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

LO4 **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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Review industrial thermodynamic systems and their properties</td><td rowspan="2">D1 Analyse an operational industrial thermodynamic system in terms of work done</td></tr>
<tr><td>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</td><td>M1 Determine the index of compression in polytrophic processes</td></tr>
<tr><td colspan="2">LO2 Examine the operation of practical steam and gas turbines plants</td><td rowspan="2">D2 Evaluate the modifications made to the basic Rankine cycle to improve the overall efficiency of steam power plants</td></tr>
<tr><td>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</td><td>M2 Justify why the Rankine cycle is preferred over the Carnot cycle in steam production plants around the world</td></tr>
</table>

Pass	Merit	Distinction
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	
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.

Websites

http://www.freestudy.co.uk	Free Study (Tutorials)
http://www.khanacademy.org	Khan Academy (Tutorials)

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