Interpretation of a given brief for an engineered product

GETTING STARTED

Working in a small group, discuss and make a list of the types of information that will be needed in a design brief for an engineered product.

LINK IT UP

In Component 1: Learning aim B, you looked at engineering design briefs as a part of the design process.

When designing engineered products, it is important that you can interpret a design brief and then explore design ideas that provide a solution to the brief. To do this, you need to understand the information included in the design brief and know how to address each point of the brief in your designs.

Analysing the existing product with reference to the design brief

All products, from a simple coat hook to an aeroplane engine, are produced from a design brief

A design brief for an engineering product will include a range of factors, including:

- physical requirements
- aesthetics
- size
- function
- performance requirements.

The amount of information for each factor will vary depending on the type of product. For example, a component that is going to fit inside an engine will probably have fewer aesthetic requirements than it has performance requirements.

Physical requirements

Does the design need to meet any specific physical requirements? Will the component need to be able to hold a specific loading or be connected to another component in a specific way?

Does the component need to offer any form of protection to other components or features? Do the materials used for the component need to perform in any specific way?

Aesthetics

You will need to think about why the product is shaped in the way that it is. Is the component designed in a specific shape and style for a particular reason, or simply to make it look good?

Size

How big does the component or product need to be? Are there any maximum or minimum size requirements for the product?

You might be designing a component that is going to be a direct replacement for something that already exists. In this case, the size of the new component will be the same as the current one.

Function

You need to think about what the product or component is designed to do. This could be a list of statements. For example, a light switch must control electrical current to a light fitting and must also enclose all the wires and prevent the user from getting an electric shock. In lots of cases, there will be an overlap with performance requirements.

Performance requirements

You need to think about how the success of the product is measured. Does it need to last for a set time or be able to move a specified distance? Performance requirements will be different for each product, but they can often be thought of as targets that need to be met for the product or component to be termed a success.

ACTIVITY

Research an engineered product, either by looking on the internet or by examining a physical product.

Write out a design brief for the product. You need to include the following:

1. physical requirements
2. aesthetics
3. size
4. function
5. performance requirements.

Exchange your design brief with a partner and see if they can identify what the product is just from the description in the brief.

CHECK MY LEARNING

In this lesson, you have analysed an existing engineered product with reference to its design brief.

Working with a partner, analyse one product that is in your workshop or classroom and write a design brief for the product.

Features of engineered products

GETTING STARTED

Working with a partner, examine a component from an engineered product that you are familiar with. Make a list of what you think the features of the product are.

When you are investigating an existing engineered product to help with the design of something new, you will need to consider the features of the product. There are different types of feature that products can have.

ACTIVITY

Working with your partner, research an example of a fabricated component.

1. Sketch the component.
2. Label the features of the component.
3. Highlight the features of the component that you think are most important for it to work as intended.

Dimensions

The dimensions of a product are very important. If a dimension is too big, it will probably not fit in the space it is designed for; if it is too small, then connections to other components will not be possible. This is known as tolerance, which can be linear (straight-line) or radial (for circular features).

When you examine a product to check its dimensions, you will use one of the following measuring tools.

- Steel rule – steel rules are used for measuring lengths to a precision of 1 mm.
- Micrometer – these can be used to find the dimensions of small components to a precision of 0.001 mm.
- Vernier callipers – these are used to measure the length or diameter of smaller components to a precision of 0.02 mm. Vernier callipers are used for very accurate measurements.
- Tape measure – these are used for larger dimensions where precision is less important.

When you are selecting measuring equipment to collect data, you need to think about the following points.

- How precise do the measurements need to be?
- How many measurements will you need to take?
- What is the reason for taking the measurements?
- The size and shape of the component to be measured.

You should always record length measurements in millimetres (mm).

Tolerances

For component parts of an engineered product to fit together properly, they need to be produced to an agreed tolerance. Sometimes there are slight variations in the sizes or positions of features when components are made. Providing these are within tolerance, the parts will fit together and work as intended.

Surface finishes

The surface finish of an object says how smooth its surface is. Surface finish is measured in micrometres (μm). 1 μm = 0.0000001 m.

The finish applied to the component will have a significant impact on how the component looks, but will also influence how resistant the component will be to wear and damage, or to corrosion, e.g. rust. As with dimensions, there are tolerances for surface finish – for example, how smooth a feature must be or how thick a paint finish should be.

Many different surface finishes can be applied to materials to change their appearance

Physical form

The physical form of a component is the shape it takes. Try to be descriptive about the form of an object; think about whether it is a regular shape, such as a cone, cube or cylinder, or an abstract shape that is harder to describe. Consider using terms such as 2D, 3D, flat and curved to support your descriptions.

Try to describe the form using a combination of shapes. In the case of the component in the photograph, a description could be that it has a long rectangular body that is connected to an approximately square plate with a hole in its centre.

Consider other physical attributes that might cause problems, such as injury from impacting sharp corners or moisture traps in which water could collect and damage the product.

CHECK MY LEARNING

You have learned about the types of feature an engineered product can have. In your class group, discuss what you understand by tolerances and the importance of these for engineered products.

Selecting engineering materials

GETTING STARTED

Write down as many examples of materials as you can think of for each of the following material categories: ferrous and non-ferrous metals, and thermosetting and thermoforming polymers.

LINK IT UP

To remind yourself of the range of engineering materials used in manufacturing engineered components and products, go back to Component 2: Learning aim A.

Most of the materials you will encounter when investigating existing solutions will be similar to the four material categories that you have already covered.

Categories of material

The following is a review of the general properties and characteristics of each material group and how these influence material choices.

Ferrous metals

Ferrous metals contain iron. Ferrous metal alloys also contain other metals to give them the properties required. For example, stainless steel is corrosion resistant because it contains other metals such as chromium and nickel (see Table 3.7).

Table 3.7: Examples of ferrous metals

Material	Properties
Mild steel	• Good tensile strength • Good levels of malleability and ductility
Stainless steel	• Very tough • Corrosion resistant
Wrought iron	• Very tough • Corrosion resistant • Good levels of malleability and ductility

Non-ferrous metals

Non-ferrous metals do not contain iron. Unlike ferrous metals, they are not magnetic and usually have better corrosion resistance (see Table 3.8).

Table 3.8: Examples of non-ferrous metals

Material	Properties
Aluminium	• Soft and malleable • Good conductor of heat and electricity • Corrosion resistant
Titanium	• Low density • Quite good levels of ductility
Copper	• Tough material • Very ductile • Very good electrical conductor

Thermosetting polymers

Thermosetting polymers have a rigid molecular structure that is made up of lines of molecules that are heavily cross-linked. They can be heated and shaped once, but they cannot be reshaped, because they become permanently stiff and solid after being heat treated (see Table 3.9).

Table 3.9: Examples of thermosetting polymers

Material	Properties
Phenol-formaldehyde	• High electrical resistance • High heat resistance • Hard wearing
Polyimides	• Hard and tough with good rigidity • Self-lubricating • Resistant to oil, fuels and chemicals
Polyurethane	• Good hardness properties • High tensile and compression strength • Impact and abrasion resistant

Thermoforming polymers

Thermoforming polymers have fewer cross-links than thermosetting polymers. This means that when they are heated they become soft and can be formed into a variety of shapes and forms. When they cool, they become stiff and solid again. However, the process can be repeated many times (see Table 3.10).

Table 3.10: Examples of thermoforming polymers

Material	Properties
Polyethylene	• Excellent chemical resistance • Good fatigue and wear resistance
Polypropylene	• Quite high tensile strength • Good resistance to stress and cracking
Acrylic	• Very stiff material • Good durability • Good electrical insulator

ACTIVITY

Find an example of an engineered product (from the internet or from your teacher) and examine the product to identify the materials used to make it.

1 Name all materials used in the product and what they are used for.
2 Research the properties of these materials.
3 Suggest alternative materials that have similar properties to the existing materials.

CHECK MY LEARNING

You have learned about the properties of some of the materials used in engineered products.

In a small group, discuss and explain the reasons why you chose the alternative materials for the engineered product you looked at in the main lesson activity.

Manufacturing processes

GETTING STARTED

Working in groups, disassemble an engineered product. Write a list of the processes that you think have been used in the manufacture of the product.

LINK IT UP

Go to Component 1: Learning aim B and Component 2: Learning aim A to review processes used in manufacturing.

When an engineered product is manufactured, a range of processes, generally divided into four groups, is used to make sure that it is produced to the highest possible standard.

Cutting processes

Cutting involves the removal of unwanted material. Sometimes you are left with more than one piece, such as when you use a saw. Other processes only leave swarf or filings, such as drilling and filing. Table 3.11 lists some examples of cutting processes.

Table 3.11: Examples of cutting processes

Process	Examples of use
Drilling	• Making holes through a material • Counterboring to allow components to sit below the surface of a workpiece • Producing blind holes and flat-bottomed holes that do not go all the way through material
Sawing	• Mechanical or manual methods can be used • Hacksaws are generally used for metallic materials and have different blade types for different thicknesses of metal • Coping saws can be used for cutting many polymers
Filing	• Used to remove burrs or sharp edges from the surface of metal • Can be used to add a round edge or chamfer to a cut material • Can be used to make holes bigger or to shape them to specification
Shearing	• Used to produce straight cuts • Can be used on sheet material or bar and angle stock

Shaping processes

Shaping processes are most often used with metals. They involve using cutting tools to remove material and produce the shape of the component required by the design. Table 3.12 lists some examples of shaping processes.

Table 3.12: Examples of shaping processes

Process	Examples of use
Turning	• Producing flat faces that are a square end to a bar • Producing a range of diameters on bars, including parallel, stepped and tapered • Adding features to the outside of a bar, including screw threads, knurling and chamfers
Milling	• Producing flat, square and parallel features • Machining shoulders, steps, slots, grooves and recesses

Forming processes

Forming processes often involve the use of heat, changing materials from one form to another. For example, polymer pellets are first heated and then injection moulded to form products. Table 3.13 lists some examples of forming processes.

Table 3.13: Examples of forming processes

Process	Examples of use
Casting	• Sand casting is used for large components, where dimensional accuracy is less important • Die casting is used for large batches and where tolerances are tight • Investment casting is used for very complex shapes, where dimensional tolerances are very important
Forging	• Drop forging is used for smaller shapes, where production rates are high • Upset forging is used for simple products, such as the head of a bolt • Press forging is used for large objects
Extruding	• Extruding is a process used for polymers. Complicated hollow sections can be made by forcing soft polymers through a die
Moulding	• Injection moulding is used for complex shapes, such as housings for electronics • Blow moulding is used for hollow containers, such as bottles • Vacuum forming is used for simple hollow containers and enclosures

Joining and fabrication processes

Once component parts have been manufactured, they need to be joined together. These joining processes can be permanent or temporary and may depend, for example, on whether maintenance requires the parts to be taken apart. Table 3.14 lists some examples of joining processes.

Table 3.14: Examples of joining processes

Process	Examples of use
Fastening	• Fastenings provide a mechanical joint between components. Most are temporary, e.g. screws, nuts, bolts and clips • Permanent fasteners include rivets
Bonding	• Bonding is similar to gluing, giving an adhesive joint between materials • Factors that influence the strength of bonding include the pressure applied, the materials to be joined and the temperature
Soldering	• This process is used for joining electronic components to circuit boards • A soldering iron is used to melt solder, which solidifies to make the joint
Brazing	• A process similar to soldering but at a much higher temperature • Used to join different metals together, e.g. in heating systems

ACTIVITY

Examine an engineered product and investigate the manufacturing processes used to make it.

1. Name all of the processes used to manufacture the product.
2. Research two contrasting production processes – for example, one forming and one joining.
3. Create a short presentation that describes the two processes.

CHECK MY LEARNING

As covered in this lesson and in Components 1 and 2, different types of manufacturing process can be used. In a small group, discuss the different options that can be used to manufacture an engineered product.