

Course No.	:	ENR 131
Course title	:	Thermodynamics and Combustion
Number of credits	:	4
Number of lectures-tutorial-practicals	:	42-14-0
Faculty Name	:	Dr. Najmur Rahman, Dr. OP Rao, Dr. VVN Kishore

Course outline

This course deals with the basic concepts of thermodynamics and combustion relevant to the use of renewable energy sources. At the end of the course the students will be able to develop an understanding of thermodynamic systems and thermodynamic properties, analyze and evaluate energy transfer to and from thermodynamic systems and various thermodynamic cycles used for energy production - work and heat, within the natural limits of conversion. Students will also be familiarized with the basics of fuels and combustion and combustion process in furnaces, boilers and internal combustion engines.

Evaluation procedure

- Assignments : 20%
- Two Minor Exams : 15% each
- Major Exam : 50%

Details of course contents and allotted time

Sr. No.	Contents	Allotted time (hours)	
		Lectures	Tutorials
1.	<i>Fundamental Concepts of Thermodynamics:</i> Importance of thermodynamics for use of renewable energy sources, basic definitions and scope of thermodynamics, microscopic and macroscopic approaches, practical applications of engineering thermodynamics, closed and open systems, control surface, control volume, thermodynamic state and equilibrium, intensive and extensive properties, processes: quasi-static, cyclic and noncyclic	2	
2.	<i>Properties of Pure Substances:</i> Definition of a pure substance, phases of a substance, triple point and critical point, sub-cooled liquid, saturated liquid, vapour pressure, two phase mixture of liquid and vapour, saturated vapour and superheated vapour Ideal gas equation of state, other equations of state, compressibility factor.	6	1
3.	<i>Work and Heat:</i> Temperature and zeroth law of thermodynamics,	6	1

Sr. No.	Contents	Allotted time (hours)	
		Lectures	Tutorials
	thermodynamic definition of work and heat, displacement work at the system boundary, expressions for displacement work in various processes through p-v diagrams First law of thermodynamics, first law for open systems: Steady Flow Energy Equation, Uniform Flow Energy Equation		
4.	<i>Second Law of Thermodynamics:</i> Introduction to second law, Kelvin-Planck and Clausius statements of the second law, reversible and irreversible processes, factors that make a process irreversible, reversible heat engine and heat pump, efficiency and coefficient of performance, Carnot cycle, reverse Carnot cycle Evolution of thermodynamic temperature scale, internal energy and enthalpy, entropy, entropy-temperature diagram for steam, steam tables, exergy analysis, second law efficiency	7	1
5.	<i>Basics of Energy conversion cycles:</i> Basic power generation cycles, Otto, Diesel, Rankine and Brayton cycles, Stirling cycle, organic Rankine cycle and refrigeration cycles: vapor compression and vapor absorption cycles	7	1
6.	<i>Principles of Combustion:</i> Importance of combustion in use of renewable energy sources, basic physical laws governing combustion, air as a source of oxygen for combustion, combustion principles of solid-liquid-gaseous fuels, proximate and ultimate analysis of solid and gaseous fuels, enthalpy of formation and estimation of calorific values, three Ts of combustion process, flame velocity, excess air requirements and estimation, flue gas analysis, combustion efficiency, stoichiometry, equivalence ratio, adiabatic flame temperature, kinetics, emissions	12	3
7.	<i>Combustion Processes and Equipment:</i> Combustion in furnaces, boilers, and internal combustion engines, solid, liquid and gas burners Fluidized bed combustion: atmospheric fluidized bed combustion, pressurized fluidized bed combustion	6	

Suggested readings

Text Books:

- RE Sonntag, C Borgnakke, GJ Van Wylen: **Fundamentals of Thermodynamics**, Sixth Edition, (*Wiley-India, 2007*).
- PK Nag: **Engineering Thermodynamics**, Third Edition (*Tata McGraw-Hill, 2005*)
- YA Cengel and MA Boles: **Thermodynamics: An Engineering Approach**, Sixth Edition (*Tata McGraw-Hill, 2008*)
- SR Turns: **An Introduction to Combustion: Concepts and Applications**, Second Edition (*McGraw Hill, 2000*)

Reference Books:

- LC Witte, PS Schmidt and DR Brown: **Industrial Energy Management and Utilization** (Springer-Verlag)
- TD Eastop, A McConkey: **Applied Thermodynamics**, Fifth Edition (*Prentice Hall, 1996*)
- MJ Moran, HN Shapiro: **Fundamentals of Engineering Thermodynamics**, Fifth Edition (*John Wiley & Sons, 2004*)
- G Rogers, Y Mayhew: **Engineering Thermodynamics**, Fourth Edition (*Pearson Education, 2007*)
- TA Eastop, DR Croft: **Energy Efficiency** (Longman Scientific and Technical, 1990)
- DP Mishra: **Fundamentals of Combustion** (Prentice Hall of India)