Unit 50: Aircraft Gas Turbine Engines

Delivery guidance

Approaching the unit

This unit should give the learner an understanding of the scientific principles, operation and performance of aircraft gas turbine engines, including their impact on the environment.

It would be most effective to deliver the unit learning aims in order. Delivery should cover the operation and construction of Turbojet, Turbofan, Turboprop and Turboshaft engines. Depending on available resources, you may not be able to cover the full range of engine types through practical activities. However, you will need to give opportunities for the learners to identify the components/construction of an actual engine where possible. Visits to manufacturers could help to achieve this.

You can use a range of delivery methods for this unit, such as:

- individual or group presentations covering the operation and performance of selected aircraft gas turbine engine types
- industrial visits to an engine manufacturer or maintenance organisation to examine an actual turbine engine installation and identify the systems/components discussed in class
- case studies of different engines and systems
- practical demonstrations and, if a small gas turbine test rig is available, exercises such as oil temperature and pressure monitoring or the use of engine controls
- videos
- if learners are in relevant employment, they should be encouraged to use the resources available to them at their workplace
- use of simulators for the investigation of engine operation and performance.

Where group work is allowed you must ensure that each learner produces their own evidence and that it is sufficient for assessment when at this stage.

Before any visits or practical activities are planned, you should ensure that the learners are aware of the health and safety issues and precautions to be taken with aircraft fuels and pressurised fuel systems.

You can involve local employers in the delivery of this unit if there are opportunities to do so.

Delivering the learning aims

For learning aim A you should introduce the topic by giving a brief history of aircraft power plant development from piston engines to gas turbines. You should then introduce the scientific principles underlying the operation of a gas turbine engine. The gas laws and thermodynamic processes should be explained and developed into thermodynamic cycles leading to an investigation of the theoretical and actual Brayton cycles. In the course of this investigation you should explain the use of pressure/volume (PV) and temperature/volume (TV) diagrams. The learners should then be required to research the Brayton cycle and investigate the features of a practical working cycle (the animations available on www.thermofluids.net could be used to aid this).

Further input will be required to introduce Newton's laws and develop the concept of

thrust and the thrust equation. The learners should be required to solve a range of problems involving engine thrust calculations.

You should then introduce the four types of gas turbine engine (Turbojet, Turbofan, Turboprop and Turboshaft). The learners should be required to investigate each engine design and produce a presentation describing the components, construction and applications of each type. They should then make comparisons between designs, highlighting advantages and disadvantages of each.

For learning aim B you should introduce the topic by giving an overview of gas turbine engine components including compressors and fans, combustors, turbines, intakes and exhausts. The learners should be required to research and develop a report describing the function and operation of each component in more detail. This could be supported by an industrial visit to an engine manufacturer or maintenance organisation.

Further input will be required to introduce starter and fluid systems to ensure coverage of the unit content. The topic of fluid systems should include fuel, oil and air systems. Fluid systems are also covered in more depth in *Unit 51: Aircraft Propulsion Systems*, and if this unit is also being delivered there is the opportunity to consolidate delivery of this area of content for both units. You should try to ensure that theoretical concepts are reinforced by exposure to actual engine components and availability of a range of these would enhance delivery.

For learning aim C you should give input on measures of engine performance and the effect of gas turbine cycle parameters on performance. The learners should then be required to complete a practical activity using an engine simulator to investigate the factors affecting engine performance and efficiency leading to an investigation of the impact of efficiency on fuel consumption.
Further input will be required to introduce thrust enhancement methods.

Finally, you should introduce the environmental impact of the operation of gas turbine engines in terms of noise and emissions. The learners should be required to work in groups to research noise measurement, noise sources and reduction and produce a presentation of their findings. You will need to give further input to cover the process of combustion in basic terms to ensure that the learners are aware of the products of combustion related to the operation of aircraft gas turbine engines.

Learning aim	Key content areas	Recommended assessment approach
A Examine the scientific principles and operation of aircraft gas turbine engines that produce thrust	**A1** Scientific principles relating to gas turbine engines **A2** Types and operation of aircraft gas turbine engines	A report covering the scientific principles, function and operation of two engine types selected from turbojet, turbofan, turboshaft and turboprop gas turbine engines.
B Examine the function and operation of gas turbine engine components and systems that produce thrust	**B1** Function and operation of turbine engine components **B2** Function and operation of engine starter and fluid systems	A report covering the function and operation of aircraft gas turbine engine components, and starting and fluid systems.
C Investigate the factors affecting the performance and environmental impact of aircraft using gas turbine propulsion	**C1** Aircraft gas turbine engine performance **C2** Environmental impact of gas turbine engines	A report covering the factors that affect the performance of aircraft gas turbine engines and the nature of, and measures being taken to help reduce, the adverse effects of gas turbine engine pollutants.

Assessment guidance

This unit is internally assessed through a number of independent tasks. Each task should cover at least one entire learning aim. There are three suggested assignments for this unit, each covering one of the learning aims. All learners must independently generate individual evidence that can be fully authenticated.

For learning aim A evidence is likely to be in the form of a written report incorporating detailed research into the thermodynamic cycle on which the operation of an aircraft gas turbine engine is based. The report should include an explanation of each process involved in the Brayton cycle and should be supported by calculations using the appropriate gas laws, Newton's laws and the thrust equation. The report will further explain and analyse the function and operation of two types of gas turbine engine detailing how each component affects the properties of the working fluid on its passage through the engine. The text should be supported by relevant drawings, schematics and photographs. The report will include a fully referenced bibliography.

For learning aim B evidence is likely to be in the form of a written report incorporating detailed research covering the function and operation of gas turbine engine components including compressors, combustors, turbine, intakes andexhausts.
Further evidence will include an explanation of engine starter systems and fluid systems including fuel, oil and air systems. The text should be supported by relevant drawings, schematics and photographs. The report will include a fully referenced bibliography.

For learning aim C evidence is likely to be in the form of a written report incorporating an explanation of the factors affecting engine performance in terms of thrust and fuel consumption with example calculations. Further research will explain thrust enhancements methods. The report will consider the environmental impact of the operation of aircraft gas turbine engines with respect to noise and emissions. Further analysis will review the methods used to limit these effects.

Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 50: Aircraft Gas Turbine Engines

Introduction

Introduce the unit to the learners through a group discussion explaining various aircraft roles and the type of engine installed, e.g. turbojet, turbofan, turboprop and turboshaft. Discuss the unit content, learning aims and assessment methods to be used. Where learners are in relevant employment they should be encouraged to make use of the resources available at their place of work when performing the activities suggested below.

Learning aim A – Examine the scientific principles and operation of aircraft gas turbine engines that produce thrust

- Introduce this learning aim by discussing the gas laws and develop this further to examine thermodynamic processes. The Brayton cycle should then be examined covering both the theoretical and actual cycles and the differences between them. Newton's laws should then be explained and linked to the thrust equation. You should emphasise the calculation of mass and volumetric flow rates.
- You should reinforce the theoretical concepts discussed above with calculations and exercises to verify the concepts. This could be in the form of group or individual work. Ensure that the learners appreciate the importance of the use of correct units in any calculations and tests to generate reasonable answers.
- As a further activity, you could ask the learners to work in small groups to investigate the factors affecting engine performance by running simple simulations using 'EngineSim' (from the National Aeronautics and Space Administration [NASA]) or any available simulation software.
- Ask learners to work in groups to research the features of the four basic aircraft gas turbine engines - turbojet, turbofan, turboprop and turboshaft. The groups are then to deliver their presentations, which will be followed by a group question and answer session to develop/reinforce any points raised by the presentations.
- Give further input to reinforce the research from the previous activity and fill in any missing areas of function or operation of gas turbine engines.
- It would be engaging for the learners at this point if you were to arrange either an industrial visit to an aircraft manufacturer or maintenance organisation or a guest speaker from one of these organisations to talk about the features and design of gas turbine engines.
- You should then assign a final activity where the learners are required to perform a simple engine design exercise perhaps using the features of the TEST website (see below. The aim of the activity should be to appreciate the factors involved in the generation of thrust and torque.

Learning aim B – Examine the function and operation of gas turbine engine components and systems that produce thrust

- Introduce this learning aim by discussing the basic components of an aircraft gas turbine engine, e.g. intake, compressor, combustor, turbine, exhaust. This website (requires Flash Player), http://html.investis.com/R/Rolls-Royce/corp/interactive-games/journey03/, can be used to support this presentation.
  Ask the learners to work in small groups to research each of the basic components of a gas turbine engine and produce a presentation to explain its features, function and operation. You may need to give further input to ensure the learners have covered all of the unit content.
- Introduce engine starter systems and fluid systems (air, fuel and oil).
- Ask the learners to work in small groups to investigate engine starter systems and produce a detailed presentation of the function and operation of each system. The Boeing 767 videos listed in the resources section could be used to illustrate some of these features. Access to starter system components and location on a gas turbine engine should be used to link theory with practice.
- Ask the learners to work in small groups to investigate engine air systems and produce a detailed presentation of the function and operation of each system. The Boeing 767 videos listed in the resources section could be used to illustrate some of these features. Access to air system components and location on a gas turbine engine should be used to link theory with practice.
- Ask the learners to work in small groups to investigate engine fuel systems and produce a detailed presentation of the function and operation of each system. The Boeing 767 videos listed in the resources section could be used to illustrate some of these features. Access to engine fuel system components and where possible airframe fuel systems should be used to link theory with practice and encourage learners to identify each component.
- Ask the learners to work in small groups to investigate engine oil systems and produce a detailed presentation of the function and operation of each system. The Boeing 767 videos listed in the resources section could be used to illustrate some of these features. Access to oil system components and location on a gas turbine engine should be used to link theory with practice.

Learning aim C – Investigate the factors affecting the performance and environmental impact of aircraft using gas turbine propulsion

- Introduce this learning aim by providing an overview of measures of engine performance and reviewing the environmental impact of gas turbine operation.
- Give input to define measures of performance, the impact of gas turbine parameters and the effects of thermal efficiency. Ask the learners to work in small groups to solve problems related to performance and efficiency stressing the importance of the correct use of units.
- As a further activity, ask the learners to work in small groups to research methods of thrust enhancement and produce a presentation explaining their findings. Reinforce the results of the research with a question and answer session.
- Hold a class discussion to review possible environmental effects of gas turbine operation ensuring that noise and emissions are covered. Support the discussion with input defining the decibel rating and giving a basic overview of the combustion process.
- Ask the learners to work in groups to research sources of aircraft noise and methods used to reduce this. The groups should then report back to the class.
- Ask the learners to work in small groups to research gas turbine engine emissions and the methods used to reduce them. The groups should report back to the class and discuss their findings in a question and answer session.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

Pearson BTEC International Level 3 Qualifications in Engineering:

- *Unit 29: Principles and Applications of Fluid Mechanics*
- *Unit 48: Aircraft Flight Principles and Practice*
- *Unit 51: Aircraft Propulsion Systems*
- *Unit 55: Aircraft First Line Maintenance Operations*

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International Level 3 Qualifications in Engineering. Check the Pearson website (http://qualifications.pearson.com/en/support/published-resources.html) for more information as titles achieve endorsement.

Textbooks

- Gunston B – *The Development of Jet and Turbine Aero Engines, 4th Edition* (Patrick Stephens Ltd, 2006) ISBN 978-1852606183.
  This book gives a comprehensive overview of the development and types of gas turbine aero engines.
- Jeppesen and Atlantic Flight Training **–** *Powerplant JAA ATPL Training, 2nd Edition* (Jeppesen and Atlantic Flight Training, 2007) ISBN 978-0884874928. Contains several chapters on gas turbine engines and systems with useful diagrams.
- Jeppesen and Atlantic Flight Training **–** *Airframes & Systems JAAATPL Training* (Jeppesen and Atlantic Flight Training, 2007) ISBN 978- 0884874546.
  Contains useful chapters on aircraft fuel systems, ice protection and fire protection systems with good diagrams.
- Rolls Royce – *The Jet Engine, 5th Edition* (Wiley-Blackwell, 2015) ISBN 978-1119065999.
  Contains a readable account of all the major engine systems and gives coverage of the content for a large part this unit.
- FAA, 2012 – *Aviation Maintenance Technician Handbook – Airframe, Volumes 1 and 2, FAA* [Online]. Available at: www.faa.gov/regulations_policies/handbooks_manuals
  These handbooks have detailed chapters on airframes including aircraft fuel systems with excellent illustrations.
- FAA, 2012 – *Aviation Maintenance Technician Handbook – Powerplant, Volumes 1 and 2, FAA* [Online]. Available at: www.faa.gov/regulations_policies/handbooks_manuals/aircraft
  These handbooks have detailed chapters on power plants with excellent illustrations.

Websites

- www.animatedengines.com/jets.html
  This website has simple animations of the main types of gas turbine engine.
- www.grc.nasa.gov/www/K-12/airplane/ngnsim.html
  This website, which is maintained by NASA, has an engine simulator that may be used to investigate gas turbine engine performance. The simulator uses Java and may need some IT input to install.
- www.grc.nasa.gov/WWW/K-12/airplane/shortp.html
  This is the Propulsion Index page of the NASA education website that contains many useful aeronautical resources.
- www.thermofluids.net
  Known as TEST (The Expert System for Thermodynamics), this is an excellent site containing many useful animations/problems of varying complexity related to gas turbine engines.
- http://html.investis.com/R/Rolls-Royce/corp/interactive-games/journey03/ This site offers a good overview of the construction of aircraft gas turbine engines (requires Flash Player).