# Unit T15: Rapid Prototyping Technologies

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| Unit code: | R/503/7413 |
| QCF level: | 6 |
| Credit value: | 15 |

## Aim

This unit aims to develop learners' understanding of rapid prototyping technologies through the study of their evolution, mechanisms, classification and operational implications. Learners will also develop the skills needed to evaluate applications of rapid prototyping technologies.

## Unit abstract

Rapid prototyping (RP) has become a widely used tool in product development and encompasses a range of approaches to fabricating models, parts or tooling.

Creating a model or prototype for engineering analysis, concept evaluation, verification and visualisation purposes is an integral part of the product design process. Product designers benefit from new rapid prototyping technologies by developing physical models of prototypes fabricated in minimal time. They no longer have to rely solely on computer-aided design (CAD) models. The development of rapid prototyping technologies offers a viable alternative to subtractive manufacturing of prototypes.

One of the most significant benefits of such technologies, when compared with traditional manufacturing processes, is the capability to fabricate complex 3-dimensional shapes directly from a computer model without specific tooling or fixturing. With advances in additive manufacturing (AM) and the continuing development of new technologies and materials, the direct or rapid manufacturing of previously unimaginably complex designs and features is predicted to become common place.

This unit introduces the evolution of rapid prototyping from traditional pattern making to modern digital manufacturing and explores its role in the product-development cycle. The diverse technologies associated with rapid prototyping are evaluated, covering principal mechanisms, process characteristics and material requirements. This unit develops learners' understanding of economic and environmental issues in modern manufacturing.

 

# Learning outcomes

**On successful completion of this unit a learner will:**

1 understand the evolution of rapid prototyping in the product development process

2 understand the mechanisms and classification of rapid prototyping technologies

3 understand the operational implications of rapid prototyping technologies

4 be able to evaluate applications of rapid prototyping technologies.

# Unit content

## 1 Understand the evolution of rapid prototyping in the product development process

*Development of rapid prototyping*: traditional model and pattern-making processes; subtractive or material removal processes with the use of computer-based technologies, eg machining of prototypes or components, manufacturing software, computer numerically controlled (CNC) machinery

*Approaches to rapid prototyping*: additive or material addition processes such as layer manufacturing of prototypes or final components (additive manufacturing, solid free-form fabrication); virtual prototyping for design evaluation, eg virtual reality environments

*Role of rapid prototyping in the product development process*: product life cycle; efficient and effective use of resources during the design stage; evaluation of manufacturability and design effectiveness

## 2 Understand the mechanisms and classification of rapid prototyping technologies

*Classification of rapid prototyping technologies*: classification based on the form of the starting material (liquid-based systems, powder-based systems, solid-based systems); methods of building and adding layers to create a solid part

*Computational modelling*: computer-aided design (CAD); data and control instructions; geometric modelling; 3D solid modelling (optimised and efficient shapes, lightweight parts); tessellation of geometric models, eg tessellation formats; computational steps to generate sliced 3D data files

*Rapid prototyping technologies*: stereolithography; fused deposition modelling; selective laser sintering; direct metal laser sintering; 3-D printing (powder-based technologies, polymer-based technologies); electron beam manufacturing; multi-jet modelling; direct composite manufacturing; laminated object manufacturing; solid ground curing

## 3 Understand the operational implications of rapid prototyping technologies

*Costings and requirements*: investment costs (equipment, auxiliary devices, software, installation); operating costs (energy intensive processes, raw material consumption and waste, manning); maintenance costs; software and hardware specifications; training; materials (metallic, ceramic, polymer materials, natural materials, resins); sustainability of materials (recyclability, reusability, biodegradability of materials)

*Process characteristics*: fabrication times (build rates, part fabrication times); layer thickness and resolution; build size

*Product characteristics*: dimensional accuracy; surface finish; mechanical properties of materials and finished products; physical properties of materials and products

## 4 Be able to evaluate applications of rapid prototyping technologies

*Applications*: rapid prototyping for design evaluation and verification, eg visualisation, demonstration purposes, aesthetics; rapid prototyping for engineering analysis, eg testing of stress and flow, production planning; tool design; direct rapid tooling (keltool process, Laser Engineering Net Shaping (LENS), Direct Acetal Clear Epoxy Solid Injection Moulding [Direct AIM], direct shell production casting); indirect rapid tooling (vacuum casting, spray metal tooling); rapid manufacturing (direct digital manufacturing); 3-D scanning (reverse engineering); economic issues; environmental impacts

 

## Learning outcomes and assessment criteria

| Learning outcomes<br><br>On successful completion of this unit a learner will: | Assessment criteria for pass<br><br>The learner can: |
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| LO1 Understand the evolution of rapid prototyping in the product development process | 1.1 Critically appraise the key factors affecting the development of rapid prototyping<br>1.2 Critically appraise the differing approaches to rapid prototyping<br>1.3 Explain how rapid prototyping can support the entire product cycle from concept design to manufacturing |
| LO2 Understand the mechanisms and classification of rapid prototyping technologies | 2.1 Explain how rapid prototyping technologies are classified<br>2.2 Describe the computational modelling requirements of rapid prototyping<br>2.3 Critically analyse the contrasting mechanisms of rapid prototyping technologies |
| LO3 Understand the operational implications of rapid prototyping technologies | 3.1 Assess the cost implications of various rapid prototyping technologies<br>3.2 Critically analyse the differing process operating characteristics of rapid prototyping technologies<br>3.3 Describe the product characteristics achievable using rapid prototyping technologies |
| LO4 Be able to evaluate applications of rapid prototyping technologies | 4.1 Critically evaluate applications of rapid prototyping technologies. |

# Guidance

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

The learning outcomes associated with this unit are closely linked with:

| Level 5 | Level 6 |
|---|---|
| *Unit 10: Manufacturing Process* | *Unit T5: Advanced Manufacturing Processes* |
| *Unit 16: Advanced Manufacturing Technologies* | |
| *Unit 69: Advanced Computer-aided Design Techniques* | |

The content of this unit has been designed and mapped against the Engineering Council's current Learning Outcomes for IEng Accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng Registration.

See *Annexe B* for summary of mapping information for IEng Accreditation.

## Resources

### Books

Groover M P – *Principles of Modern Manufacturing*, 4th edition (John Wiley & Sons, 2011) ISBN 978-0470505922

Kalpakjian S and Schmid S R – *Manufacturing Engineering and Technology*, 6th edition (Prentice-Hall, 2010) ISBN 978-9810681449

Wohlers T – *Additive Manufacturing: State of the Industry* (Annual Worldwide Progress Report, 2010) ISBN 978-0975442968

 