Unit 4013: Fundamentals of Thermodynamics and Heat Transfer

Unit Code: D/651/0727

Level: 4

Credits: 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, the chemical energy from the fuel or electrical energy from the batteries are converted into mechanical 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 learn about fundamental thermodynamic systems and their properties, the steady flow energy equation to plant equipment, principles of heat transfer to industrial applications, and the performance of internal combustion engines.

Learning Outcomes

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

LO1 Investigate fundamental thermodynamic systems and their properties

LO2 Apply the Steady Flow Energy Equation for analysis of thermodynamic systems

LO3 Determine the performance of heat engines

LO4 Examine the principles of heat transfer applied to industrial applications.

Essential Content

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

Fundamental systems:

Application Areas of Thermodynamics

Forms of energy and basic definitions

Energy, Work and Power

Thermodynamic state and equilibrium

Definitions of systems (open and closed) and surroundings

Properties of pure substances and property tables.

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, isothermal and isentropic process.

LO2 **Apply the Steady Flow Energy Equation for analysis of thermodynamic systems**

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 **Determine the performance of heat engines**

Performance:

Application of the second law of thermodynamics to heat engines, heat pumps and Refrigerators.

Reversible and Irreversible Processes

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 (SI) engines with alternative fuels such as biofuels, hydrogen and ammonia, including their relative mechanical and thermodynamic efficiencies

Describe possible efficiency improvements to heat engines.

LO4 **Examine the principles of heat transfer applied to industrial applications**

Principles of heat transfer:

Modes of heat transfer: conduction, convection and radiation

Heat conduction in plane walls and thermal resistance concept

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

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

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

Regenerators

Safety first culture: health and safety policies, procedures and regulations; compliance; risk assessment process and procedures and mitigation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate fundamental thermodynamic systems and their properties		
P1 Investigate the operation of thermodynamic systems identifying its boundaries and surroundings. **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** Investigate the index of compression in polytrophic processes.	**D1** Apply the first law principles to derive the work and heat transfer for thermodynamic processes of perfect gas.
LO2 Apply the Steady Flow Energy Equation for analysis of thermodynamic systems		
P4 Explain system parameters using the Non-Flow Energy Equation. **P5** Apply the Steady Flow Energy Equation to plant equipment.	**M2** Apply Steady Flow Energy Equations for analysis of closed systems.	**D2** Evaluate application of Steady Flow Energy Equation for analysis of open systems.
LO3 Determine the performance of heat engines		
P6 Describe with the aid of a PV (pressure volume) the principals of Carnot or Otto or Diesel cycles based on the air-standard assumptions. **P7** Determine the maximum efficiency of heat engine or heat pump or refrigerators.	**M3** Analyse the operating condition of Carnot heat engine/heat pumps with the efficiency.	**D3** Calculate the working fluid properties in an ideal Otto/Diesel cycle and the cycle efficiency.
LO4 Examine the principles of heat transfer applied to industrial applications		
P8 Examine the principles of heat transfer through composite walls. **P9** Apply heat transfer formulae to heat exchangers.	**M4** Explore heat losses through lagged and unlagged pipes.	**D4** Distinguish the differences between parallel and counter flow recuperator heat exchangers and their heat transfer efficiencies

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Ansermet J.P. and Brechet S.D. (2019) *Principles of Thermodynamics* Hardcover. Cambridge University Press.

Assael M.J., Maitland G.C., Maskow T., Von Stockar U., Wakeham W.A. and Will S. (2022) *Commonly asked questions in thermodynamics*. CRC Press.

Borgnakke C. and Sonntag R. (2022) *Fundamental of Thermodynamics*. 10th Ed. Wiley

Cengel Y. (2019) *Thermodynamics: An Engineering Approach SI*, 9th Ed. McGraw Hill.

Cengel Y. (2020) *Heat and Mass Transfer: Fundamentals and Applications*, 6th Ed. McGraw Hill.

Desmet B. (2022) *Thermodynamics of Heat Engines*. Wiley.

Heywood J. (2018) *Internal combustion engine fundamentals*. McGraw-Hill.

Holman J. (2009) *Heat Transfer*. McGraw- Hill.

Lee J.H. and Ramamurthi K. (2022) *Fundamentals of thermodynamics*. CRC Press.

Lewis G.N., Randall M., Pitzer K.S. and Brewer L. (2020) *Thermodynamics*. Courier Dover Publications.

Packer N. and Al-Shemmeri T. (2018) *Conventional and Alternative Power Generation: Thermodynamics, Mitigation and Sustainability*. Wiley.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Applied Thermal Engineering

International Communications in Heat and Mass Transfer

International Journal of Heat and Mass Transfer

International Journal of Thermal Sciences

Journal of Turbomachinery

Links

This unit links to the following related units:

Unit 5005: Further Thermodynamics.

