ADVANCED THERMODYNAMICS

Course Code: 15ME2302

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Course Outcomes: At the end of the course, student will be able to

CO1: Apply the concept of entropy and irreversibility to solve practical problems.

CO2: Explain P-V, T-S, P-T and h-s diagrams of pure substance and its significance.

CO3: Distinguish the equations of state for ideal and real gases and gas mixtures.

CO4: Develop TdS, Maxwell's equations and power cycles.

CO5: Explain reactive system and its significance in combustion process

UNIT-I (10-Lectures)

Entropy: Clausius theorem - the property of entropy – the inequality of Clausius – entropy change in an irreversible process – entropy principle – applications of entropy principle to the processes of transfer of heat through a finite temperature difference, and mixing of two fluids maximum work obtainable from a finite body and a thermal energy reservoir – entropy transfer with heat flow - entropy generation in a closed system – entropy generation in an open system.

UNIT-II (10-Lectures)

Available energy: Available energy referred to a cycle - available energy from a finite energy source – maximum work in a reversible process – dead state – availability in a steady flow process – availability in a non-flow process – availability in chemical reactions.

P-V-T Relationships for pure substances: P-v diagram for a pure substance, triple point line, critical point, saturated liquid and vapor lines, P-T diagram for a pure substance - T-s diagram for a pure substance – h-s diagram (Mollier diagram) for a pure substance – dryness fraction – problems using steam tables.

UNIT-III (10-Lectures)

Properties of Gases: Equations of state – Vander Waal's equation – law of corresponding states – Beattie-Bridgeman equation, Redlich-Kwong equation.

Gas Mixtures: Dalton's law of partial pressures – enthalpy and entropy of gas mixtures.

UNIT-IV (10-Lectures)

Thermodynamic Relations: Maxwell's equations –TdS equations – difference in heat capacities – ratio of heat capacities – Joule-Kelvin effect – Clausius-Clapeyron equation.

Power Cycles: Brayton cycle – comparison between Brayton cycle and Rankine cycle – effect of regeneration on Brayton cycle efficiency – Brayton-Rankine combined cycle.

UNIT-V (10-Lectures)

Reactive Systems: Degree of reaction – reaction equilibrium – law of mass action – heat of reaction – temperature dependence of the heat of reaction – temperature dependence of the equilibrium constant – change in Gibbs function – Fugacity and activity.

Chemical Reactions: Combustion, Theoretical and actual combustion processes – Enthalpy of formation – Enthalpy of Combustion – First Law analysis of Reacting Systems – Adiabatic flame temperature – Entropy change of Reacting mixtures – Second Law analysis of Reacting systems

TEXT BOOKS:

1. P.K. Nag, "*Engineering Thermodynamics"*, 4th Edition, Tata McGraw-Hill Education Private Limited, 2010.
2. S.S. Thipse, "*Advanced Thermodynamics"*, Narosa Publishing House, New Delhi, 2013

REFERENCES:

1. Y.A. Cengel and M.A. Boles, "*Thermodynamics – An Engineering Approach"*, 5th Edition in SI Units, Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.
2. C. Borganakke and R.E. Sonntag, "*Fundamentals of Thermodynamics"*, 7th Edition, Wiley India, Delhi, 2012.
3. Van P. Carey, "Statistical thermodynamics and micro scale thermo physics", Cambridge University Press, 1999