Unit 38: Further Thermodynamics

Unit code	**D/615/1506**
Unit level	**5**
Credit value	**15**

Introduction

From the refrigerators that we use in our homes to the colossal power stations that generate the electricity we use and provide power to industry, the significance that thermodynamics plays in the 21st century cannot be underestimated.

The aim of this unit is to build on the techniques explored in *Unit 13: Fundamentals of Thermodynamics and Heat Engines*, to develop further students' skills in applied thermodynamics by investigating the relationships between theory and practice.

Among the topics included in this unit are: heat pumps and refrigeration, performance of air compressors, steam power plant and gas turbines.

On successful completion of this unit students will be able to determine the performance and operation of heat pumps and refrigeration systems, review the applications and efficiency of industrial compressors, use charts and/or tables to determine steam plant parameters and characteristics, describe the operation of gas turbines and assess their efficiency.

Learning Outcomes

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

1. Evaluate the performance and operation of heat pumps and refrigeration systems.
2. Review the applications and efficiency of industrial compressors.
3. Determine steam plant parameters and characteristics using charts and/or tables.
4. Examine the operation of gas turbines and assess their efficiency.

Essential Content

LO1 **Evaluate the performance and operation of heat pumps and refrigeration systems**

Heat pumps and refrigeration:

Reversed heat engines: reversed Carnot and Rankine cycles.

Second law of thermodynamics.

Refrigeration tables and charts (p-h diagrams).

Coefficient of performance of heat pumps and refrigerators.

Refrigerant fluids: properties and environmental effects.

Economics of heat pumps.

LO2 **Review the applications and efficiency of industrial compressors**

Performance of air compressors:

Theoretical and realistic cycles.

Isothermal and adiabatic work.

Volumetric efficiency.

Intercoolers, dryers and air receivers.

Hazards and faults: safety consideration and associated legislation.

LO3 **Determine steam plant parameters and characteristics, using charts and/or tables**

Steam power plant:

Use of tables and charts to analyse steam cycles.

Circuit diagrams showing boiler, super heater, turbine, condenser and feed pump.

Theoretical and actual operation: Carnot and Rankine cycle.

Efficiencies and improvements.

LO4 **Examine the operation of gas turbines and assess their efficiency**

Gas turbines:

Single and double shaft gas turbine operation.

Property diagrams: Brayton (Joule) cycle.

Intercooling, reheat and regeneration.

Combined heat and power plants.

Self-starting and burner ignition continuation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Evaluate the performance and operation of heat pumps and refrigeration systems		**D1** Conduct a cost-benefit analysis on the installation of a ground source heat pump on a smallholding to make valid recommendations for improvements.
P1 Using didactic sketches, evaluate the operating principles of both heat pumps and refrigeration systems. **P2** Use refrigeration tables and pressure/enthalpy charts to determine COP, heating effect and refrigeration effect of reversed heat engines.	**M1** Assess the limiting factors that impact on the economics of heat pumps. **M2** Illustrate the contradiction between refrigeration cycles and the second law of thermodynamics.	
LO2 Review the applications and efficiency of industrial compressors		**D2** Critically evaluate volumetric efficiency formula for a reciprocating compressor.
P3 Assess the different types of industrial compressor and identify justifiable applications for each. **P4** Discuss compressor faults and potential hazards. **P5** Determine the volumetric efficiency of a reciprocating compressor.	**M3** Evaluate isothermal efficiency by calculating the isothermal and polytropic work of a reciprocating compressor.	
LO3 Determine steam plant parameters and characteristics using charts and/or tables		**D3** Critically evaluate the pragmatic modifications made to the basic Rankine cycle to improve the overall efficiency of steam generation power plants.
P6 Discuss the need for superheated steam in a power generating plant. **P7** Apply the use of charts and/or tables to establish overall steam plant efficiencies in power systems.	**M4** Justify why the Rankine cycle is preferred over the Carnot cycle in steam production plants around the world.	

Pass	Merit	Distinction
LO4 Examine the operation of gas turbines and assess their efficiency		**D4** Critically analyse the practical solutions manufacturers offer to overcome problematic areas in gas turbines, such as burner ignition continuation and self-starting capabilities.
P8 Investigate the principles of operation of a gas turbine plant. **P9** Assess the efficiency of a gas turbine system.	**M5** Compare and evaluate the actual plant and theoretical efficiencies in a single shaft gas turbine system, accounting for any discrepancies found.	

Recommended Resources

Textbooks

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

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

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

Electronic

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Links

This unit links to the following related units:

Unit 13: Fundamentals of Thermodynamics and Heat Engines