

Unit 20: Engineering Primary Forming Processes

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| Unit code: | F/600/0271 |
| QCF Level 3: | BTEC National |
| Credit value: | 10 |
| Guided learning hours: | 60 |

● Aim and purpose

This unit gives learners the opportunity to explore some of the primary forming processes found in engineering that are used to make a range of different components.

● Unit introduction

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 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 will 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 Know how moulding techniques involving metals, ceramics and polymers are used
- 2 Know how deformation processes involving metals and polymers are used
- 3 Know how shaping and assembly processes involving composites are used
- 4 Understand how health and safety issues relate to primary forming processes.

Unit content

1 Know 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 Know 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 Know 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 Understand 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 Health (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 Major Accidents and Hazards Regulations 1999 (COMAH) amended 2005, 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

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 the learner is able to: | To achieve a distinction grade the evidence must show that the learner is able to: |
| P1 describe the moulding techniques used to manufacture a metal-based component | M1 compare and contrast the different moulding techniques used to manufacture products from metals, ceramics and polymers | D1 suggest improvements to a primary forming process used in the manufacture of a product |
| P2 describe the moulding techniques used to manufacture a ceramic-based component | M2 compare and contrast the different deformation processes used to manufacture products from metals and polymers | D2 suggest improvements that could reduce the risk to the health and safety of a primary forming process operator. |
| P3 describe the moulding techniques used to manufacture a polymer-based component | M3 explain why a composite shaping process is appropriate for a given manufactured product. | |
| P4 describe the deformation processes used to manufacture a metal-based component | | |
| P5 describe the deformation processes used to manufacture a polymer-based component | | |
| P6 describe the shaping processes used to manufacture a composite-based component | | |
| P7 describe the methods used to manufacture a composite-based assembly | | |
| P8 explain the health and safety issues that relate to each of the primary forming processes considered | | |
| P9 describe methods of reducing risk for each of the primary forming processes considered [EP4]. | | |

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.

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

Essential guidance for tutors

Delivery

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 knowledge 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 are the best processes to use for specific components.

The unit provides opportunities for learners to gain experience of a range of primary forming processes through demonstration and 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 (for example 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.

Web based research can form an integral part of learning with outcomes being documented and presented as peer findings and work to be shared.

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 |
|---|
| <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• introduction to unit content, scheme of work and method of assessment• introduction to moulding techniques in general• practical demonstration on moulding metals/company visit. <p><i>Individual activity:</i></p> <ul style="list-style-type: none">• individual research exercises on casting methods; metal applicable to process including ferrous and non-ferrous; form of material supply; mould production; component removal and finishing. <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• videos of techniques• presentation by learners of techniques. |
| <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• practical demonstration on moulding ceramics/company visit. <p><i>Individual activity:</i></p> <ul style="list-style-type: none">• individual research exercises on powder metallurgy; sintering; secondary operations; ceramics applicable to process. <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• videos of techniques• presentation by learners of techniques. |
| <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• practical demonstration on moulding polymers/company visit. <p><i>Individual activity:</i></p> <ul style="list-style-type: none">• individual research exercises on polymer moulding techniques; polymers applicable to process; use of additives; mould tools; moulding parameters. <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• videos of techniques• presentation by learners of techniques. |
| <p>Preparation for and carrying out Assignment 1: Moulding Techniques for Metals, Polymers and Ceramics (P1, P2, P3 and M1) (can also include reference to P8 and P9).</p> |
| <p><i>Individual activity:</i></p> <ul style="list-style-type: none">• individual research exercises on metal deformation processes; polymers applicable to process; use of additives; mould tools; moulding parameters. <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• videos of processes• presentation by learners of processes. |

Topic and suggested assignments/activities and/assessment

Individual activity:

- preparation for a company visit – research information about deformation processes involving polymers, eg types of processes; polymers applicable to process; use of additives; features to be considered; parameters in the process and product.

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.

Preparation for and carrying out **Assignment 2: Deformation Processes for Metals and Polymers** (P4, P5 and M2) (can also include reference to P8 and P9).

Whole-class teaching:

- describe shaping processes associated with ceramics including use of fibre; use of resin; composite materials applicable to process; design features; types of reinforcement; reference to health and safety.

Whole-class teaching:

- describe assembly processes associated with ceramics including features; assembly methods; joining methods; composite components; non-composite components; reference to health and safety.

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 business.

Presentation by visiting engineer:

- detailed information about the use of composites in their company, shaping processes used, assembly processes used, products manufactured, hazards encountered.

Small-group working:

- produce reports on what was presented by the speaker.

Preparation for and carrying out **Assignment 3: Shaping and Assembling Composite Based Products** (P6, P7 and M3) (can also include reference to P8 and P9).

Whole-class teaching:

- describe the range of health and safety issues associated with the processes and techniques involved with metals, polymers and ceramics within this unit
- explain why businesses have a duty of care towards their employees, suppliers, customers and anyone else that they have a relationship with.

Small-group or pair working:

- research health and safety legislation specific to the operation/management of an engineering process or techniques as ranged by this unit.

Whole-class teaching:

- videos of health and safety.

Topic and suggested assignments/activities and/assessment

Pair working:

- research the HSE website and prepare a presentation on risk reduction.

Individual activity:

- use a practical area of the workshop/company that involves either moulding of metals, polymers or ceramics, deformation of metals or polymers, or the shaping/assembly of composites to carry out a risk assessment.

Whole-class activity:

- presentation by learners of risk reduction.

Preparation for and carrying out **Assignment 4: Improvements to Processes and Health and Safety in Primary Forming** (P8, P9, D1 and D2).

Review of unit delivery and assessment.

Concluding points.

Assessment

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 needs 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 assessed by the first two assignments. These assignments 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 assignments could require learners to compare and contrast particular moulding techniques (M1) and deformation processes (M2) for products made from the materials listed in the content for learning outcomes 1 and 2 respectively.

A third 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. This could be done by further tasks set within the three assignments described above. However, a better approach may be to link this with the tasks for the distinction criteria in the fourth and last assignment.

The final assignment should enable learners to achieve the distinction criteria, D1 and D2 as well as P8 and P9. They should be asked to explain the health and safety issues that relate to the processes covered earlier (P8) and to describe risk reduction for one process (P9). Learners should be able to see this as an extension to their investigation of each of the primary forming processes considered for P1 to P7. Learners' choice of process/component used for D1 could 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 (for example 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 (for example use of equipment, guards, clothing, handling). The most important aspect of the evidence for distinction will be the 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 responses in a portfolio that may include information and diagrams. Centres need to take care that the evidence used for assessment is the learner's own work and that where learners make use of other people's work then this is clearly acknowledged and referenced. Centres may find it helpful to guide learners by providing a recommended structure for their descriptions and in particular a format/system for including references.

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, M1 | Moulding Techniques for Metals, Polymers and Ceramics | An activity requiring learners to carry out research based on actual engineering techniques associated with metals, polymers and ceramics. | A portfolio containing written responses and diagrams showing moulding techniques for each material family type. Carried out under controlled conditions. This activity could be supported by a PowerPoint presentation. |
| P4, P5, M2 | Deformation Processes for Metals and Polymers | An activity to investigate the processes associated with the deformation of a range of metals and polymers. | A portfolio containing written responses and diagrams showing deformation processes for metals and polymers. Carried out under controlled conditions. This activity could be supported by a PowerPoint presentation. |
| P6, P7, M3 | Shaping and Assembling Composite Based Products | An activity to investigate the shaping and assembly processes associated with composite product manufacture. | A portfolio containing written responses and diagrams showing composite shaping processes and assembly processes used to manufacture composite based products. Carried out under controlled conditions. This activity could be supported by a PowerPoint presentation. |
| P8, P9, D1, D2 | Improvements to Processes and Health and Safety in Primary Forming | An investigative activity involving the review of the health and safety issues associated with primary forming processes involving metals, polymers and ceramics. Followed by a case study to improve the primary forming process of a manufactured product and making a safer environment for an operator. | A portfolio containing a written commentary about health and safety and risk reduction. This activity could be supported by an evaluation of a process to suggest improvements to the process and its safe operation. Evidence could also be made available by a PowerPoint presentation. |

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 the following unit titles in the Engineering suite:

| Level 1 | Level 2 | Level 3 |
|---------|---|--|
| | Casting and Moulding Engineering Components | Properties and Applications of Engineering Materials |
| | | 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.

Employer engagement and vocational contexts

Much of the investigative work for this unit can be set in the context of learners' work placements supported by case studies of local employers' techniques and processes as well as well known national companies. Learning outcomes 1, 2 and 3 lend themselves well to visits or input from visiting speakers employed by local engineering businesses.

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

Black B – *Workshop Processes, Practices and Materials* (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

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 ... |
|-------------------------|---|
| Effective participators | identifying improvements that would benefit others as well as themselves by reducing risks. |

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 relating to primary forming processes, judging its relevance and value |
| Reflective learners | reviewing progress and acting on the outcomes. |

● 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 health and safety issues and primary forming processes |
| English | |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | identifying safety legislation and regulations which impact on the way that engineering primary forming processes operate |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | describing the moulding techniques, deformation processes and shaping processes. |