Unit 136: Polymer Process Engineering

Unit code: Y/602/3460

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The unit provides learners with an understanding of mechanical drive systems including belt, gear and chain drives. Learners will develop knowledge, skills and techniques through investigation of hydraulic systems and the methods used to heat and control polymer processing equipment. Learners will also explore the types and applications of industrial robots.

Unit introduction

The unit addresses the process engineering principles used in the polymer industry. This unit builds on the polymer processing covered in the Basic Polymer Technology unit. Learners will gain knowledge of the systems used in typical polymer processing plants such as injection moulding machines, extruders, presses and mills. It is important that operatives and technical staff have an understanding of the concepts and principles in polymer process engineering to suggest ways to improve efficiency and find ways of reducing the use of resources such as water and heating, and the effect of waste on the environment.

Learners will also explore the principles of drive systems, hydraulics, temperature measurement and control, and the use of robots in processing plants.

Learning outcomes

On completion of this unit a learner should:

1 Understand the principles of mechanical drive systems

2 Be able to investigate the construction and operation of hydraulic systems

3 Be able to investigate the heating systems, temperature measurement and control used on polymer processing equipment

4 Be able to investigate the different types and applications of industrial robots.

Unit content

1 Understand the principles of mechanical drive systems

Belt drive systems: construction; operation; flat belt; V-belts; toothed belts; benefits of each type; limitations of each type; typical applications within the polymer industry

Belt calculations: speed ratios; belt speeds

Gear systems: construction; operation of spur; helical; herringbone; benefits of each type; limitations of each type; typical applications within the polymer industry

Gear calculations: speed ratios for simple, compound gear trains

Roller chain systems: construction; operation; benefits; limitations

2 Be able to investigate the construction and operation of hydraulic systems

Principles of hydraulics: typical fluids; properties

Circuit diagrams: terminology; standard symbols; hydraulic circuit diagrams

Standard hydraulic components: construction; operation; pumps (gear, vane and piston types); fixed and variable displacement; valves (pressure relief, pressure regulator and directional control valves); cylinders (single acting, double acting, differential, and cushioned types); accumulators (gas-filled diaphragm and bladder designs); intensifiers; motors (gear, vane and piston types); fixed and variable displacement

Simple circuits for polymer processing equipment: 'upstroke' and 'downstroke' presses; injection moulding machines; hydrostatic variable speed drives

Pressure measurement: principles; bourdon tube gauges; pressure transducers

3 Be able to investigate the heating systems, temperature measurement and control used on polymer processing equipment

Electrical methods of heating: polymer processing equipment; resistance, induction, dielectric systems infrared high frequency and microwave

Fluid heating methods: polymer processing equipment; steam, oil, pressurised water

Temperature measuring device: principles; operation; thermocouples; expansion thermometers; resistance thermometers; pyrometers

Temperature control: 'on-off'; proportional band; PID controllers

4 Be able to investigate the different types and applications of industrial robots

Applications of robots: applications eg 'pick and place', machining, inspection, coating, packaging

Common robot configurations: cartesian; cylindrical; revolute; pendulum; degrees of freedom; axis of movement; operating envelope

End effectors and types of grippers: mechanical; vacuum

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 the principles of mechanical drive systems [RL6]	**M1** explain the operation of belt, chain and gear drives	**D1** calculate drive ratios for the different drive systems
		D2 evaluate applications of the different drive systems in polymer processing equipment
P2 investigate the construction and operation of hydraulic systems [SM3, EP2, IE1]	**M2** explain the operation of simple hydraulic circuits	**D3** evaluate applications of hydraulic components and pressure measuring systems
P3 investigate heating systems, temperature measurement and control used in polymer processing equipment [SM3, EP2]	**M3** explain the principles of different heating methods and temperature measuring devices	**D4** evaluate different heating systems and measuring devices for their applications in polymer processing equipment
	M4 explain the applications of heating methods and temperature measuring devices within the polymer industry	
P4 investigate the different types of industrial robots [SM3, EP2]	**M5** review robot configurations and cargo gripping systems	**D5** evaluate robotic systems used in the polymer industry
P5 describe the applications of industrial robots [RL6]	**M6** explain 'degrees of freedom' and 'axis of movement'	

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

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

Essential guidance for tutors

Delivery

The concepts covered by this unit should be delivered through a programme of tuition and practical work in the laboratory. Delivery should be based on a well-structured programme of practical exercises to develop learners' skills and generate evidence to meet the unit assessment and grading criteria. Delivery should also cover the processing of recycled polymers.

If it is appropriate to use facilities other than those in the centre (eg on employers' or university premises), arrangements to use such off-site facilities should ensure that they enable the necessary formative activities to be undertaken; one-off use of equipment will not meet the outcomes of this unit.

Health and safety should be a recurring theme throughout the delivery and assessment of this unit. Learners must be taught the nature of hazards and where to find appropriate information on them. Learners are not 'competent persons' under the COSHH regulations; they should not, therefore, be expected to carry out full risk analyses for practical work to be undertaken.

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
Introduction to unit.
Formal input: principles of mechanical drive systems.
Demonstration and learner investigation of different types mechanical drive systems.
Case studies on polymer process engineering.
Visit to polymer process plant.
Belt and gear calculations.
Assignment research activities.
Assignment 1: Mechanical Drive Systems (P1, M1, D1, D2)
Formal input: principles of hydraulics.
Demonstration and exercises on circuit diagrams.
Demonstration and learner investigation of hydraulic components.
Demonstration and learner investigation of pressure measurements.
Learner investigation – formative assignment.
Assignment 2: Hydraulic Systems (P2, M2, D3)
Formal input: electrical methods of heating and components.
Demonstration and learner investigation of electrical components.
Formal input: fluid heating methods.

Topic and suggested assignments/activities and/assessment
Learners investigate fluid heating methods.
Formal input: temperature control and measuring devices.
Demonstration and learner investigation of measuring and control devices.
Assignment tasks and activities.
Assignment 3: Heating Systems (P3, M3, M4, D4)
Formal input: types and applications of robots.
Case study of use of robots.
Visit to processing plant using robots.
Formal input: robot configurations and gripping systems.
Formative assignment on industrial robots.
Assignment 4: Industrial Robots (P4, P5, M5, M6, D5)
Review of unit and overview of assessment.

Assessment

The focus of assessment should be on learners carrying out the required tasks, as well as producing reports as evidence to meet the assessment and grading criteria. Learner presentations, supported by assessor witness testimony, would also form a suitable assessment method. Tutors should observe learners undertaking practical activities and clearly record assessment decisions using an appropriate assessor's observation record, retained for audit purposes. Throughout this unit learners need to be aware of issues such as sustainability and the effects of waste products on the environment.

Safety requirements must be applied to all activities. Learners must work safely and accurately within supplied methods; this must be applied rigorously to all activities.

For the pass assessment criteria, learners need to investigate and describe engineering systems, including mechanical drives, hydraulics and heating and also the types and applications of robots. Delivery of the unit should be based on the development of skills in industrially relevant methods to meet these assessment criteria.

For the merit criteria, learners need to explain the operation of engineering systems. Learners need to be able to explain the systems, principles, components and operation. This requires delivery of the underlying principles, which may be introduced before or during the practical work, but should be emphasised throughout the formative programme preceding assessed exercises.

For the distinction criteria, learners need to adopt a more evaluative approach to engineering systems. It may be appropriate to analyse one activity in detail as a group exercise. Thereafter, activities may be left to independent study, with appropriate guidance from tutors. If group work is undertaken, tutors must ensure that each learner individually produces sufficient evidence to meet the assessment and grading criteria and that assessment decisions are clearly recorded using an appropriate observation sheet.

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, M1, D1, D2	Mechanical Drive Systems	Processing Engineer has been asked to report on the mechanical drive systems being used on the processing plant	Report. Diagrams.
P2, M2, D3	Hydraulic Systems	The quality control engineer has asked for an investigation into construction and operation of the plant hydraulic systems	Annotated Report.
P3, M3, M4, D4	Heating Systems	The plant manager has asked for an investigation to be carried out on heating systems to find out if any reductions can be made in heat losses	Report.
P4, P5, M5, M6, D5	Industrial Robots	Process engineer has been asked to investigate different types and applications of robots to upgrade the process plant	Case study. Report.

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

This unit forms part of the BTEC Applied Science sector suite. This unit has particular links with the following unit titles in the BTEC Applied Science suite:

Level 2	Level 3
Applications of Physical Science	Plastics Materials
Energy and Our Universe	Plastics Processing
Designing and Making Useful Devices in Science	Basic Polymer Technology
Electronics in Action	Scientific Practical Techniques
	Fundamentals of Science
	Energy Changes Sources and Applications
	Electronics for Science Technicians

Essential resources

Learners need access to appropriate laboratory facilities and specialist resources to cover the contextualisation of the underlying concepts to their polymer specialism eg plastics, rubber or related areas. Site visits to relevant industrial facilities to see practical techniques in operation would be invaluable. Input from industry experts, as guest speakers, would enhance unit delivery.

Employer engagement and vocational contexts

British Plastics Federation

Cogent – Sector Skills Council

Network for Science, Technology, Engineering and Maths – Network Ambassadors Scheme

The Polymer Society

Indicative reading for learners

Journals

British Rubber and Plastics

Materials Foresite

Materials World

Plastics, Rubber and Composites

Websites

www.bpf..co.uk	British Plastics Federation
www.cia.org.uk	Chemical Industries Association
www.cogent-ssc.com	COGENT – Sector Skills Council
www.en.wikipedia.org/wiki/polymers	Polymers
www.expainthatstuff.com/bioplastics.html	Bioplastics
www.iom3.org	The Institute of Materials, Minerals and Mining
www.iom3.org/content/polymersociety	The Polymer Society
www.rsc.org.uk	The Royal Society of Chemistry
www.stemnet.org.uk	Network for Science, Technology, Engineering and Maths – Network Ambassadors Scheme

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	obtaining data and using results to predict properties
Reflective learners	using case studies
Self-managers	planning and completing experiments
Effective participators	undertaking site visits to manufacturers