Unit 64: Thermofluids

Unit code	**M/615/1526**
Unit level	**5**
Credit value	**15**

Introduction

In everyday life you are never too far away from some system or device that relies on both fluid mechanics and thermodynamics. From the water circulating in your home central heating radiators to the hydraulic door closer on the back of a fire door, the presence of thermofluids is constantly around us.

The aim of this unit is to provide a rational understanding of functional thermodynamics and fluid mechanics in common industrial applications. The unit promotes a problem-based approach to solving realistic work-related quandaries such as steam plant efficiency and fluid flow capacities.

Students will examine fundamental thermodynamic principles, steam and gas turbine systems and viscosity in fluids, along with static and dynamic fluid systems. Each element of the unit will identify a variety of engineering challenges and assess how problems are overcome in real-life industrial situations.

Additionally, students will develop their perceptions of industrial thermodynamic systems, particularly those involving steam and gas turbine power. In addition, they will consider the impact of energy transfer in engineering applications along with the characteristics of fluid flow in piping systems and numerous hydraulic devices, all of which are prevalent in typical manufacturing and process facilities.

Learning Outcomes

By the end of this unit students will be able to:

1. Review industrial thermodynamic systems and their properties.
2. Examine the operation of practical steam and gas turbines plants.
3. Illustrate the properties of viscosity in fluids.
4. Analyse fluid systems and hydraulic machines.

Essential Content

LO1 **Review industrial thermodynamic systems and their properties**

Thermodynamic systems:

Power generation plant.

Significance of first law of thermodynamics.

Analysis of Non-Flow Energy Equation (NFEE) and Steady Flow Energy Equation (SFEE) systems.

Application of thermodynamic property tables.

Energy transfer systems employing polytropic processes (isothermal, adiabatic and isentropic).

Pressure/volume diagrams and the concept of work done: use of conventions.

The application of the Gas Laws and polytropic laws for vapours and gases.

LO2 **Examine the operation of practical steam and gas turbines plants**

Steam and gas turbine plant:

Principles of operation of steam and gas turbine plants.

Use of property diagrams to analyse plant.

Characteristics of steam/gas turbine plant as used in energy supply.

Energy-saving options adopted on steam plants operating on modified Rankine cycle.

Performance characteristics of steam and gas power plant.

Cycle efficiencies: turbine isentropic efficiencies and overall relative efficiency.

LO3 **Illustrate the effects of viscosity in fluids**

Viscosity in fluids:

Viscosity: shear stress, shear rate, dynamic viscosity, kinematic viscosity.

Viscosity measurement: operating principles of viscosity measuring devices e.g. falling sphere, U-tube, rotational and orifice viscometers (such as Redwood).

Newtonian fluids and non-Newtonian fluids: pseudoplastic, Bingham plastic, Casson plastic and dilatant fluids.

O4 **Analyse fluid systems and hydraulic machines**

Fluid systems:

Characteristics of fluid flow: laminar and turbulent flow, Reynolds number.

Friction factors: relative roughness of pipe, use of Moody diagrams.

Head losses across various industrial pipe fittings and valves, use of Bernoulli's Equation and Darcy's Formula.

Hydraulic machines:

Turbines: Pelton wheel, Kaplan turbine, Francis wheel.

Pumps: centrifugal, reciprocating.

Analysis of systems:

Dimensional analysis: verification of equations for torque, power and flow rate.

Application of dimensional analysis to determine the characteristics of a scale model.

Use of Buckingham Pi Theorem.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Review industrial thermodynamic systems and their properties		**D1** Analyse an operational industrial thermodynamic system in terms of work done.
P1 Discuss the operation of industrial thermodynamic systems and their properties. **P2** Describe the application of the first law of thermodynamics to industrial systems. **P3** Illustrate the relationships between system constants for a perfect gas.	**M1** Determine the index of compression in polytrophic processes.	
LO2 Examine the operation of practical steam and gas turbines plants		**D2** Evaluate the modifications made to the basic Rankine cycle to improve the overall efficiency of steam power plants.
P4 Explain the principles of operation of steam turbine plant. **P5** Calculate overall steam turbine plant efficiencies by the use of charts and/or tables. **P6** Discuss the principles of operation of gas turbine plants.	**M2** Justify why the Rankine cycle is preferred over the Carnot cycle in steam production plants around the world.	
LO3 Illustrate the effects of viscosity in fluids		**D3** Compare the results of a viscosity test on a Newtonian fluid with that which is given on a data sheet and explain any discrepancies.
P7 Illustrate the properties of viscosity in fluids. **P8** Explore three viscosity measurement techniques.	**M3** Evaluate the effects of shear force on Newtonian and non-Newtonian fluids.	

Pass	Merit	Distinction
LO4 Analyse fluid systems and hydraulic machines		**D4** Evaluate the use of dimensionless analysis using the Buckingham Pi Theorem for a given industrial application.
P9 Examine the characteristics of fluid flow in industrial piping systems. **P10** Discuss the operational aspects of hydraulic machines. **P11** Apply dimensional analysis to fluid flow.	**M4** Review the significance of the Reynolds number on fluid flow in a given system.	

Recommended resources

Textbooks

DUNN, D. (2001) *Fundamental Engineering Thermodynamics*. Longman.

EASTOP, T.D. and MCCONKEY, A. (1996) *Applied Thermodynamics for Engineering Technologists*. 5th Ed. Prentice Hall.

MASSEY, B.S. and WARD-SMITH, J. (2011) *Mechanics of Fluids*. 9th Ed. Oxford: Spon Press.

ROGERS, G.F.C and MAYHEW, Y.R (1994) *Thermodynamic and Transport Properties of Fluids: S. I. Units*. 5th Ed. Wiley-Blackwell.

Electronic

www.freestudy.co.uk

www.khanacademy.org

Links

This unit links to the following related units:

Unit 11: Fluid Mechanics

Unit 29: Electro, Pneumatic and Hydraulic Systems

Unit 13: Fundamentals of Thermodynamics and Heat Engines