.

9. Battery coil ignition system is preferred in most of the automobiles – justify this statement.

10. How do you avoid the overheating, and over cooling of the internal combustion engines?

PART B — (5 × 13 = 65 marks)

11. (a) For the same compression ratio, prove that the efficiency of the Otto cycle is greater than that of the diesel cycle.

Or

(b) In an air standard diesel cycle with a compression ratio of 14, the condition of air at the start of the compression stroke are 1 bar and 300 K. After addition of heat at constant pressure, the temperature rises to 2775 K. Determine the thermal efficiency of the cycle, network done per kg of air.

12. (a) Calculate the critical pressure ratio and throat area per unit mass flow rate of steam, expanding through a convergent-divergent steam nozzle from 10 bar, dry saturated down to atmospheric pressure of 1 bar. Assume that the inlet velocity is negligible and that the expansion is isentropic.

Or

(b) A nozzle is to be designed to expand steam at the rate of 0.1 kg/sec from 500 kPa, 210°C to 100 kPa. Neglect the inlet velocity of steam. For a nozzle efficiency of 0.9, determine the exit area of the nozzle.

13. (a) In a gas turbine power plant, air enters the compressor at 15°C and it is compressed through a pressure ratio of 4 with isentropic efficiency of 85%. The air-fuel ratio is 80 and the calorific value of the fuel is 42,000 kJ/kg. The turbine inlet temperature is 1000 K and the isentropic efficiency of the turbine is 82%. Find the overall plant efficiency.

Or

(b) Explain the concept of advanced techniques adapted in gas turbine power plant with neat line schematic diagram. Also represent the cycle in all P-v, T-s and h-s diagrams. Give merits of the advance techniques.

14. (a) Define the detonation. Give its effects on Spark Ignition Engines.

Or

(b) Explain the working principle of simple carburetor with neat sketch. Give its limitations.

15\. (a) A full load test was conducted on a two stroke engine and the following results were obtained:

Speed of engine = 500 rpm; Brake load = 500 N; Air /fuel ratio 30; oil consumption = 5kg/hr; Room temperature = 25°C; Atmospheric pressure = 1 bar; diameter of cylinder = 22cm; stroke length 28cm; Brake diameter = 1.6m. Calculate the volumetric efficiency and brake specific fuel consumption.

Or

(b) The following results refer to at test on a four stroke petrol engine:

The diameter of the cylinder is 30 cm and stroke length of the piston is 45 cm. The Engine runs at the speed of 1000 rpm. The brake specific fuel consumption is 0.35 kg/kWh. The calorific value of the fuel is 43,900 kJ/kg. The indicated mean effective pressure is 540 kPa. Calculate the following:

(i) Indicated thermal efficiency

(ii) Brake thermal efficiency

(iii) Mechanical efficiency

PART C — (1 × 15 = 15 marks)

16\. (a) Two engines are operated in ideal Otto and diesel cycles for which the following information are available:

Maximum temperature = 1227°C

Exhaust temperature = 447°C

Ambient condition = 1.013 bar and 35°C

Air consumption = 2 kg/min

Estimate the following:

(i) Compression ratio

(ii) Air standard efficiency

(iii) Power output

Or

(b) An ideal regenerative steam cycle operates with the steam entering the turbine at 30 bar and 500°C and is exhausted at 0.1 bar. A feed water heater is used which operates at 5 bar. Calculate the following:

(i) The thermal efficiency

(ii) Steam rate of the cycle

(iii) Increase in average temperature of heat addition

(iv) Compare the values of thermal efficiency and steam rate with ideal Rankine cycle

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Reg. No. : ☐☐☐☐☐☐☐☐☐☐☐☐

Question Paper Code : 21297

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023

Fourth Semester

Mechanical Engineering

ME 3451 — THERMAL ENGINEERING

(Common to Mechanical Engineering (Sandwich))

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is air standard cycle?

2. Draw the P-V and T-S diagram for ideal dual combustion cycle.

3. What do you mean by meta stable flow in steam nozzles?

4. What are the applications of convergence divergence nozzle?

5. Is it always useful to have a regenerator in a gas turbine power cycle. Why?

6. Write about dryness fraction of wet steam.

7. Comment on firing order of a multi-cylinder engine. How it is significant?

8. Draw the ideal and actual value-timing diagrams for a 4 stroke diesel engine.

9. What do you understand by the terms naturally aspirated and turbocharged in an engine?

10. Why emission testing is required in terms of performance evaluation of internal combustion engines?

PART B — (5 × 13 = 65 marks)

11. (a) The maximum pressure and temperature in an Otto cycle are 10 kPa and 27°C. The amount of heat added to the air per cycle is 1500 kJ/kg.

(i) Determine the pressure and temperatures and pressures at all points of the air standard Otto cycle.

(ii) Calculate the specific work and thermal efficiency of the cycle for a compression ratio of 8:1.

Take for air : $C_v = 0.72$ kJ/kgK and $\gamma = 1.4$.

Or

(b) In an engine working on Dual cycle, the temperature and pressure at the beginning of the cycle are 90°C and 1 bar respectively. The compression ratio is 9.2. The maximum pressure is limited to 68 bar and total heat supplied per kg of air is 1750 kJ. Calculate :

(i) Pressure and temperature at all salient points

(ii) Air standard efficiency

(iii) Mean effective pressure.

12. (a) Steam at a pressure of 10.5 bar and 0.95 dry is expanded through a convergent divergent nozzle. The pressure of steam leaving the nozzle is 0.85 bar. Find the velocity of steam at the throat for maximum discharge. Take n = 1.135. Also find the area at the exit and steam discharge if the throat area is 1.2 cm^2. Assume flow is isentropic and there are no friction losses.

Or

(b) Brief the following in case of steam nozzles :

(i) Critical pressure ratio

(ii) Effect of friction

(iii) Metastable flow and its effect.

13. (a) The gas turbine has an overall pressure ratio of 5:1 and the maximum cycle temperature is 550°C. The turbine drives the compressor and an electric generator, the mechanical efficiency of the drive being 97%. The ambient temperature is 20 he turbine drives the compressor and an electric 20°C and the isentropic efficiencies for the compressor and the turbine are 0.8 and 0.83 respectively. Calculate the power output in megawatts for an air flow of 15 kg/s. Also calculate the thermal efficiency and work ratio.

Neglect the changes in kinetic energy and loss of pressure in combustion chamber.

Or

(b) A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 15 MPa and 10 kPa. The mass flow rate of steam through the cycle is 12kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10%, determine the following.

(i) Reheat pressure

(ii) Heat input to the Boiler

(iii) Thermal efficiency of the cycle.

Represent the cycle on T-s diagram.

14. (a) What do you mean by knocking? Describe the phenomenon of knocking in SI engine. What are the factors affect the knocking? How can it be controlled?

Or

(b) Explain the different types of combustion chambers used in CI engines.

15. (a) A six cylinder, gasoline engine operates on the four stroke cycle. The bore of each cylinder is 80 mm and the stroke is 100 mm. The clearance volume per cylinder is 70 cc. At the speed of 4100 rpm, the fuel consumption is 5.5 gm/sec and the torque developed is 160 Nm. Calculate :

(i) Brake power

(ii) Brake mean effective pressure

(iii) Brake thermal efficiency if the calorific value of the fuel is 44000 kJ/kg and

(iv) Relative efficiency on a brake power basis assuming the engine works on the constant volume cycle γ = 1.4 for air.

Or

(b) During the trial of a four stoke, single cylinder, oil engine the following observations were recorded: bore = 300 mm. stroke = 400 mm, speed = 200 rpm, duration of trial = 60 minutes. fuel consumption = 7.050 kg. calorific value = 14000 kJ/kg, area of indicator diagram = 322 mm², length of indicator diagram = 62 mm, spring index = 1.1 bar/mm, dead load on the brake drum = 140 kg, spring balance reading = 5 kg, brake drum diameter =1600 mm, total weight of cooling water = 495 kg, temperature rise of cooling water = 38°C, temperature of exhaust gases = 300°C, air consumption = 311 kg, specific heat of exhaust gases = 1.004 kJ/kg K, specific heat of water = 4.186 kJ/kg K; room temperature = 20°C. Determine

(i) Brake power

(ii) Indicated power

(iii) Mechanical efficiency

(iv) Indicated thermal efficiency

PART C — (1 × 15 = 15 marks)

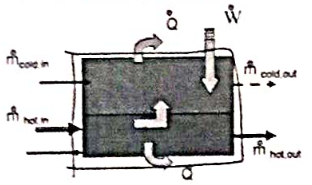
16. (a) Explain normal and abnormal combustion in IC engines. List the factors affecting knocking phenomenon.

Or

(b) Write about scenarios of rich and lean mixture of as 4-storke IC engine, when the vehicle is travel from plain region to hilly region with clear pictures of fuel-air mixture.

CONTENT BEYOND SYLABUS

A True Adiabatic Heat Exchanger : SSSF

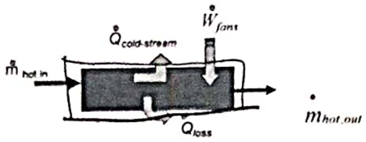


$$\dot{m}_{cold,in}+\dot{m}_{hot,in}=\dot{m}_{cold,out}+\dot{m}_{hot,out}$$

$$\overset{\to 0}{\cancel{\dot{Q}_{CV}}}+\dot{m}_{cold,in}\times h_{cold,in}+\dot{m}_{hot,in}\times h_{hot,in}=\dot{m}_{cold,out}\times h_{cold,out}+\boxed{\dot{W}_{fan}+\dot{W}_{pump}}$$

$$+\dot{m}_{hot,out}\times h_{hot,out}$$

Donor of A Heat Exchanger:SSSF



$$\dot{m}_{hot,in}=\dot{m}_{hot,out}$$

$$\dot{Q}_{cold-stream}+\overset{\to 0}{\cancel{\dot{Q}_{loss}}}+\dot{m}_{hot,in}\times h_{hot,in}=\dot{m}_{hot,out}\times h_{hot,out}+\dot{W}_{fans}$$

Generation of Motive Power was the Mother of Heat Exchanger Invention

The Role of Hxs in the 21st Century

Heat exchangers serve a straightforward purpose: controlling a system's or substance's temperature by adding or removing thermal energy.

Devices for Energy Mediation in Thermal Engineering

- A Device to facilitate transfer of energy by using an action called Heat or Heat transfer.
- Enhances the value of Fuel energy.
- Facilitates energy conservation in any industry.
- A great tool for control of thermal environment.
- A Good Heat Exchanger is a True Mediator.

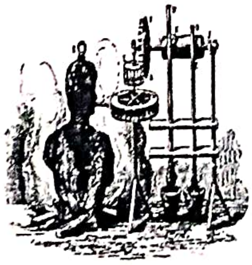
The Aelopile

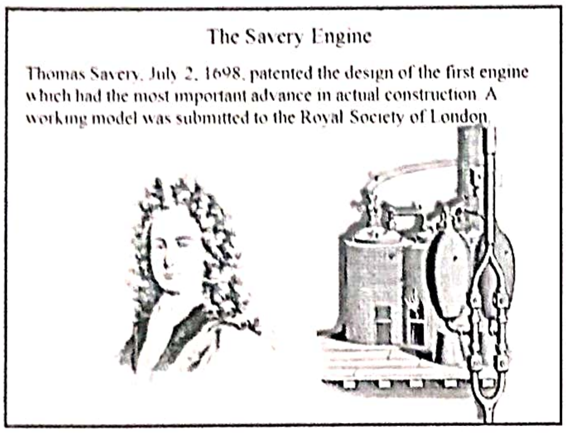
- In 130BC Hero, a Greek mathematician and scientist is credited with inventing the first practical application of steam power, the aelopile.

Branca's Steam Turbine

AP

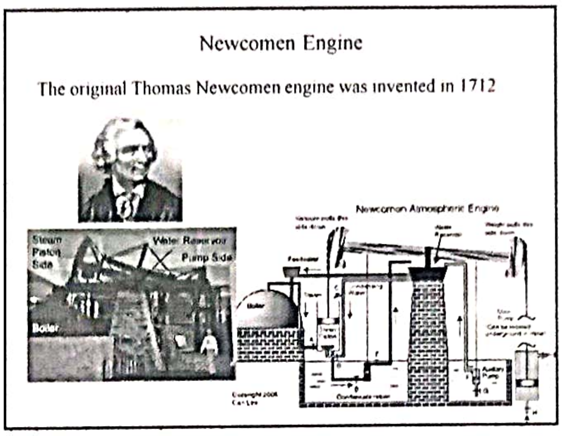
- In 1629, Giovanni Branca, of the Italian town of Loretto, described, in a work' published at Rome, a number of ingenious contrivances.





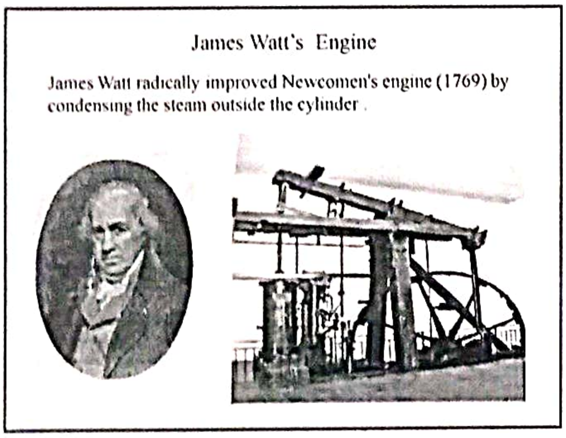
The Savery Engine

Thomas Savery, July 2, 1698, patented the design of the first engine which had the most important advance in actual construction. A working model was submitted to the Royal Society of London.



Newcomen Engine

The original Thomas Newcomen engine was invented in 1712

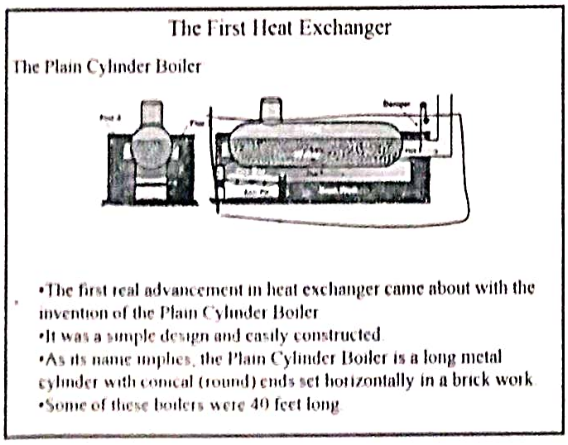


James Watt's Engine

James Watt radically improved Newcomen's engine (1769) by condensing the steam outside the cylinder .

No Recognition to these Boilers as a Heat Exchanger !!!?!?!?

Creativity without science is very Costly !!!?!?!?



The First Heat Exchanger

The Plain Cylinder Boiler

- The first real advancement in heat exchanger came about with the invention of the Plain Cylinder Boiler
- It was a simple design and easily constructed
- As its name implies, the Plain Cylinder Boiler is a long metal cylinder with conical (round) ends set horizontally in a brick work
- Some of these boilers were 40 feet long