Unit 13: Fundamentals of Thermodynamics and Heat Engines

Unit code	**D/615/1487**
Unit level	**4**
Credit value	**15**

Introduction

Thermodynamics is one of the most common applications of science in our lives, and it is so much a part of our daily life that it is often taken for granted. For example, when driving your car you know that the fuel you put into the tank is converted into energy to propel the vehicle, and the heat produced by burning gas when cooking will produce steam which can lift the lid of the pan. These are examples of thermodynamics, which is the study of the dynamics and behaviour of energy and its manifestations.

This unit introduces students to the principles and concepts of thermodynamics and its application in modern engineering.

On successful completion of this unit students will be able to investigate fundamental thermodynamic systems and their properties, apply the steady flow energy equation to plant equipment, examine the principles of heat transfer to industrial applications, and determine the performance of internal combustion engines.

Learning Outcomes

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

1. Investigate fundamental thermodynamic systems and their properties.
2. Apply the Steady Flow Energy Equation to plant equipment.
3. Examine the principles of heat transfer to industrial applications.
4. Determine the performance of internal combustion engines.

Essential Content

LO1 **Investigate fundamental thermodynamic systems and their properties**

Fundamental systems:

Forms of energy and basic definitions

Definitions of systems (open and closed) and surroundings

First law of thermodynamics

The gas laws: Charles’ Law, Boyle’s Law, general gas law and the Characteristic Gas Equation

The importance and applications of pressure/volume diagrams and the concept of work done

Polytrophic processes: constant pressure, constant volume, adiabatic and isothermal systems

LO2 **Apply the Steady Flow Energy Equation to plant equipment**

Energy equations:

Conventions used when describing the behaviour of heat and work

The Non-Flow Energy Equation as it applies to closed systems

Assumptions, applications and examples of practical systems

Steady Flow Energy Equation as applied to open systems

Assumptions made about the conditions around, energy transfer and the calculations for specific plant equipment e.g. boilers, super-heaters, turbines, pumps and condensers

LO3 **Examine the principles of heat transfer to industrial applications**

Principles of heat transfer:

Modes of heat transmission, including conduction, convection & radiation

Heat transfer through composite walls and use of U and k values

Application of formulae to different types of heat exchangers, including recuperator and evaporative

Regenerators

Heat losses in thick and thin walled pipes, optimum lagging thickness

LO4 **Determine the performance of internal combustion engines**

Performance:

Application of the second law of thermodynamics to heat engines

Comparison of theoretical and practical heat engine cycles, including Otto, Diesel and Carnot

Explanations of practical applications of heat engine cycles, such as compression ignition (CI) and spark ignition engines, including their relative mechanical and thermodynamic efficiencies

Describe possible efficiency improvements to heat engines

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate fundamental thermodynamic systems and their properties		**D1** Illustrate the importance of expressions for work done in thermodynamic processes by applying first principles
P1 Describe the operation of thermodynamic systems and their properties **P2** Explain the application of the first law of thermodynamics to appropriate systems **P3** Explain the relationships between system constants for a perfect gas	**M1** Calculate the index of compression in polytrophic processes	
LO2 Apply the Steady Flow Energy Equation to plant equipment		**D2** Produce specific Steady Flow Energy Equations based on stated assumptions in plant equipment
P4 Explain system parameters using the Non-Flow Energy Equation **P5** Apply the Steady Flow Energy Equation to plant equipment	**M2** Derive the Steady Flow Energy Equation from first principles	

Pass	Merit	Distinction
LO3 Examine the principles of heat transfer to industrial applications		**D3** Distinguish the differences between parallel and counter flow recuperator heat exchangers
P6 Determine the heat transfer through composite walls **P7** Apply heat transfer formulae to heat exchangers	**M3** Explore heat losses through lagged and unlagged pipes	
LO4 Determine the performance of internal combustion engines		**D4** Evaluate the performance of two stroke and four stroke diesel engines
P8 Describe with the aid of a PV (pressure volume) diagram the operational sequence of four stroke spark ignition and four stroke compression ignition engines. **P9** Explain the mechanical efficiency of two and four stroke engines	**M4** Review the relative efficiency of ideal heat engines operating on the Otto and Diesel cycles	

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.

EASTOP, T.D. and MCCONKEY, A. (1997) *Applied Thermodynamics for Engineering Technologists Student Solution Manual*. 5th Ed. Prentice Hall.

RAYNER, J. (2008) *Basic Engineering Thermodynamics*. 5th Ed. Pearson.

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

Links

This unit links to the following related units:

Unit 38: Further Thermodynamics