Unit 4007: Machining and Processing of Engineering Materials

Unit Code: D/651/0718

Level: 4

Credits: 15

Introduction

Practical articles that we see and use every day such as automobiles, aircraft, trains, and even the cans we use to store our food, came from the ideas and visions of engineers and designers. The production of these articles is based on well-established production processes, machines, and materials.

The aim of this unit is to introduce students to the application of a variety of material forming processes involved in the production of components and articles for everyday use. Among the topics included in this unit are: conventional machining, additive layer manufacturing (ALM), shaping and moulding processes used in the production of components, machine tooling, jigs and fixtures required to support the manufacture of components, using metallic and non-metallic materials such as polymers and composites.

On successful completion of this unit students will be able to describe moulding, shaping, and forging, ALM manufacturing processes, explain the importance of material selection, and summarise the impact machining processes have on the physical properties of a component.

Learning Outcomes

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

LO1 Explore the conventional machining, additive manufacture and forming processes and their application in the production of engineered components

LO2 Explain how component materials, metals and non-metals, affect the selection of the most appropriate machining or forming process

LO3 Examine the most appropriate machine tooling, jigs and fixtures to support the production of an engineered component

LO4 Discuss the most appropriate moulding and shaping process used to produce a range of metal and non-metal engineered components.

Essential Content

LO1 **Explore the conventional machining, additive manufacture and forming processes and their application in the production of engineered components**

Manufacturing processes:

Material removal machining processes including: conventional manual processes, CNC machining and erosion machining technologies

Selection of machining processes to generate geometrical forms: flat and cylindrical geometry

Additive manufacture principles, techniques (e.g., 3D printing,), processes and applications; virtual machining/forming technologies and example case studies

Impact of material removal rate on surface finish and texture and speed of production

Consideration of the effect of production volume (prototypes, batch, and high volume) on the selection of the most appropriate process, tooling and resource commitment

Safe working practices when operating machining and process forming equipment.

LO2 **Explain how component materials, metals and non-metals, affect the selection of the most appropriate machining or forming process**

Material choice and machine process:

Impact of material types on the choice of machining process including: round, square and hexagonal bar, tube, plate, section and pre-cast

Effective of post processing activities of additive layer manufactured parts, e.g. hot isostatic pressing and shot peening.

Machining characteristics when using polymers, composites, non-ferrous and ferrous metals and exotic materials

Composites for machining/forming, latest advancements in composites

How the mechanical properties of the component material can be affected by the machining process

Effect of lubricants, coolants and cutting fluids on tooling, production speed, and quality of finish.

LO3 **Examine the most appropriate machine tooling, jigs and fixtures to support the production of an engineered component**

Awareness of the range of cutting tools:

Factors that prolong tool life, increased material removal rate and improved surface finish

Properties for cutting tool materials

Cause and effect of premature and catastrophic tool failure, preventative measures to promote tool life.

Cutting forces and the mechanics of chip formation:

Factors that affect cutting speeds and feeds, calculating cutting speeds and feeds

Relationship between cutting speed and tool life, economics of metal removal

Range of tooling jigs and fixtures including mechanical, magnetic, hydraulic and pneumatic

Work-holding: six degrees of freedom.

LO4 **Discuss the most appropriate moulding and shaping process used to produce a range of metal and non-metal engineered components**

Moulding and shaping processes:

Range of metal and ceramic powder moulding and shaping processes

Casting, powder metallurgy and sintering

Range of plastic moulding and shaping processes: blow, compression, extrusion, injection, laminating, reaction injection, matrix, rotational, spin casting, transfer and vacuum forming

Discuss in groups industry case studies and good practices in producing metal and non-metal engineered components.

Range, benefits and limitations of various shaping processes:

Extrusion, forging, rolling, hot and cold presswork.

Range of casting processes:

Sand, permanent mould, investment, lost foam, die, centrifugal, glass and slip casting.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the conventional machining, additive manufacture and forming processes and their application in the production of engineered components		
P1 Explain the most appropriate machining or additive manufacture process to manufacture a selected component **P2** Explore the reasons why a specific moulding process would be used to manufacture a selected component.	**M1** Analyse the characteristics of conventional machining processes, additive manufacture processes, plastic moulding processes and powder metallurgy used in producing components.	**D1** Evaluate the benefits and limitations of components manufactured using conventional machining, additive manufacture and moulding processes.
LO2 Explain how component materials, metals and non-metals, affect the selection of the most appropriate machining or forming process		
P3 Explain how the manufacturing process can affect the structure and properties of the parent material **P4** Describe the effect lubricants, coolants and cutting fluids have on tooling, production speed, and quality of finish.	**M2** Detail the characteristics of cutting tool geometries **M3** Examine why different tool geometries are required for different material types.	**D2** Evaluate the structure and mechanical properties of a given engineered component manufactured using the die-casting process and conventional material-removal machining processes.

Pass	Merit	Distinction
LO3 Examine the most appropriate machine tooling, jigs and fixtures to support the production of an engineered component		
P5 Examine the parameters of metal removal that determine the appropriate tooling for the production of a given engineered component **P6** Describe the range of tooling jigs and fixtures needed to retain a component during manufacture to mitigate possible failures linked to the cutting tools employed during the process.	**M4** Analyse the properties and modes of failure of modern cutting tools used in machining operations.	**D3** Critique the relationship between metal removal rate and tool life on the economics of material removal.
LO4 Discuss the most appropriate moulding and shaping process used to produce a range of metal and non-metal engineered components.		
P7 Explain which material characteristics determine the choice of moulding processes **P8** Discuss the benefits and limitations of products manufactured by sintering and moulding processes.	**M5** Analyse each of the stages of the moulding process and comment on the benefits associated with this manufacturing process.	**D4** Evaluate how the composition and structure of metal alloys, polymers and polymer matrix composites are affected by the material machining or forming process.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bhattacharyya B. and Doloi B. (2019) *Modern machining technology: Advanced, hybrid, micro machining and super finishing technology*. Academic Press.

Chang K.H. (2021) *Virtual Machining Using CAMWorks 2021: CAMWorks as a solidworks Module*. 1st Ed. SDC Publications.

Gajrani K.K., Prasad A. and Kumar A. (2022) *Advances in Sustainable Machining and Manufacturing Processes.* 1st Ed. CRC Press.

Gibson I., Rosen D., Khorasani M. and Stucker B. (2020) *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*. 3rd Ed. Cham, Switzerland: Springer Nature.

Groover M.P. (2020) *Fundamentals of Modern Manufacturing: Materials, Processes, And Systems*. John Wiley and Sons.

Gupta K. and Davim J.P. (2020) *High-Speed Machining.* 1st Ed. Academic Press.

Huda Z. (2021) *Machining Processes and Machines: Fundamentals, Analysis, and Calculations*. 1st Ed. CRC Press.

Kalpakjian S. and Schmid R.S. (2013) *Manufacturing Engineering and Technology*. 7th Ed. Pearson.

Nayak R.K., Pradhan M.K. and Sahoo A.K. (2022) *Machining of Nanocomposites.* 1st Ed. CRC Press.

Pramanik A. (2021) *Machining and Tribology: Processes, Surfaces, Coolants, and Modeling.* 1st Ed. Elsevier.

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.

International Journal of Machining and Machinability of Materials

International Journal of Machine Tools and Manufacture

Journal of Materials: Design and Applications,

Machining Science and Technology

Links

This unit links to the following related units:

Unit 4009: Materials, Properties and Testing

Unit 4010: Mechanical Workshop Practices.