Unit 21: Engineering Secondary/Finishing Processes

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

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 (eg lathes and drilling machines) and others found in a more specialist workshop (eg spark or wire erosion methods).

The unit provides an opportunity for learners 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 may loosely be associated with computer-aided manufacture and other modern approaches, such as flexible manufacturing systems.

Finally, learners will understand how finishing techniques are deployed in engineering to add either function or aesthetics to a part component or product. Whilst anodising and plating methods will be discussed, hot processes used to obtain a required finish — such as powder coating or hot dipping — will also need careful consideration of associated health and safety aspects.

Summary of learning outcomes

To achieve this unit a learner must:

1 Know how a range of secondary machining techniques are used

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

3 Understand how heat treatment processes and assembly techniques are used

4 Understand how finishing techniques are used.

Unit content

1 **Know 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 **Understand 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 **Understand 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

Grading grid

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

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 describe how five different secondary machining techniques are used on a range of materials P2 explain kinematics when applied to secondary machining techniques P3 identify appropriate non-traditional techniques for six given products 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	M1 compare and contrast why different secondary machining techniques are used when manufacturing products M2 compare and contrast why different heat treatment processes are used when manufacturing products from ferrous metals M3 suggest alternative assembly and finishing techniques when given restrictions and information.	D1 evaluate the effective use of an appropriate secondary machining technique D2 evaluate a given secondary machining technique and heat treatment process for health and safety risk and impact on the environment.

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:**
P8 identify the appropriate heat treatment processes, secondary, finishing and assembly techniques needed to manufacture four given components.		

Essential information for teachers

Delivery

Ideally a practical approach to delivery would be used, although this may not 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.

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 knowledge of the different processes and techniques, 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. 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 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.

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

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.

The unit has links with the specialist units that cover using processes, materials and techniques such as *Unit 8: Engineering Design*, *Unit 10: Properties and Applications of Engineering Materials*, *Unit 20: Engineering Primary Forming Processes* and *Unit 30: Setting and Proving Secondary Processing Machines*. It also links to *Unit 7: Health, Safety, Risk Assessment and Welfare in the Engineering Workplace*.

Essential resources

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

Indicative reading for learners

Textbooks

Timings R L — *Basic Manufacturing* (Newnes, 2004) ISBN 0750659904

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

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• describing how different secondary machining techniques are used • describing the characteristics of different heat treatment processes for ferrous metals • describing the characteristics of different assembly techniques • describing the characteristics of different finishing techniques.	C3.2 Read and synthesise information from at least two documents about the same subject. Each document must be a minimum of 1000 words long. C3.3 Write two different types of documents, each one giving different information about complex subjects. One document must be at least 1000 words long.