Mech-323

APPLIED THERMODYNAMICS

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Total Contact Hours		T	P	C
Theory	64	2	3	3
Practical	96			

AIMS: To transfer the knowledge of fundamentals of thermodynamics, laws and properties of gases, thermodynamic processes and cycles, formation and properties of steam, steam boilers and their performance , steam and Gas turbines , I.C. Engines, Air compressors and their performance, refrigeration and air conditioning etc.

Course Contents:

Fundamentals of Thermodynamics	08 Hrs
Laws and properties of perfect gases	06 Hrs
Thermodynamic processes and cycles	10 Hrs
Formation and properties of Steam	04 Hrs
Steam Boilers and their performance	08 Hrs
Steam and Gas turbines	08 Hrs
Internal Combustion Engines	08 Hrs
Air Compressors and their performance	06 Hrs
Refrigeration and Air Conditioning	06 Hrs
	Total 64 Hrs

Details of Contents:

Fundamentals of Thermodynamics **8 Hrs**

1.1 Introduction to thermodynamics
1.2 Units, Systems of units, Thermodynamic systems, its classification and properties
1.3 Heat, Mass and weight, Force, Work and power
1.4 Temperature, Absolute Temperature and Temperature Scales, Normal / Standard Temperature and Pressure
1.5 Pressure, Absolute pressure, Gauge pressure and Vacuum pressure
1.6 Energy, Potential energy, Kinetic energy and Internal energy of gas
1.7 Laws of thermodynamics, Laws of conservation of energy and matter, limitations of 1'st law of thermodynamics
1.8 Solution of problems by direct application of formulae for above topics
1.9 Mode of heat transfer

Laws and properties of perfect gases **6 Hrs**

2.1 Introduction
2.2 Boyle's law, Charles law, Gay-Lussac's law, Joule's law, Avogadro's law, Regnault's law and Dalton's law
2.3 General gas equation, Characteristic Gas equation, Universal Gas equation
2.4 Specific heats of a gas, Molar specific heats of a gas and its mathematical relations
2.5 Enthalpy, and Entropy of a gas, importance of Entropy and relation between Heat & Entropy
2.6 Solution of problems by direct application of formulae for above topics

Thermodynamic processes and cycles **10 Hrs**

3.1 Introduction of thermodynamic process
3.2 Classification/types of thermodynamic processes
3.3 Application of 1st law of thermodynamics for work done during a non flow-reversible process
3.4 Heating and Expansion of gases in Non flow-Reversible & Irreversible processes
3.5 Solution of problems by direct-application of formulae
3.6 Introduction and classification/types of thermodynamic cycles
3.7 Assumptions in thermodynamic cycles
3.8 Reversible and Irreversible cycles
3.9 Working of an ideal engine
3.10 CARNOT's Cycle, OTTO Cycle, DIESEL Cycle and Dual Combustion Cycle
3.11 Solution of problems for air standard efficiency of thermodynamics cycles

Formation and properties of Steam **4 Hrs**

4.1 Introduction of steam, its formation, properties and classification
4.2 Important terms used for steam
4.3 Temperature-Enthalpy and Temperature- Entropy diagrams for steam formation
4.4 Use of steam tables
4.5 Calculation of total heat of Wet ,dry and super-heated steam (Solution of Problems)

Steam Boilers and Their performance **8 Hrs**

5.1 Introduction of boiler
5.2 Classification of boilers
5.3 Selection of a steam boiler
5.4 Important terms used for steam boilers
5.5 Constructions and Working of:
- 5.5.1 Simple vertical boiler (Single tube boiler)
- 5.5.2 COCHRAN boiler (Multi tubular boiler)
- 5.5.3 Locomotive Boiler
- 5.5.4 Marine boiler (scotch type)
- 5.5.5 Babcock and Wilcox Boiler

5.6 Boiler mountings and accessories
5.7 Comparison between Water Tube and Fire Tube boilers
5.8 Performance of steam boilers, Equivalent evaporation and boiler efficiency
5.9 Solution of problems regarding equivalent evaporation, power/H.P and efficiency of boiler

Steam and Gas Turbines **8 Hrs**

6.1 Introduction and classification of turbines
6.2 Steam Turbine (Impulse type)
- 6.2.1 Introduction

6.2.2 De-Laval impulse turbine
6.2.3 Advantages **of steam turbine**

6.3 Steam turbine (Reaction type)
6.3.1 Introduction.
6.3.2 PARSON's Reaction turbine.
6.3.3 Comparison between Impulse & Reaction Turbines

6.4 Gas Turbines
6.4.1 Introduction
6.4.2 Classification
6.4.3 Cycles of Gas turbines
6.4.4 Uses of Gas turbines
6.4.5 Comparison of closed cycle and open cycle turbines
6.4.6 Comparison of Gas turbine & Steam turbine

7. Internal Combustion Engines 8Hrs

7.1 Introduction of Internal & External Combustion Engines
7.2 Classification of I.C. Engines
7.3 Cycle of operations & important terms used
7.4 Comparison of Two Strokes Cycle and Four Strokes Cycle Engines
7.5 Petrol Engine
7.5.1 Construction and working with the help of P-V , T-S diagrams & neat sketch
7.5.2 Valve Timing Diagrams for two strokes and four strokes cycle petrol engine
7.6 Diesel Engine
7.6.1 Construction and working with its P-V, T-S diagrams and neat sketch
7.6.2 Valve Timing Diagrams for two strokes cycle and four strokes cycle Diesel engine
7.7 Indicated power, Brake power, Friction power and efficiencies of I.C. Engines
7.8 Comparison of I.C. engine and E.C. engine
7.9 Comparison of Petrol and Diesel engines
7.10 Solution of Problems regarding I.P, B.P, Friction Power and efficiencies of I.C. engines

8. Air Compressors and their performance (Reciprocating & Rotary) 6 Hrs

8.1 Introduction
8.2 Classification of air compressors(Reciprocating & Rotary)
8.3 Technical terms used
8.4 Construction and working of single stage reciprocating Air Compressor with help of PV-diagram and neat sketch
8.4.1 Work done per cycle by a single stage reciprocating air compressor without and with clearance volume.
8.5 Multistage compression and its advantages
8.6 Two stage reciprocating air compressor with intercooler, work done per cycle with polytrophic law of compression
8.7 Power required to drive a single stage and two stage reciprocating air compressors
8.8 Comparison of reciprocating and rotary air compressors
8.9 Work done per cycle and power required to drive a rotary compressor
8.10 Solution of Problems regarding work done power required for single stage & multistage rotary air compressors

Refrigeration and Air Conditioning 6Hrs

9.1 Introduction

9.2 Classification of refrigeration systems / cycles
9.3 Units, terms used
9.4 Refrigerants and its properties
9.5 Introduction to vapor compression , vapour absorption in refrigeration system
9.6 Fundamentals of air conditioning system

9.7 Classification of air conditioning systems

Recommended Textbooks:

1. **Principle of Refrigeration by Royj. Dossat**
2. **Air conditioning principles and system an energy approach by Edward. G. Pita**
3. **Applied Thermodynamics T.D Eastop, A. Mcconkey**
4. **Thermodynamics by Rayner Joel**
5. **Thermodynamics Applied to Heat Engines by E.H.LEWITT (Published by; Sir ISAAC Pitman & Sons Ltd London)**
6. **Heat Engines by D.A Low (McGraw Hill Book Company , New York)**

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Instructional Objectives:

At the completion of this course, the students will be able to:

1. **Know the Fundamentals of Thermodynamics**
   1.1 State the following:

1.1.1 Fundamentals of thermodynamics
1.1.2 Units and Systems of units

1.2 Describe the Thermodynamic systems, its classification and properties

1.3 State the following:
1.3.1 Heat
1.3.2 Mass and weight
1.3.3 Force
1.3.4 Work and power

1.4 Describe the following:
1.4.1 Temperature, Absolute Temperature and Temperature Scales
1.4.2 Normal Temperature and Pressure
1.4.3 Standard Temperature and Pressure

1.5 Describe the following:
1.5.1 Pressure and Absolute pressure.
1.5.2 Gauge pressure and Vacuum pressure

1.6 State the following:
1.6.1 Energy, Potential energy and Kinetic energy
1.6.2 Internal energy of a gas

1.7 Describe the following:
1.7.1 Laws of thermodynamics
1.7.2 Laws of conservation of energy and matter
1.7.3 Limitations of 1st law of thermodynamics

1.8 Describe mode of heat transfer
1.8.1 Describe Conduction
1.8.2 Describe Convection
1.8.3 Describe Radiation

1.9 Solve the problems by direct application of formulae for the above topics

2. Understand the laws and properties of perfect gases

2.1 State the perfect gas and its properties

2.2 Describe the following; also derive its mathematical relations:
2.2.1 Boyle's law
2.2.2 Charles's law
2.2.3 Gay-Lussac's law
2.2.4 Joule's law
2.2.5 Avogadro's law
2.2.6 Regnault's law
2.2.7 Dalton's law

2.3 Describe the following; also derive its mathematical relations:
2.3.1 General gas equation
2.3.2 Characteristic Gas equation
2.3.3 Universal Gas equation

2.4 Describe the following:
2.4.1 The two specific heats of a gas and derive its mathematical relations
2.4.2 The molar specific heats of a gas and derive its mathematical relations

2.5 State the following:
2.5.1 Enthalpy of a Gas
2.5.2 Entropy of a gas
2.5.3 Importance of Entropy
2.5.4 Relation between Heat & Entropy

2.6 Solve the problems by direct application of formulae for the above topics

3. Understand the Thermodynamics Processes and Cycles

3.1 State the thermodynamic process
3.2 State Classification /Types of thermodynamic processes
3.3 State the application of 1st law of thermodynamics for work done during a non flow-reversible process
3.4 Describe the following
- 3.4.1 The Non flow-Reversible & Irreversible processes with the help of P-V & T-S diagrams
- 3.4.2 The constant pressure process with the help of P-V & T-S diagrams: also derive its mathematical relations for work done during expansion
- 3.4.3 The constant volume process with the help of P-V & T-S diagrams: also derive its mathematical relations for work done during expansion
- 3.4.4 The constant temperature process with the help of P-V & T-S diagrams: also derive its mathematical relations for work done during expansion
- 3.4.5 The adiabatic process with the help of P-V & T-S diagrams: also derive its mathematical relations for work done during expansion
- 3.4.6 The polytrophic process with the help of P-V & T-S diagrams: also derive its mathematical relations for work done during expansion

3.5 Solve the problems by direct application of formulae for the above topics
3.6 Describe the following:
- 3.6.1 Thermodynamic cycle with the help of P-V diagram
- 3.6.2 Classification / Types of thermodynamic cycles

3.7 Describe the assumptions in thermodynamic cycles
3.8 Describe the Reversible & Irreversible cycles with help of PV diagram
3.9 Explain the construction and working of an ideal engine with the help of neat sketch
3.10 Explain the following
- 3.10.1 CARNOT'S CYCLE with the help of P-V & T-S diagrams; also derive its mathematical relations for Air Standard Efficiency during the cycle of operation
- 3.10.2 OTTO CYCLE with the help of P-V & T-S diagrams; also derive its mathematical relations for Air Standard Efficiency during the cycle of operation
- 3.10.3 DIESEL CYCLE with the help of P-V & T-S diagrams; also derive its mathematical relations for Air Standard Efficiency during the cycle of operation
- 3.10.4 DUAL COMBUSTION CYCLE with the help of P-V & T-S diagrams; also derive its mathematical relations for Air Standard Efficiency during the cycle of operation

3.11 Solve the problems by direct application of formulae for the above topics

4. Understand the Formation and properties of Steam

4.1 Describe the steam formation, its properties and classification
4.2 State the important terms used for steam
4.3 Describe the Temperature-Enthalpy and Temperature- Entropy diagrams for steam formation
4.4 Describe the use of steam tables with help of examples
4.5 Describe the following:
- 4.5.1 Derive the formulae for the calculation of total heat of wet, Dry, and super heated steam
- 4.5.2 Solve the problems by direct application of formulae for the above topics

5. Understand the Steam Boilers & its performance

5.1 Describe the working and general construction of a boiler
5.2 Describe the classification of boilers
5.3 State the selection factors of a good steam boiler

7.7.1 Indicated power
7.7.2 Brake power
7.7.3 Friction power
7.7.4 Efficiencies of I.C. engines

7.8 Make a Comparison of I.C. and E.C. engines
7.9 Make a Comparison of PETROL and DIESEL engines
7.10 Solve problems for calculation of I.P, B.P, Friction Power and efficiencies of I.C. engines

8. Understand the Air Compressors and their performance (Reciprocating & Rotary)

8.1 State the introduction of Air Compressors
8.2 Describe the classification / types of Air Compressors(Reciprocating & Rotary)
8.3 State the terms used for Air Compressors
8.4 Explain the following:
8.4.1 The Construction and working single cylinder- single stage double acting reciprocating air compressor with the help of P-V diagram and neat sketch
8.4.2 The work done single stage. Single cylinder reciprocating air compressor without and with clearance volume; also drive its Mathematical Expression.
8.5 Describe the Multistage compression with the help of P-V diagram and its advantages
8.6 Describe the two stage reciprocating air compressor with intercooler; also derive its mathematical Expression for the work done per cycle considering polytropic law of compression
8.7 Describe the power required to drive a single stage and two stages reciprocating Air compressors; also derive its formulae
8.8 Make a comparison of reciprocating and rotary air compressors
8.9 Describe the work done and power required to drive a rotary air compressor; also derive its formulae
8.10 Solution of the problems regarding work done and power required to drive the rotary and reciprocating air compressors

9. Understand the Refrigeration and Air Conditioning

9.1 State the concept of Refrigeration and Air conditioning
9.2 Describe the Classification/types of Refrigeration systems
9.3 State the Units and terms used for Refrigeration and Air Conditioning
9.4 State the names and Properties of refrigerants
9.5 Describe the simple mechanism of a vapour compression and vapour absorption in refrigeration system with the help of neat schematic diagram
9.6 State the fundamentals of Air Conditioning Systems
9.7 Describe the Classification/types Air Conditioning Systems

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List of Practical:

1. **Pressure measurement by Barometer**
2. **Introduction of Thermometers and Thermocouples**
3. **Sketch and study of Steam Boilers**
   - 3.1 Simple vertical boiler
   - 3.2 Cochran (Multi tubular) boiler
   - 3.3 Marine boiler(Scotch type)
   - 3.4 Locomotive boiler
4. **Sketch and study of Boiler Mountings and Accessories**
   - 4.1 Pressure gauge (Bourdon type)
   - 4.2 Water level indicator
   - 4.3 Safety valve (Spring loaded)
   - 4.4 Feed water pump
5. **Problem solving on steam generation**
6. **Practice on Petrol Engine**
7. **Practice on Diesel Engine**
8. **Practice on Ignition systems for I.C. Engines**
9. **Study and problem solution on Steam Turbine**
10. **Study of Gas Turbine**
11. **Performance Test of Reciprocating Air Compressor**
12. **Performance Test of Heating and Cooling system (Compression type A/C system)**
13. **Performance Test of Refrigeration system (Compression type)**