APPLIED THERMODYNAMICS AND HEAT TRANSFER

ENME 206

Lecture	**: 3**	**Year : II**
Tutorial	**: 1**	**Part : I**
Practical	**: 1.5**	

Course Objectives:

The objective of this course is to provide comprehensive understanding of thermodynamic systems and their applications in engineering and make students able to analyze and compare various power cycles, and apply principles such as energy balance and efficiency calculations.

1 Gas Power Cycle (7 hours)

1.1 Thermodynamics of combustion engines
- 1.1.1 Working mechanism of gasoline engine (Otto Cycle)
- 1.1.2 Working mechanism of Diesel engine (Diesel Cycle)
- 1.1.3 Working mechanism of gas turbine engine (Brayton Cycle)
- 1.1.4 Working principle of dual cycle
- 1.1.5 Comparison of thermodynamic cycles with respect to various conditions
- 1.1.6 Work output, efficiency and mean effective pressure

1.2 Rankine cycle, the ideal efficiency and isentropic efficiency

2 Air Compressor (6 hours)

2.1 Types of air compressor and working principle

2.2 Power and efficiency (Volumetric efficiency, isothermal efficiency and adiabatic efficiency) equation for reciprocating compressor

2.3 Factors governing volumetric efficiency

2.4 Free air delivery of reciprocating compressor

2.5 Applications of air compressor

3 Refrigeration System (6 hours)

3.1 Types of refrigeration system

3.2 Vapour compression refrigeration system
- 3.2.1 Working of simple vapour compression refrigeration system
- 3.2.2 Tracing on Temperature-entropy (T-s) and Pressure-enthalpy (P-h) diagram, coefficient of performance, power and flow rate analysis

- 3.3 Air refrigeration system
  - 3.3.1 Working principle
  - 3.3.2 Types of air refrigeration system
  - 3.3.3 Coefficient of performance, power and flow rate analysis

4 Heat Exchangers (4 hours)

- 4.1 Types of heat exchanger
- 4.2 Analysis of heat exchangers, fouling factor
- 4.3 Logarithmic mean temperature difference (LMTD) and effectiveness-number of transfer unit (NTU) method

5 Boilers (4 hours)

- 5.1 Classification and applications of boilers
- 5.2 Comparison of fire tube and water tube boiler
- 5.3 Requirements for an ideal boiler and boiler efficiency
- 5.4 Boiler mountings and accessories: Water level indicator, feed check valve, blow off cock, steam separator, safety valves, feed pump, air preheater, super heater and economizer

6 Conduction (8 hours)

- 6.1 Heat transfer mechanism
- 6.2 One dimensional heat conduction equation
  - 6.2.1 Heat conduction equation in large plane wall
  - 6.2.2 Heat conduction equation in cylinder and sphere
  - 6.2.3 Composite wall, cylinder and sphere
  - 6.2.4 Critical radius of insulation
- 6.3 Extended surfaces/heat transfer from finned surface
- 6.4 Unsteady heat conduction
  - 6.4.1 Lumped Analysis
  - 6.4.2 Introduction of Heislar chart

7 Convection (7 hours)

- 7.1 Hydrodynamic and thermodynamic boundary layer
- 7.2 Dimensional analysis related to convection heat transfer
- 7.3 Convective heat transfer coefficients, combined heat transfer and overall heat transfer coefficient
- 7.4 Forced convection: Laminar flow, turbulent flow, empirical co-relation (Laminar flow over flat plates, laminar flow inside tubes turbulent flow over flat plates, turbulent flow inside tubes, turbulent flow over cylinders)
- 7.5 Free convection: Characteristics parameters in free convection, empirical correlations for free convection on vertical and horizontal plates

8 Radiation (3 hours)

8.1 View factor and view factor relations
8.2 Radiation heat transfer on black surface, diffuse and gray surface
8.3 Radiation shield

Tutorial (15 hours)

1. Numerical exercises on Otto cycles, Diesel cycle, Brayton cycle and Rankine cycle
2. Numerical exercises on work done, mean effective pressure, volumetric efficiency, adiabatic efficiency and isothermal efficiency, free air delivery of reciprocating compressor
3. Numerical exercises on vapour compression refrigeration system and air refrigeration system
4. Numerical exercises on heat exchanger, LMTD and NTU
5. Numerical exercises on one dimensional conduction (Wall and cylinder), extended surface and unsteady heat transfer (Lumped analysis and Heislar chart)
6. Empirical numerical exercises on force convection heat transfer over flat plate and inside tube, and outside tube
7. Numerical exercises on view factor, radiation heat transfers on black surface, gray surface, radiation shield

Practical (22.5 hours)

1. Determination of coefficient of performance of vapour compression refrigeration with regard to different water flow rate in condenser and evaporator
2. Demo of air cycle machine for air-conditioning system
3. Heat exchanger, LMTD and effectiveness calculation for parallel and counter-flow HE
4. Conduction heat transfer: Verification of conduction laws, drawing of temperature profile and comparison between thermal conductivities of different types of materials
5. Convection heat transfer
6. Free and force convection from flat plates
7. Free and force convection from fins plate
8. Radiation heat transfer
9. Heat transfer by radiation to define emissivity of different material surface

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	7	8
2	6	8
3	6	8
4 and 5	8	10
6	8	12
7 and 8	10	14
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Çengel, Y.A., Ghajar, A.J., Kanoğlu, M. (2016). Heat and Mass Transfer: Fundamentals & Applications. India: McGraw Hill Education (India).
2. Rajput, P.K (2003). Heat and Mass Transfer. India: S. Chand & Company Ltd.
3. Luintel, M.C. (2019). Fundamentals of thermodynamics and heat transfer. Nepal: Heritage Publishers and Distributors.
4. Singh, O. (2006). Applied thermodynamics. India: New Age International.
5. Khurmi, R.S. (2001). A textbook of refrigeration and air conditioning (3rd edition). Eurasia Publishing House.