Unit T5: Advanced Manufacturing Processes

Unit code:	T/503/7341
QCF level:	6
Credit value:	15

Aim

The aim of this unit is to develop the learner's understanding of a range of advanced manufacturing processes.

Unit abstract

Industry, driven by issues of sustainability, is constantly striving to improve its ability to produce products to optimum specifications that might include high strength to weight ratios, the smallest possible size and high levels of geometric complexity. Manufacturing processes have been developed to address many of these demands and to cope with modern materials that because of their high levels of hardness are, for example, difficult or impossible to process using more traditional approaches.

These advanced manufacturing processes are being developed to address the needs of, for example, the aerospace, electronics and automotive industries. This unit provides an understanding of these advanced manufacturing processes. It covers non-contact machining processes, the manufacturing of polymer matrix components, micro- and nano-scale manufacturing technology, non-conventional sheet metal and tubular component manufacture and modern surface enhancement processes.

Learning outcomes

On successful completion of this unit a learner will:

1 understand how non-contact machining processes are applied in advanced manufacturing

2 understand methods used to fabricate polymer matrix components and their applications

3 understand how micro- and nano- scale manufacturing processes are used to produce microelectromechanical systems and devices

4 understand how non-conventional forming processes are applied to produce sheet metal and tubular components

5 understand surface enhancement processes in advanced manufacturing and their applications.

Unit content

1 Understand how non-contact machining processes are applied in advanced manufacturing

Mechanical processes: ultrasonic machining; abrasive jet machining; water jet cutting; abrasive flow machining

Electro-chemical processes: electro-chemical machining; electro-chemical grinding

Thermal processes: electric discharge machining (EDM) (ram EDM, wire EDM); electron beam machining; laser beam machining; plasma arc cutting processes Chemical processes: engraving; photo chemical milling; photo chemical blanking

Applications: eg manufacture of mould tooling, complex detailing, printed circuit boards; advantages; limitations

2 Understand methods used to fabricate polymer matrix components and their applications

Polymer Matrix Component (PMC) manufacturing processes: open mould processes (hand lay up, spray lay up); closed mould processes (compression moulding of dough moulding compound (DMC), sheet moulding compound (SMC), resin transfer moulding (RTM), vacuum assisted resin transfer moulding (VARTM); digitally controlled processes (pultrusion, pulforming, filament winding, tape laying); mechanisms

Applications: eg manufacture of high performance yacht hulls, F1 car components, wind turbine blades, A380 Airbus wing; advantages; limitations

3 Understand how micro- and nano- scale manufacturing processes are used to produce microelectromechanical systems and devices

Micro- and nano- manufacturing processes: dimensional scale of products (macro, meso, micro, nano); micromachining (laser micromachining; EDM micromachining, micromilling); bulk and surface micromachining (production of silicon based components); microfabrication processes by layering (layer addition, layer alteration, layer removal, LIGA, HEXSIL, microstereolithography); nano-scale manufacturing top down processes, eg photo lithography; nano-scale manufacturing bottom-up processes, eg scanning tunnelling microscopy; mechanisms

Applications: eg accelerometers and gyroscopes, optical devices, micro-drug pumps, nanorobots; advantages; limitations

4 **Understand how non-conventional forming processes are applied to produce sheet metal and tubular components**

Forming processes: hydroforming (sheet hydroforming, tube hydroforming); high energy rate forming (explosive forming, electrohydraulic forming, electromagnetic forming, laser forming); structures produced by combining superplastic forming and diffusion bonding; mechanisms

Applications: eg bicycle frames, car body panels, aero engines; advantages; limitations

5 **Understand surface enhancement processes in advanced manufacturing and their applications**

Surface enhancement processes: principles (plating, electro plating, electro forming, conversion coating, vapour deposition); thermal spraying (high velocity oxy-fuel spraying (HVOF), plasma spraying, electric arc spraying, flame spraying); physical vapour deposition (ion plating, vacuum evaporation, sputtering); chemical vapour deposition; laser treatment additive manufacturing eg laser metal deposition; laser treatment surface engineering eg alloy, harden, anneal; mechanisms

Applications: eg hardening of engine components, coating cutting tools, coating lenses and mirrors, rebuilding worn parts; advantages; limitations

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Understand how non-contact machining processes are applied in advanced manufacturing	1.1 Describe non-contact machining processes 1.2 Critically appraise the potential applications of non-contact technologies
LO2 Understand methods used to fabricate polymer matrix components	2.1 Describe the manufacturing processes used to fabricate polymer matrix components 2.2 Critically appraise the potential applications of polymer matrix manufacturing processes
LO3 Understand how micro- and nano-scale manufacturing technology is used to produce microelectromechanical systems and devices	3.1 Describe the manufacturing processes used to create micro- and nano-scale products 3.2 Critically appraise the potential applications of micro- and nano-scale manufacturing processes
LO4 Understand how non-conventional forming processes are applied to produce sheet metal and tubular components	4.1 Describe the non-conventional forming processes used in the production of sheet metal and tubular components 4.2 Critically appraise the potential applications of non-conventional forming processes
LO5 Understand surface enhancement processes in advanced manufacturing and their applications	5.1 Describe surface enhancement processes used in advanced manufacturing 5.2 Critically appraise the potential applications of surface enhancement processes.

Guidance

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The learning outcomes associated with this unit are closely linked with:

Level 4	Level 5	Level 6
	Unit 16:Advanced Manufacturing Technologies	*Unit T15: Rapid Prototyping Technologies*

The content of this unit has been designed and mapped against the Engineering Council's current Learning Outcomes for IEng Accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng Registration.

See *Annexe B* for summary of mapping information for IEng Accreditation.

Assessment

Each learning outcome could be assessed through the following assignment:

In a tutorial or seminar situation discuss the selection of a process (or processes) to produce the component(s) identified by the unit lecturer. Fully justify the selection based on considerations such as cost, health and safety and sustainability as well as technical capabilities. Discuss any reservations and risks associated with recommending this technology.

Learning outcomes could be assessed through individual contributions to the tutorial or seminar, and through production of an appropriate report, possibly in the form of a process specification sheet or a process FMEA (Failure Mode Effects Analysis).

There could be five short (nine-hour) assignments or a smaller number of longer exercises supported by self-learning.

Any of the five learning outcomes could equally be assessed through formal examinations.

Resources

Books

Kalpakjian S and Schmid S R – *Manufacturing, Engineering and Technology* (Prentice Hall, 2010) ISBN 978-9810681449

Websites

www.internano.org/	InterNano is an information resource for the nanomanufacturing community
www.microbridge.cf.ac.uk/	MicrBridge aims to promote and transfer the new technologies for the enhancement of micro and nano manufacturing capabilities across the UK, Europe and world-wide. Their website contains good descriptions of processes
www.netcomposites.com/education.asp?sequence=2	NetComposites provides details of polymer matrix component manufacturing processes
www.twi.co.uk/content/mats_index.html	The Welding Institute (TWI) has material on this site relating to surface enhancement