ES3A8-15 Design for Manufacture

23/24

Department
School of Engineering
Level
Undergraduate Level 3
Module leader
Darren Hughes
Credit value
15
Module duration
10 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Design for Manufacture

Module web page

Module aims

This module investigates the detailed links between component design, material selection, product requirements and limitations of manufacturing processes. Through the application of sound engineering design perinciples, it is shown how a product can be optimised for a given manufacturing route and also ensures that the optimum manufacturing process is chosen.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

This course focusses on the balance between design of a component and the restrictions imposed by a given manufacturing route. A number of modern manufacturing processes are directly addressed but the principles used apply to all manufacturing methodologies. The course aims to develop an understanding of the behaviour of materials during manufacturing operations both at a

macroscopic scale and at a microscopic scale. The links between material properties arising from the manufacturing route and the performance of the product will be explored. By understanding the links between materials, defects and processing , an insight will be provided into optimal design of a component for the manufacturing process.
A focus is made on the differences between solid and liquid processing of both polymers and metals. It will be shown that differences arise both at a macroscopic level (component scale) and at microscopic level (to atomic level) but that both are linked to component design. Six groups of processes are considered. For each process, consideration will be given to links between:

- The manufacturing process (plant, tooling and the process itself)
- The material selected
- Design limitations including defects and other performance limiting aspects.

The core processes that are covered:

- Casting: Differences between die casting, sand casting and Investment casting will be discussed. The modulus technique will be introduced and further developed to show its use in design optimisation. The modulus technique will be used particularly for feeding a casting to overcome starvation and macroporosity. Defects in castings will be addressed both in terms of origins and including methods for their reduction.
- Forging: Plant requirements for different forging techniques will be introduced. Closed die forging will be considered in detail. Folds, laps, etc. will be explained. Detail of forging plant and the relation to component geometry and type of operation will be covered.
- Heat Treatment: Basic steel metallurgy will be assumed. The concept of through-thickness hardening will be introduced in terms of austenite decomposition. Tools to understand hardening behaviour in a real component will be discussed (via CCT diagrams). Modulus will be revisited as an enabler to understand cooling/hardening.
- Injection Moulding: This will be concerned with the flow of material in the mould resulting in porosity, residual stress and distortion, polymer and fibre alignment, weld lines and sink marks.
- Joining: The processes of welding, mechanical and adhesive joining will be covered. Particular focus will be made of automotive sector joining technologies including the current state of the art. The design, preparation and quality of the joint will be featured. Some examples of non-destructive evaluation will also form part of this section.
- Assembly: This will cover the DFA techniques developed by Boothroyd and Dewhurst. Methods for improvement of design using DFA will be discussed. Negative aspects of DFA will also be explored. A case study will be provided as a group activity.

At the end of this course, students should have an appreciation, in some depth, of the design considerations needed for manufacture using the above processes and importantly have the tools to question other processes and limitations not covered here.

Learning outcomes

By the end of the module, students should be able to:

- Understand the relationship between the tooling geometry and limitations on component design.

- Contrast plant requirements for different manufacturing processes.
- Relate the effect of material behaviour during processing to the components that can be achieved.
- Summarise the differences between solid and liquid manufacturing routes and link them to component design.
- Analyse a components design given the confines of a particular manufacturing route and make recommendations for improvement.

Indicative reading list

DeGarmo's Materials and Processes in Manufacturing, 11th International student edition. J. T. Black, Ronald A. Kohser (2012). ISBN 9780470873755

Product design for manufacture and assembly, 3rd Edition. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight (2011). ISBN 9781420089271. Warwick library - TS171.4.B66. [Note ebook of 2nd edition available from library)

Introduction to manufacturing processes, Mikell P. Groover (2012). ISBN 9780470632284. Warwick library - TS183.G785.

Introduction to materials science for engineers, James F. Shackelford (2015). ISBN 9780136012603. Warwick library - TA 403.S4.

Manufacturing engineering and technology, Serope Kalpakjian. (2014) ISBN 9789810694067. Warwick library - TS176.K34.

Subject specific skills

Detailed understanding of how design decisions impact on component quality for different processing methods
Ability to analyse the design process, including cost drivers, material selection and evaluating component outcomes
Ability to conceive, make and realise a component, product or system via a given manufacturing process
Ability to develop performance viable, economical, sustainable solutions for product manufacture
Understanding of the key considerations needed for process decision-making
Ability for pragmatic decision-making, using sound engineering skills, when considering any proposed component or manufacturing route.
Ability to apply a systematic engineering approach including the logical and practical steps necessary for, often complex, concepts to become reality
Ability to seek creative, innovative and sustainable solutions to new product manufacturing challenges

Transferable skills

Pragmatic use of engineering skills for decision-making in new situations.
Apply problem solving skills, information retrieval, and the effective use of general IT facilities
Awareness of the requirements of industry in the creation of economic and social value

Overcome difficulties by employing skills, knowledge and understanding in a flexible manner

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Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Other activity	2 hours (1%)
Private study	118 hours (79%)
Total	150 hours

Private study description

118 hrs guided independent learning

Other activity description

2 x 1 hrs revision class

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group B

	Weighting	Study time
Online Examination 2 X 1HR QMP ~Platforms - QMP	100%	

- Online examination: No Answerbook required
- Students may use a calculator

	Weighting	Study time

- Engineering Data Book 8th Edition
- Graph paper

Feedback on assessment

Written comments on assignment
Cohort level feedback on examinations

Past exam papers for ES3A8

Availability

Courses

This module is Core for:

- Year 3 of UESA-H335 BEng Automotive Engineering
- Year 4 of UESA-H334 BEng Automotive Engineering with Intercalated Year
- Year 3 of UESA-HH73 BEng Manufacturing and Mechanical Engineering
- Year 3 of UESA-HH75 BEng Manufacturing and Mechanical Engineering
- Year 4 of UESA-HH74 BEng Manufacturing and Mechanical Engineering with Intercalated Year
- Year 3 of UESA-H336 MEng Automotive Engineering
- Year 3 of UESA-HH76 MEng Manufacturing and Mechanical Engineering
- UESA-HH38 MEng Manufacturing and Mechanical Engineering with Intercalated Year
    - Year 3 of HH38 Manufacturing and Mechanical Engineering with Intercalated Year MEng
    - Year 4 of HH38 Manufacturing and Mechanical Engineering with Intercalated Year MEng

This module is Core optional for:

- Year 4 of UESA-H334 BEng Automotive Engineering with Intercalated Year
- Year 4 of UESA-H337 MEng Automotive Engineering with Intercalated Year
- Year 3 of UESA-H115 MEng Engineering with Intercalated Year
- UESA-HH38 MEng Manufacturing and Mechanical Engineering with Intercalated Year
    - Year 3 of HH38 Manufacturing and Mechanical Engineering with Intercalated Year MEng
    - Year 4 of HH38 Manufacturing and Mechanical Engineering with Intercalated Year MEng
- UESA-HH77 MEng Manufacturing and Mechanical Engineering with Intercalated Year
    - Year 3 of HH77 Manufacturing and Mechanical Engineering MEng with Intercalated Year

    - Year 4 of HH77 Manufacturing and Mechanical Engineering MEng with Intercalated Year
- Year 3 of UESA-H11L Undergradaute Engineering (with Intercalated Year)

This module is Optional for:

- Year 3 of UESA-H113 BEng Engineering
- Year 3 of UESA-H114 MEng Engineering
- Year 4 of UESA-H115 MEng Engineering with Intercalated Year
- UESA-H11L Undergradaute Engineering (with Intercalated Year)
    - Year 3 of H11L Engineering (with Intercalated Year)
    - Year 4 of H11L Engineering (with Intercalated Year)

This module is Option list A for:

- Year 4 of UESA-H111 BEng Engineering with Intercalated Year
- UESA-H112 BSc Engineering
    - Year 3 of H112 Engineering
    - Year 3 of H112 Engineering

This module is Option list B for:

- Year 3 of UESA-HN12 BEng Engineering Business Management
- Year 3 of UESA-HN15 BEng Engineering Business Management
- Year 4 of UESA-HN13 BEng Engineering Business Management with Intercalated Year