Unit 21: Engineering Secondary and Finishing Techniques

Unit code: J/600/0272

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners the opportunity to explore some of the specialist techniques found in engineering that are used to machine or finish complicated shapes.

Unit introduction

For everyday products and components to be manufactured to a required standard, the machines that produce them need to be operated in an efficient and safe manner. During this process, trial components are made to check accuracy and ensure a minimum amount of waste during production. Machine operators will produce better components if they are aware of a range of finishing and secondary processes that can be used. A secondary process is where raw material or a component is taken for further working, usually involving material removal, and is carried out after a primary forming process.

This unit aims to provide learners with a detailed knowledge of the use of secondary processing machines, including traditional machines (for example lathes and drilling machines) and others found in a more specialist workshop (for example spark or wire erosion methods).

The unit gives learners an opportunity to examine a range of secondary processing machines, their design and application. To a lesser extent they will also be able to identify a range of 'non-traditional' techniques, such as electro discharge and broaching.

Learners will investigate heat treatment processes, which are often used to get a product or component into its final state and ready for use. Without these processes parts would fail prematurely or further manipulation would not be possible on certain materials to create a final component. Learners will also understand assembly methods, including automated techniques that can be associated with computer-aided manufacture and other modern approaches, such as flexible manufacturing systems.

Finally, learners will understand how finishing techniques are used in engineering to add either function or aesthetics to a part component or product. Anodising and plating methods will be discussed, as well as hot processes used to obtain a required finish (such as powder coating or hot dipping) and the associated aspects of health and safety.

Learning outcomes

On completion of this unit a learner should:

1 Understand how a range of secondary machining techniques are used

2 Know how a range of non-traditional techniques are used

3 Know how heat treatment processes and assembly techniques are used

4 Know how finishing techniques are used.

Unit content

1 Understand how a range of secondary machining techniques are used

Turning: machine eg centre lathe, turret; features of the workpiece eg flat faces, diameters (such as parallel, stepped, tapered), holes (such as drilled, bored, reamed), profile forms, threads (such as internal, external), eccentric features, parting off, chamfers, knurls or special finishes, grooves, undercuts

Milling: machine eg horizontal, vertical, universal, planer/gantry; up-cut; down-cut; features of the workpiece eg faces (such as flat, square, parallel, angular), steps/shoulders, slots (such as open ended, enclosed/recesses, tee), holes (such as drilled, bored), profile forms (such as vee, concave, convex, gear), serrations, indexed or rotated forms, special forms

Boring: machine eg horizontal, vertical; features of the workpiece eg bored holes (such as through workpiece, to a depth, tapered), holes (such as drilled to depth, drilled through workpiece, reamed, threaded), external diameters, grooves/recesses, chamfers/radii, faces (such as flat, square, parallel, angular, milled), slots, forms (such as indexed, rotated), external tapers

Grinding: machine eg surface (such as horizontal, vertical), cylindrical (such as external, internal), centreless, universal, thread, profile; features of the workpiece eg faces (such as flat, vertical, parallel, square to each other, shoulders and faces), slots, diameters (such as parallel, tapered), bores (such as counterbores, tapered, parallel), profiles forms, thread forms (such as vee, right hand, single start, multi-start, internal, external), angular faces

Presswork: machines eg single action, multiple action; features of the workpiece eg blanking, notching, piercing, joggling, cropping/shearing, bending/forming, coiling/rolling, planishing/flattening, first draw, second draw, compound operations, cupping, embossing, coining

Health and safety: appropriate legislation and regulations eg Health and Safety at Work Act 1974, Fire Precautions Act 1971, manual handling, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Provision and Use of Work Equipment Regulations (PUWER) 1998, Health and Safety (First Aid) Regulations 1981; use of personal protective equipment (PPE)

Materials: eg ferrous, non-ferrous, non-metallic, stainless, special alloys, deep drawing steels

Kinematics: machine tool design; generation and forming of shapes; six degrees of freedom

2 Know how a range of non-traditional techniques are used

Electro discharge: machines eg spark erosion, wire erosion; features of the workpiece eg holes, faces (such as flat, square, parallel, angular), forms (such as concave, convex, profile, square/rectangular), other features (such as threads, engraving, cavities, radii/arcs, slots)

Broaching: machines eg horizontal, vertical; features of the workpiece eg keyways, holes (such as flat sided, square, hexagonal, octagonal), splines, serrations, other special forms

Honing and lapping: machines eg honing (such as horizontal, vertical), lapping (such as rotary disc, reciprocating); features of the workpiece eg holes (such as through, blind, tapered), faces (such as flat, parallel, angular)

3 Know how heat treatment processes and assembly techniques are used

Heat treatment processes for ferrous metals: surface hardening; other processes eg hardening, tempering, annealing, normalising; appropriate health and safety requirements eg Health and Safety at Work Act 1974, requirements relating to chemicals and materials handling (such as Control of Substances Hazardous to Health (COSHH) Regulations 2002, safe disposal of waste materials and components (fluids, hardening materials), manual handling, safe use of electrical and pressurised equipment, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Provision and Use of Work Equipment Regulations (PUWER) 1998)

Assembly techniques: manual eg screwed fasteners, locking devices, keys, dowels, circlips; automated eg part feeding devices, transfer and indexing, orientation devices

4 Know how finishing techniques are used

Hot processes: eg hot dip treatment (such as molten wax, molten tin to steel, molten zinc to steel, organic coatings), powder coating (such as fluidised bed thermoplastic coating powder, fluidised bed thermosetting powder, electrostatic grade thermoplastic powder, electrostatic grade thermosetting powder)

Anodising: eg sulphuric acid, chromic acid, hard anodising

Plating methods: eg electroplating (such as copper, gold, silver, cadmium, platinum), electroless nickel, mechanical (such as mechanical zinc, mechanical tin-zinc, mechanical aluminium-zinc), alloy (such as brass, nickel-iron, tin-lead, zinc-nickel, zinc-iron, zinc-cobalt), zinc (such as cyanide zinc, alkaline zinc, acid zinc), nickel and chromium, hard chromium; substrates eg mild steel, stainless steel, brass, copper, zinc based, aluminium

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain how five different secondary machining techniques are used safely on a range of materials	**M1** compare and contrast why different secondary machining techniques are used when manufacturing products	**D1** evaluate the effective use of an appropriate secondary machining technique
P2 explain kinematics in secondary machining techniques	**M2** compare and contrast why different heat treatment processes are used when manufacturing products from ferrous metals	**D2** evaluate a given secondary machining technique and heat treatment process for health and safety risk and impact on the environment.
P3 identify appropriate non-traditional techniques for six given products [IE1]	**M3** from given restrictions and information justify alternative assembly and finishing techniques.	
P4 describe an appropriate non-traditional technique for a given product		
P5 describe surface hardening and another heat treatment process for ferrous metals		
P6 describe two different manual and an automated assembly technique		
P7 describe a hot process, anodising and plating method when used for finishing on different components		
P8 identify the appropriate heat treatment processes, secondary, finishing and assembly techniques needed to manufacture four given components.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

The practical approach to delivery may not always be possible due to the wide range of processes and techniques to be covered. Certain areas rely on a good understanding of the different processes and techniques and their application, whereas others – such as non-traditional techniques – only need an overview. Learners need a broad outline of the different secondary machining techniques, heat treatment processes and finishing and assembly techniques to enable the correct application to be made. A good understanding of the techniques engineers use in deciding which process or technique to apply is also required.

Often learners will be from a background where such processes or techniques are used and they can be better motivated if they study processes or techniques they are already familiar with. Industrial visits will help learners appreciate the breadth of secondary machining, heat treatment, finishing and assembly techniques used and, in some cases, may well be the only way to provide them with practical experience.

The learning outcomes would be best delivered in order, as knowing how components are machined in a traditional sense will help learners understand a range of non-traditional techniques. With respect to the first two learning outcomes, it may be appropriate to consider concurrent delivery with *Unit 30: Setting and Proving Secondary Processing Machines*, which covers a similar range of machining techniques.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to secondary machining and non-traditional techniques in general • practical demonstration on secondary machining/company visit. *Individual activity*: • individual research exercises on turning; milling; boring; grinding; presswork. *Whole-class teaching*: • videos of techniques • presentation by learners of techniques. *Individual activity*: • individual research exercises on health and safety. *Whole-class teaching*: • describe the materials used in secondary machining and outline the kinematics applicable to these techniques. *Pair work*: • case study about the machining of given products • peer discussion and assessment.
Whole-class teaching: • practical demonstration on non-traditional techniques/company visit. *Individual activity*: • individual research exercises on electro discharge machining; broaching; honing and lapping. *Whole-class teaching*: • videos of techniques • presentation by learners of techniques. *Pair work*: • case study about the non-traditional machining of given products • peer discussion and assessment.
Preparation for and carrying out **Assignment 1: Secondary and Non-Traditional Machining Techniques** (P1, P2, P3, P4, M1 and D1).

Topic and suggested assignments/activities and/assessment
Pair working: • prepare for a presentation by a speaker from local industry – research data about their company, eg products they manufacture, materials they use, legislation specific to the heat treatment processes and assembly techniques. *Presentation by visiting engineer*: • detailed information about the use of heat treatment in their company, health and safety requirements, assembly techniques used, products manufactured, hazards encountered. *Small-group working*: • produce reports on what was presented by the speaker. *Whole-class teaching*: • videos of heat treatment processes and assembly techniques • presentation by learners of processes and techniques. *Individual activity*: • individual research exercises (web base) on hazards, legislation and regulation associated with heat treatment processes and automated assembly techniques. *Whole-class teaching*: • presentation by learners of processes and techniques.
Individual activity: • preparation for a company visit – research information about hot processes, eg hot dip treatment; power coating. *Whole-class activity*: • industrial visit to a local, regional or national engineering company (it may be more appropriate to use a number of shorter highly focused visits – this will depend on logistical factors). *Small-group working*: • produce reports about the visit – information presented should relate just to topics investigated in this part of the unit.
Individual activity: • preparation for a company visit – research information about anodising and plating methods, eg hard anodising; electroplating; use of substrates. *Whole-class activity*: • industrial visit to a local, regional or national engineering company (it may be more appropriate to use a number of shorter highly focused visits – this will depend on logistical factors). *Small-group working*: • produce reports about the visit – information presented should relate just to topics investigated in this part of the unit.
Whole-class teaching: • discussion about heat treatment processes and assembly techniques.
Whole-class teaching: • discussion about hot processes, anodising and plating methods.
Preparation for and carrying out **Assignment 2: Heat Treatment Processes, Assembly and Finishing Techniques** (P5, P6, P7, M2, and M3).

Topic and suggested assignments/activities and/assessment
Preparation for and carrying out **Assignment 3: Secondary Processes and Finishing Techniques Associated with Manufacturing Products** (P8 and D2).
Review of unit delivery and assessment.

Assessment

It is important that the assessment strategies used are designed to suit the needs of learners. Good assessment strategies are most likely to be supported by proper presentation of appropriate evidence. A portfolio or file of evidence should not contain course notes, research etc unless it is to become part of the required evidence and assessment.

Work done through the use of case-study material can be used to generate evidence for the portfolio, particularly if industrial visits are well embedded in delivery. It is likely that a range of products will need to be investigated to ensure learners have opportunities to cover the required range of secondary machining techniques and heat treatment processes, together with finishing and assembly techniques.

To achieve a pass, learners need to demonstrate understanding and knowledge of the different processes and techniques, explain or describe their characteristics and how they are used. While learners need to explain what is meant by kinematics in relation to secondary techniques, they only need to show enough knowledge to describe one non-traditional technique. However, they must be able to select appropriate non-traditional techniques for six different products. Learners also need to describe both surface hardening and one of the other processes, such as annealing, and both types of assembly techniques (manual and automated). They should also be able to describe all three types of finishing techniques as listed in the unit content.

This unit could be assessed through three assignments. The first assignment could be a series of written tasks to cover P1, P2, P3 and P4. The task for P1 should have enough detail for learners to cover turning, milling, boring, grinding and presswork. The types of machine they consider from each of these could be left to the learner, as they may have a preference from their place of work. Alternatively, a specific machine type could be given to different learners across the range. This would help centres authenticate each learner's response.

The tasks should also ensure that learners consider the health and safety requirements and cover at least three of the material types listed in the content.

The six products given for P3 must cover the three non-traditional techniques ranged – electro discharge, broaching and honing/lapping. The products should have sensible characteristics, such as type of material, quantity, size, accuracy (tolerances) and surface texture requirements to clearly direct learners towards the correct non-traditional technique. The written task for P4 could be about one of the machines from these techniques. Again, some learners may have preferences based on their workplace. This assignment could also include further written tasks to cover both M1 and D1.

The second assignment could have tasks to describe heat treatment processes (P5) and assembly techniques (P6). Surface treatment must be covered but freedom can be given as to which other process is described. The task should also ask learners about the health and safety requirements. The task addressing P6 must cover two manual and one automated technique.

A further task could be developed to cover M2, which would give learners an opportunity to cover more of the range of heat treatment processes. A comparison between hardening, tempering and annealing would be sensible. Another task in the assignment could cover P7 ensuring that all finishing techniques are covered.

Another task should be given to allow learners to suggest alternative assembly and finishing techniques (M3). In doing so, a range of restrictions and information should be given to ensure learners are able to come up with some sensible alternatives. An example is when the modification of an assembled component allows an automatic feeding device to be used, assuming the batch quantity information indicates it would be viable, or a material amendment needs a change of finishing technique.

The third assignment could have a task requiring learners to identify appropriate processes and techniques as listed in P8 for four different components. These components need to be fairly complex to include a requirement for a heat treatment process, a secondary, a finishing and an assembly technique. These requirements must not be given but be suggested by the component characteristics and specification. This can be done by a set of drawings/specifications or by actual products, with a set of notes, that would ensure the learners are able to identify the appropriate process and techniques. A final written task could be included to give an opportunity to cover D2.

To achieve a merit, learners need to be able to compare and explain how different machining techniques are used (M1) and how different heat treatment processes are used in manufacturing (M2). They will need to suggest alternative assembly and finishing techniques when given specific restrictions and information (M3).

To achieve a distinction, learners need to confidently evaluate the effective use of secondary machining techniques (D1) for certain circumstances. Learners should show skills in evaluating a given secondary machining technique and a given heat treatment process for health and safety risk and impact on environmental issues (D2).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, M1 and D1	Secondary and Non-Traditional Machining Techniques	An activity requiring learners to carry out research based on actual secondary and non-traditional machining techniques associated with a range of materials.	A portfolio containing written responses and diagrams showing the five different secondary machining and non-traditional techniques for a range of material types, possibly supported by a PowerPoint presentation. Alternatively a case study could be used and presented as a portfolio.
P5, P6, P7, M2 and M3	Heat Treatment Processes, Assembly and Finishing Techniques	An activity to investigate the processes associated with the heat treatment of ferrous metals, and the use of hot processes and finishing techniques.	A portfolio containing written responses and diagrams showing heat treatment processes for ferrous metals and descriptions of assembly techniques, hot processes, anodising and a plating method. This activity could be supported by a PowerPoint presentation.
P8 and D2	Secondary Processes and Finishing Techniques Associated with Manufacturing Products.	An activity to investigate the heat treatment processes, secondary, finishing and assembly techniques associated with product manufacture.	A portfolio containing written responses to show the processes and techniques used to manufacture four given components, possibly supported by a PowerPoint presentation. Alternatively a case study could be used and presented as a portfolio.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
	Selecting and Using Secondary Machining Techniques to Remove Material	Properties and Applications of Engineering Materials
		Engineering Primary Forming Processes
		Setting and Proving Secondary Processing Machines

This unit covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Mechanical Manufacturing Engineering, particularly:

- Unit 5: Machining Components using Centre Lathes
- Unit 7: Machining Components using Turret Lathes
- Unit 9: Machining Components using Milling Machines
- Unit 17: Machining Components using Horizontal Boring Machines
- Unit 19: Machining Components using Vertical Boring Machines
- Unit 21: Machining Components using Electro Discharge Machines
- Unit 23: Machining Components using Grinding Machines
- Unit 25: Machining Components using Honing and Lapping Machines
- Unit 61: Assembling Mechanical Products
- Unit 72: Repairing and Modifying Mechanical Assemblies.

The unit also covers some of the knowledge and understanding within the following units in the SEMTA Level 3 National Occupational Standards in Materials Processing and Finishing:

- Unit 29: Finishing Materials by Applying Powder Coating
- Unit 30: Finishing Materials by Applying Hot Dip Treatments
- Unit 31: Finishing Materials by Electroplating Methods
- Unit 32: Finishing Materials by Applying Coatings by Electroless Nickel Plating
- Unit 33: Finishing Materials by Chemical Conversion Processes
- Unit 34: Finishing Materials by Sulphuric Acid Anodising
- Unit 35: Finishing Materials by Chromic Acid Anodising
- Unit 36: Finishing Materials by Hard Anodising
- Unit 37: Finishing Materials by Mechanical Plating
- Unit 40: Finishing Materials by Alloy Plating Processes
- Unit 41: Finishing Materials by Phosphating
- Unit 42: Finishing Materials by Zinc Plating
- Unit 44: Finishing Materials by Nickel and Chromium Plating
- Unit 45: Finishing Materials by Hard Chromium Plating.

Essential resources

Centres should have access to as large a range of the machinery and processes outlined in the unit content as possible.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the investigative activity can be set in the context of learners' work placements supported by case studies of local employers and well known national companies. All four learning outcomes lend themselves well to visits or input from visiting speakers from local employers.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Health and Safety Executive – *Health and Safety in Engineering Workshops* (Health and Safety Executive, 2004) ISBN 0717617173

Timings R L – *Manufacturing Technology* (Prentice Hall, 1998) ISBN 0582356938

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	identifying appropriate non-traditional techniques for six given products.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	analysing and evaluating information when researching secondary processes, judging its relevance and value.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	researching information about secondary machining techniques, non-traditional techniques, heat treatment processes and assembly techniques
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching information about secondary machining techniques, non-traditional techniques, heat treatment processes and assembly techniques
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	preparing written responses which contain images making and presenting a PowerPoint presentation
Present information in ways that are fit for purpose and audience	preparing written responses which contain images making and presenting a PowerPoint presentation
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	making and presenting a PowerPoint presentation
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching information about secondary machining techniques, non-traditional techniques, heat treatment processes and assembly techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining how different secondary machining techniques describing non-traditional techniques and heat treatment processes describing manual and automated assembly techniques describing hot processes, anodising and plating methods used for finishing on different components.