Unit 20: Engineering Primary Forming Processes

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Almost everything we touch in the world of technology has been created through some technique or process associated with primary forming — the forming of shapes with minimal waste and loss of volume. Without these primary forming processes, the technological world as we know it today would not exist.

Many engineering components are initially formed to shape by moulding, deformation or shaping. Over the years, these processes have been refined to suit the introduction of new materials and the demands of quantity production. In some processes, the shaped component is almost ready for use and requires only a little cleaning and trimming. In others it is produced slightly oversize and, after cleaning and trimming, it is machined accurately to the required dimensions.

The main aim of this unit is to provide a broad understanding of manufacturing processes associated with primary forming. It will give learners a broad understanding of moulding techniques for metals, ceramics and polymers, deformation processes for metals and polymers, and shaping and assembly of composites. The unit will introduce learners to a range of techniques and primary processes but provide a deeper understanding of the more common processes.

For each technique and process learners will form an appreciation of the fundamental process requirements, the working techniques used and the relevant health and safety considerations. The use of these primary processes sometimes creates a dangerous environment and knowledge of relevant health and safety and related legislation is very important.

Learning outcomes

On completion of this unit a learner should:

1 Understand how moulding techniques involving metals, ceramics and polymers are used

2 Understand how deformation processes involving metals and polymers are used

3 Understand how shaping and assembly processes involving composites are used

4 Know how health and safety issues relate to primary forming processes.

Unit content

1 **Understand how moulding techniques involving metals, ceramics and polymers are used**

Moulding techniques involving metals: casting method eg sand, die (gravity, pressure), investment, continuous; metal applicable to process eg ferrous (carbon steels, stainless steels, cast iron), non-ferrous (aluminium, copper, brass, zinc, magnesium, nickel, titanium, alloys); form of material supply eg pig iron, scrap, ore, ingots, recycled material, metal composition, trace elements, coke, limestone; mould production eg patterns, cores, dies, moulding parts (boxes, sand, reinforcements, releasing agents, runners, risers, sprues); component removal and finishing eg knock out, ejection, fettling

Moulding techniques involving ceramics: powder metallurgy (blending, compacting); sintering; secondary operations eg infiltration, sizing, coining, machining, impregnation, plating, heat treatment; ceramics applicable to process eg metallic carbides, nitrides, oxides

Moulding techniques involving polymers: techniques eg compression, transfer, injection, rotational moulding, blow moulding; polymers applicable to process eg thermoplastics, thermosetting plastics, polystyrene, polyethylene, acetal, acrylonitrile butadiene styrene (ABS), nylon, polycarbonate, polypropylene; use of additives eg stabilisers, flame retardants, fillers (asbestos, cotton flock, fibres, mica, graphite, wood flour), plasticisers, antistats, colorants, lubricants; mould tools eg two plate, three plate, combination/composite, split, unscrewing; moulding parameters eg temperature, pressure, speed/timings, distance, flashing, short shot, distortion, burning, colour deviation

2 **Understand how deformation processes involving metals and polymers are used**

Deformation processes involving metals: processes eg extrusion (direct, indirect, impact), forging (drop, pressure, upset), rolling (hot, cold), presswork (forming, bending, deep drawing), metal spinning; metals applicable to process eg ferrous (carbon steels, stainless steels), non-ferrous (aluminium, copper, brass)

Deformation processes involving polymers: processes eg vacuum forming, extrusion, calendaring; polymers applicable to process eg thermoplastics, polycarbonate, polysulphon, acrylic, polyvinyl chloride, ABS, thermoplastic sheet; use of additives eg plasticisers, antistats, lubricants, heat stabilisers; features eg double curvatures, shapes (male, female), stiffened mouldings, section shape; parameters eg temperature, pressure, speed/timings, distance, flashing, short shot, distortion, burning, colour deviation

3 **Understand how shaping and assembly processes involving composites are used**

Composite shaping processes: processes eg pre-preg laminating, wet lay-up, moulding; use of fibre (glass, polyethylene, aramid, carbon); use of resin (polyester, vinyl ester, epoxy, phenolic); composite materials applicable to process eg wood, Coremat, foam, honeycomb (Nomex, aluminium), syntactic core, expanding core; design features eg corners (internal, external), surface (concave, convex, return, vertical), double curvature, nett edges, joggle details; types of reinforcement eg roving, braids, tapes, chopped strand, continuous filament, uni-directional, woven, multi-axis

Composite assembly processes: types eg trial, one-off, batch, assembly line; features eg tolerances (loose or close fit), fixing (permanent or non-permanent), shape location, joins (joggle, return or overlap); assembly methods eg fettling, pinning, clamping, trial fitting, aligning, assembly jigs and sequences; joining methods eg thread inserts, fasteners (mechanical, quick release), anchor nuts, rivets; composite components eg trim, panels (closing, body), tubes, structural, aerodynamic, core materials, sections, inserts, housings; non-composite components eg brackets, fixtures, fittings, trim, tapes, memory foam, films

4 **Know how health and safety issues relate to primary forming processes**

Health and safety: relevant health and safety legislation and regulations eg Control of Substances Hazardous to Heath (COSHH) Regulations 2002, Provision and Use of Work Equipment Regulations (PUWER) 1998, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Lifting Operations and Lifting Equipment Regulations 1998, Manual Handling Operations Regulations 1992, Personal Protective Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Control of Noise at Work Regulations 2005, Health and Safety (First Aid) Regulations 1981, European directives, relevant codes of practice; requirements for the use of guards, screens, ventilation; use of personal protective equipment (PPE); manual lifting and handling techniques

Reducing risks: eg use of risk assessment methods, avoidance of dangerous conditions, appropriate training, good housekeeping, safe use of tools and equipment

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 the learner is able to:**	**To achieve a distinction grade the evidence must show that the learner is able to:**
P1 identify and describe the moulding techniques used to manufacture a metal-based component P2 identify and describe the moulding techniques used to manufacture a ceramic-based component P3 identify and describe the moulding techniques used to manufacture a polymer-based component P4 identify and describe the deformation processes used to manufacture a metal-based component P5 identify and describe the deformation processes used to manufacture a polymer-based component P6 identify and describe the composite shaping processes used to manufacture a composite-based component	M1 compare and contrast the different moulding techniques used to manufacture products from metals, ceramics and polymers M2 compare and contrast the different deformation processes used to manufacture products from metals and polymers M3 explain why a composite shaping process is appropriate for a given manufactured product.	D1 evaluate and suggest improvements to a primary forming process used in the manufacture of a product D2 evaluate and suggest improvements that could reduce the risk to the health and safety of a primary forming process operator.

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 the learner is able to:**	**To achieve a distinction grade the evidence must show that the learner is able to:**
P7 identify and describe the methods used to manufacture a composite-based assembly P8 identify and explain the health and safety issues that relate to each of the primary forming processes considered P9 suggest methods of reducing risk for each of the primary forming processes considered.		

Essential information for tutors

Delivery strategies

Ideally, a practical approach to delivery would be used, although this may not be feasible due to the wide range of processes to be covered. Certain areas rely on a good understanding of the different techniques and applications of primary forming processes. Learners need a broad overview of the different moulding techniques, deformation, shaping and composite assembly processes to enable them to consider the appropriate applications of the range of primary forming processes. They will also need to gain an understanding of how engineers decide which is the best process to use for specific components.

The unit provides opportunities for learners to gain experience of a range of primary forming processes through case-study material based on industrial applications. Learners may already have some experience of primary forming and are often better motivated if they can extend their understanding of the processes they are already familiar with.

Industrial visits would help to underpin the breadth of primary forming processes and may well be the only way to have access to real practical applications. Video-based material may provide an alternative where visits are not possible. Practical demonstrations of the principles of primary forming (eg simple casting, vacuum forming, wet lay-up) will always benefit learning and understanding.

Although the learning outcomes are ordered to lead learners through the primary forming processes, the first three could be delivered in any order. Learning outcome 4 covers aspects of health and safety. The first three learning outcomes could be delivered step-by-step as each moulding technique, deformation process and composite shaping and assembly process is introduced. Although covered by a separate learning outcome, the identification of safe working practices, use of safety equipment and reduction of risks associated with each process should be an integral part of the delivery of each of the first three learning outcomes.

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 strategies

A suitable strategy for this unit would be for learners to carry out detailed investigations into the way given or chosen products are manufactured. A range of products will be required and need to be investigated to ensure learners have opportunities to cover the range of primary forming processes listed and the requirements of the assessment criteria.

Criteria P1, P2, P3 and M1 relate to learning outcome 1 and P4, P5 and M2 relate to learning outcome 2. These could be linked together through one overarching assignment. This assignment should give learners an opportunity to demonstrate their knowledge of the different moulding techniques and deformation processes. The

tasks set should ensure that they describe a moulding technique suitable for each of the materials covered by learning outcome 1 (ie metals, ceramics and polymers) and suitable deformation processes for both metals and polymers for learning outcome 2. Tasks set within the assignment could require learners to compare and contrast particular moulding techniques (M1) and deformation processes (M2) for products made from the materials listed in learning outcomes 1 and 2 respectively.

A second assignment could concentrate on composite manufacture (learning outcome 3). A task should be set to describe both a composite shaping process (P6) and a composite assembly process (P7). A further task could then ask learners to explain why a particular composite shaping process would be appropriate for a given manufactured product (M3). Care should be taken when selecting a product for this task to ensure that it has all the requirements of the content within the learning outcome, ie the use of fibre, resin, design features and types of reinforcement. Likewise, the description for P6 should also have these aspects of content covered.

Learners should also consider health and safety and the risks (criteria P8 and P9) associated with each of the primary forming processes, through further tasks set within the two assignments described above.

A final assignment may be required to enable learners to achieve the distinction criteria, D1 and D2. However, a more efficient way to cover these might be to link them together and ask learners to cover them both as an extension to their investigation of any one of the primary forming processes considered for P1 to P7. Learners' choice of process/component used for D1 could then take into consideration their interests and experiences and possibly, where appropriate, a process/component relevant to their place of work. The suggested improvements could relate any aspect of the moulding technique, deformation or shaping/assembly process being applied (eg type of method/technique, choice of material, component design, mould design) as relevant to the learner's choice of component.

Likewise, to cover D2 learners could evaluate and suggest improvements to any relevant aspects of legislation or risk within an area of interest to them (eg use of equipment, guards, clothing, handling). The most important aspect of the evidence for distinction will be learners' ability to evaluate the situation and come up with some distinct and valid improvements.

The assessment evidence for this unit is likely to be in the form of a number of written reports that may include information and diagrams. Centres need to take care that the evidence used for assessment is the learner's own work. Where learners make use of other people's work then this must be clearly acknowledged and referenced. Centres may find it helpful to guide learners by providing a recommended structure for reports and in particular a format/system for including references.

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

This unit has links with *Unit 10: Properties and Applications of Engineering Materials* and *Unit 21: Engineering Secondary/Finishing Processes*.

The unit contributes towards the knowledge requirements for the following units in the Level 3 SEMTA National Occupational Standards in Material Processing and Finishing:

- Unit 4: Producing Sand Moulds Manually Using Loose Patterns
- Unit 5: Producing Sand Moulds Using Plated Patterns
- Unit 6: Producing Sand Cores Manually
- Unit 7: Locating, Assembling and Setting Cores in Sand Moulds
- Unit 8: Forming Runner, Riser and Feeder Systems in Sand Moulds
- Unit 9: Closing and Securing Sand Moulds for Casting
- Unit 22: Setting Pressure Die Casting Machines for Production
- Unit 24: Producing Castings Using Pressure Die Processes
- Unit 50: Producing Composite Mouldings Using Pre-Preg Laminating Techniques
- Unit 51: Producing Composite Mouldings Using Wet Lay-up Techniques
- Unit 52: Producing Composite Assemblies
- Unit 53: Producing Components by Vacuum Forming
- Unit 54: Producing Components by Acrylic Moulding
- Unit 60: Setting Plastic Injection Moulding Machines for Production
- Unit 61: Producing Components Using Plastic Injection Moulding Machines.

Essential resources

Centres must have access to a range of cast, ceramic-moulded, polymer-moulded and process-deformed components, along with a range of components made from composites, including both shaped and assembled. Ideally, centres would have facilities to practically demonstrate some of the primary processes covered by the unit content, although this is not essential. However, centres that are unable to do so should consider industry visits or, alternatively, video and other presentation resources. Access to relevant health and safety legislation will be required.

Indicative reading for learners

Textbooks

Black B — *Workshop Processes, Practices and Materials, Second Edition* (Newnes, 2004) ISBN 0750660732

Bolton W — *Materials for Engineering* (Newnes, 2000) ISBN 0750648554

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

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. Staff 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 a different moulding technique for metals, ceramics and polymers • describing different deformation processes for metals and polymers • describing a composite shaping process • describing how to produce a composite assembly.	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.