# ENGINEERING DESIGN

**LEARNING OUTCOME 1:** Understand the design cycle and the relationship between design briefs and design specifications

**TOP TIP**

To easily remember the stages of the design cycle – remember the acronym;

IDOV

I - IDENTIFY
D - DESIGN
O - OPTIMISE
V - VALIDATE

*THE DESIGN CYCLE*

## COMMON EXAM TERMINOLOGY

**EVALUATE:** Give an opinion by exploring the good & bad points. Attempt to support your argument with expert opinion.

**IDENTIFY:** Recognise, prove something as being certain.

**DEFINE:** Give the meaning. This should be short.

**DESCRIBE:** Give a detailed account.

**JUSTIFY:** Give a good reason for offering an opinion.

**GIVE REASONS FOR:** Use words like because in your answer as you will be explaining how or why something is that way.

**DISCUSS:** Explore the subject by looking at its advantages and disadvantages (i.e. for and against). Attempt to come to some sort of judgement.

**ANALYSE:** Explore the main ideas of the subject, show they are important and how they are related.

**COMPARE:** Show the similarities (but you can also point out the differences).

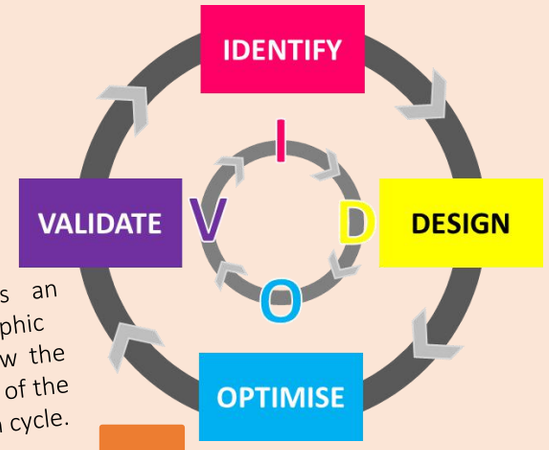
**EXPLAIN:** Describe, giving reasons and causes.

**STATE:** Write briefly the main points.

## THE DESIGN CYCLE

The design cycle covers the stages of Engineering Design from the initial design brief through to manufacturing the product and testing and evaluation. This cycles sets out the order and tasks that are generally completed when a new product is being designed and is what designers will follow to successfully bring a new product to market.

- STAGE 1: **IDENTIFY** phase – brief – research – process planning
- STAGE 2: **DESIGN** phase – specification – design – manufacturing plans
- STAGE3: **OPTIMISE** phase (e.g. virtual, physical) – model and prototype – error proofing
- STAGE 4: **VALIDATE** phase (e.g. virtual, physical) – test – evaluate




Here is an infographic to show the stages of the design cycle.

### I — IDENTIFY phase

**BRIEF** – a discussion between the client and the designer will create an initial DESIGN BRIEF that outlines the product to be designed.

**RESEARCH** – is the investigation into materials to be used, manufacturing methods, look at other existing and iconic products. This process will help you design a better suited product.

**PROCESS PLANNING** – is the connection between design and manufacturing. In this stage the use of CAM (Computer Aided Manufacture) processes are planned out with regards to creating CAD (Computer Aided Design) files, timescale and resources needed.

### D — DESIGN phase

**SPECIFICATION** – is a set of criteria that a design must meet in the design and manufacture stages. The specification points are set from a design brief.

**DESIGN** –a range of draw and sketched ideas are created that meet the specification created. The design could then be discussed with the client/target market for suggested improvements.

**MANUFACTURING PLANS** – plans are made as to the stages of production. Tools and equipment, time, health and safety and quality assurance will all be included in a detailed manufacturing plan.

### O — OPTIMISE phase

**MODEL** AND **PROTOTYPE** – modelling can be either physical or virtual. With virtual modelling we use a 3D software (for example Google Sketch Up) to model the product. Physical models are generally made from modelling foam or card for speeds and ease. Models are used to test ideas, shape, size, aesthetics and methods of production.

**ERROR PROOFING** – error proofing refers to the reduction or elimination of human error when using the product, for example instructions to show which way to insert batteries. The model will be tested for any improvement that could be made.

### V — VALIDATE phase

**MANUFACTURING** – the products components are manufactured using a range of manufacturing processes. They are then assembled together to create the final outcome. During the manufacturing stages quality control measures should be in place to check the quality of each stage of manufacture to ensure a good outcome.

**TEST** – the product is tested with the client and target market for its suitability and functionality within its working environment.

**EVALUATE** – the product is finally evaluated and further improvements suggested and developed.

## IDENTIFICATION OF **DESIGN NEEDS**

### INITIAL DESIGN BRIEF FROM THE **CLIENT**

– **SITUATION** and **CONTEXT** that has led to the brief
– **NEEDS** of the client:
- **corporate branding** – eye catching logo, colour scheme and direction for company.
- **target audience** – who is the product aimed at, who are the likely buyers/consumers of the product?

– **PURPOSE** of the product – is the product there to solve a problem.
– **FUNCTIONS** of the product – what will the product need to do, will it have more than one primary function?

### **INFORMATION** WHICH MAY INFORM THE **DESIGN BRIEF**

– **MARKET RESEARCH** :
- **focus** groups,
- **surveys**,
- needs of **target market**,
- consumer **trends**

– **STRENGTHS** & **WEAKNESSES** of competitors' products – product analysis looks at similar products on the market that could give inspiration.
– **IMPROVEMENTS** in **MATERIALS** – research into new and modern materials
– **NEW** PRODUCTION **PROCESSES** – new manufacturing methods
– **BUDGET** – the **FUNDS** available.

## THE RELATIONSHIP BETWEEN **A DESIGN BRIEF** & **A DESIGN SPECIFICATION**

**CLIENT** PROVIDES **INITIAL BRIEF** → The client will approach the designer with an initial design brief, a product or project that they would like the designer to take on. It is usually a problem that they would like the designer to solve with a suitable product or service.

**DISCUSSION** BETWEEN **CLIENT** & **DESIGNER** → The discussion will usually cover what the client wants from the design, what is possible, what can be done within budget, essential and desirable aspects, timeframe, the quantity of the product to be made and the environment that it will be used in.

FURTHER **RESEARCH** → Further research will look at materials, manufacturing methods, other similar and iconic products, assembly methods such as use of standard components. This process will involve further discussions with the client to reveal findings.

**'FINAL'** BRIEF → From the research and discussions with the client a FINAL BRIEF will be developed that will set out the goals to be achieved by the product/project. From this a suitable SPECIFICATION can be established and taken into the DESIGN stage of the project.

# ENGINEERING DESIGN

**LEARNING OUTCOME 2:** Understand the requirements of design specifications for the development of a new product

## TOP TIP

DFMA and D4D closely link to the use of STANDARD COMPONENTS that help make a product easier to take apart and also put together. When questions come up about DFMA and D4D then you should always reference standard components and provide an example.

## MAINTENANCE

*The process of keeping something in good condition.*

Maintenance of a product refers to what needs to be done to keep the product in working order:

- Changing batteries
- Cleaning
- Replacing components
- Repairing the product if broken

## TOP TIP

DESIGN BRIEFS & SPECIFICATIONS – remember that in every Y7 and Y8 product you were given a BRIEF to work to and from this brief you created your own SPECIFICATION or success criteria for your individual design project whether it was an item of copper jewellery or a mood light.

PRODUCT DESIGN ANALYSIS means studying how well a product does its job. This involves answering the following questions:

- What is the **function / purpose** of the product?
- What are the **different parts** of the product and how do they work together?
- How does the product use **shape**, **form**, **colour**, **texture** and **decoration**?
- What **materials** and **components** are used to make the product?
- Which **processes** were used to make the product?
- **Who** would **buy** this product?
- How well does the product **do its job** compared with other similar products?
- What is **unique** about the product?

# DESIGN FOR MANUFACTURING ASSEMBLY - DFMA

**DESIGN FOR MANUFACTURE AND ASSEMBLY (DfMA)** is a design approach that focuses on ease of manufacture and efficiency of assembly. By simplifying the design of a product it is possible to manufacture and assemble it more efficiently, in the minimum time and at a lower cost.

Traditionally, **DfMA** has been applied to sectors such as the design of automotive and consumer products, both of which need to efficiently produce high quality products in large numbers. More recently, construction contractors have begun to adopt **DfMA** for the off-site prefabrication of construction components such as concrete floor slabs, structural columns and beams, and so on.

**DESIGN FOR DISASSEMBLY (DfD)** is the process of designing products so that they can:
EASILY, COST EFFECTIVELY and RAPIDLY be taken apart at the end of the products life (either no longer used or broken) and can be reused or recycled. Products that have been designed for disassembly are easier to MAINTAIN, REPAIR and RECOVER COMPONENTS AND MATEIRALS for REUSE or RECYCLING purposes. D4D products are better for the ENVIRONMENT and can be said to be SUSTAINABLE DESIGNS.

Manufacturers design and manufacture products that are easy to disassemble for a number of reasons other than environmental impact, such as:

- Reduction in production costs
- Greater technical efficiency
- More flexibility during product development
- Reducing the scale of resources required.

# DESIGN FOR DISASSEMBLY – D4D

# REQUIREMENTS OF A DESIGN SPECIFICATION

The specification draws on the information collected and presented during the research section. The specification is a number of straightforward statements, made clearly outlining the nature of the project to be designed and manufactured. If the research section has not been completed fully, the specification will also be lacking.

1. The specification should be composed of simple, clear statements. Keep the statements as short as possible.
2. If possible, always refer to the research you have carried out. For example, "The colour scheme will be based on blue and red as these colours are the most popular - as seen in my questionnaire".
3. Look at each page of your research and try to write a statement based on each one. Most of the statements in the specification should refer to your research section.
4. Keep the number of statements to between 7 to 8 in total. Specifications should be short and precise in what they state.
5. Each of the statements should help determine the final design of the product. For example, there may be a statement concerning the overall size or weight of the product. This clearly places limits on the design of the product.
6. Ask another pupil or a teacher to read your draft specification. It should be easy for them to form a view of your final product, and describe it back to you. If this description is similar to what you intend for your final product, then your specification is correctly written.
7. Look at the specification written by another pupil attempting the same project. This will help you formulate further statements for your project.
8. The specification should take you no longer than an hour to write, if you have carried out a detailed research.

| | | | |
|---|---|---|---|
| AESTHETICS | The **AESTHETICS** of a product is the look and style of a product. Here you may look at the colours used, the shape of the product and the style of product that you are going to manufacture. | BENEFITS | What are the **BENEFITS** of buying and using your designed product over other products on the market. What does you product offer that others do not – this could be a key feature or a new aesthetic for example. |
| ERGONOMICS | **The study of people and their relationship with the environment around them.** When anthropometric data (see below) is applied to a product, e.g. measurements of the hand are used to design the shape and size of a handle, this is **ERGONOMICS**. | FEATURES | What are going to be the main **FEATURES** of your product – these could be the main selling points of your product, what sets it apart from other similar products on the market. These could be called your USP – Unique Selling Points. |
| ANTHROPOMETRICS | **The study of the human body and its movement,** often involving research into measurements relating to people. It also involves collecting statistics or measurements relevant to the human body, called **ANTHROPOMETRIC DATA**. | PRODUCT SAFETY | When you design a project, it is essential that it is **safe** for people to use. You should always refer to safety when creating a specification of a new product. **Safety** can cover, sharp edges, use of finishes like varnishes, having no loose small components etc. |

# TOLERANCE

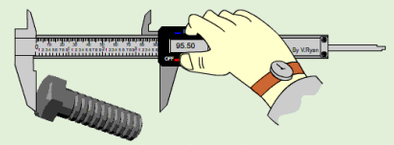
When a product is **mass produced** in thousands and hundreds of thousands, samples are regularly checked to ensure that they fall within the **tolerance** allowed. This ensures:

- The quality and consistency of the product.
- Each copy of the product is the same and works exactly the same way.
- Products that have many parts, will fit together and work in the way that they are supposed to – **DESIGN FOR MANUFACTURING ASSEMBLY**
- Products that do not fit the set tolerances, are rejected and **RECYCLED**.

Checking that a product is manufactured within an upper and lower limit.

**EXAMPLE**: Thousands of steel bolts are manufactured by a company. Samples are check that they are the correct size. Each bolt must fall within a maximum and minimum length.

The tolerance of the bolt is said to be: 80.5mm + 0.5mm / - 0.5mm



Therefore in the above example if:
The BOLT tested measured **80.3mm** – would be **accepted** as it sits **within the tolerance set**.
The BOLT tested measured **81.2mm** – the bolt would be **rejected** as it is **out of the set tolerance**.

# ENGINEERING DESIGN

**LEARNING OUTCOME 2:** Understand the requirements of design specifications for the development of a new product

## DESIGN PROTECTION

- COPYRIGHT


- REGISTERED TRADEMARK


- PATENT


## COPYRIGHT

Copyright aims to protect people, companies and organisations that produce creative and artistic work.

An author can claim copyright protection for his/her books or a song writer can protect his/her songs.

In order to claim copyright, it is essential that the work you are trying to protect is completely your own.

Copyright law covers many areas including; Literature, Drama, Music, Art, Layouts, Recordings, Broadcasts.

## REGISTERED TRADEMARK

A trademark is a symbol/sign that identifies your products or services.

A trademark can be words or pictures or a combination of both. A fee is paid to the Intellectual Property Office, who decide whether a symbol/logo can be regarded as a protected trademark. Often trademarks are used to advertise products or services. A trademark must be distinctive and distinguish your goods from those of other traders/manufacturers. It must not be confused with other trademarks. A registered trademark is denoted by ®.

## PATENT

A patent protects a person or company that invents something new. If you invent a new type of pen, you should patent your design. This should prevent anyone or another company from stealing your idea, manufacturing it and making money for themselves. A patent protects your design for the first five years and them you must apply annually for the next fifteen years (twenty years in total).

Patents apply to; a scientific discovery, a literary piece of work (e.g. musical), Computer programs, new medical treatments.

# COMMERCIAL PRODUCTION METHODS

**One-Off Production** – one product is made at a time and products made are all unique. This drives up the labour time and cost. Product may be made by hand or by machining methods such as CAD/CAM. Example products are bespoke furniture made to order.

**Batch Production** – a small quantity (usually a set amount) of identical products are made. Batch production is also includes a lot of labour however jigs and templates are used to speed up production. A jig is used to mark out components quickly and precisely and a template is something that can be drawn around to be cut or shaped. Batches can be made regularly or swapped out for a batch of a different product.

**Mass Production** – hundreds of identical products are made during mass production. A production line is generally used where individual components and assemblies are created by a single machine or worker and then it moves along the line for further assembly. Smaller parts are often bought from other companies and including in the manufacturing process. There is usually some automation of tasks (e.g. by using *Computer Numerical Control* machines) and this enables a smaller number of workers to output more products.

**Continuous Production** – thousands of identical products are manufactured. This process runs throughout the day – a 24 hour process. This means that machines do not have to be turned off and restarted at the end/beginning of the day. This process is highly automated which requires fewer workers.

# LEGISLATION & STANDARDS

**British Standards (BS)** - In the UK, standards are regulated by the British Standards Institution (BSI). Products which meet these standards can be marked with the **Kite Mark**. The products are put through testing to ensure that they meet the required standards and provides customers with confidence.

**European Conformity (CE)** - There are also separate standards for the European Union. If a product meets these, it can be given a CE Mark. The marks show government officials that the product conforms to a standard, which enables it to be legally placed on the market within their country.

**Waste Electrical and Electronic Equipment Directive (WEEE)** – WEEE Directive set collection, recycling and recovery targets for all types of electrical goods, targets were also set for manufacturers as to what they could include within electronic equipment. This meant that designers and manufacturers needed to rethink the manufacture of electronic products and particularly the materials used and how they can be wasted and recycled as the product life ends.

**Patents** - A set of exclusive rights granted by a organization to an inventor or assignee for a limited period of time. An invention is a solution to a specific technological problem and is a product or a process. Patents are a form of intellectual property. Therefore if a designer has created a solution that no one else has then they can apply for a patent to protect their work from plagiarism.

**Copyright** - Copyright is a legal right created by the law of a country that grants the designer of an original product exclusive rights for its use and distribution. This is usually only for a limited time. Therefore having the copyrights for a new product allows only you to manufacture and sell that product.

# STANDARD COMPONENTS & PRE-MANUFACTURED COMPONENTS

A **STANDARD COMPONENT** is usually an individual part or component, manufactured in thousands or millions, to the same specification (such as size, weight, material etc...). A good example is a **steel bolt**.

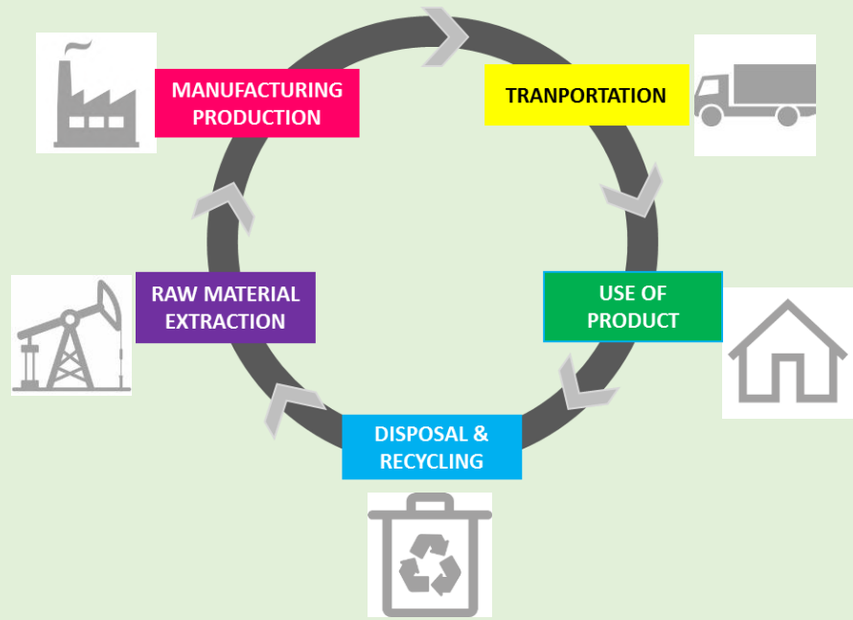
Bolts are available in a vast range of standard sizes. However, each size is manufactured to an internationally accepted standard. For example, a M20 bolt. A typical steel M20 bolt will be a specific length, diameter, quality of steel, pitch of thread etc.

## ADVANTAGE OF USING STANDARD COMPONENTS

1. **Standard components** are manufactured in vast quantities, keeping costs down.
2. **Standard components** are supplied in standard sizes. Consequently, they are easy to order. Ordering of standard components is relatively straightforward, sizes / dimensions etc... are available in table or index form.
3. Buying directly from suppliers, over the counter, at hardware stores such as B & Q, is easier as **standard components** such as screws, bolts, nails and fixings are often displayed in order. This makes it easier to find the component required.
4. Safety/quality testing is easier when dealing with **standard components**. Often a number of **standard components**, from a batch will be tested. Faulty components can be withdrawn from sale, if detected.
5. Manufacturers of 'complex' products (computers TVs, etc....), usually assemble their products from **standard components**. This allows them to concentrate on the development of their specialised product, rather than having to design each individual component. This speeds up product development.
6. Setting up a mass production line is easier if **standard components** are used. It is easier to train staff/the workforce, as they are dealing with the same **standard components**, when assembling products.

# SUPPLY CHAIN

THE SUPPLY CHAIN – is a **network** between a company and its suppliers to produce and distribute a specific product, and the **supply chain** represents the steps it takes to get the product or service to the customer. Below is an infographic to show the general supply chain of a product getting to market.



# ENGINEERING DESIGN

**LEARNING OUTCOME 3:** Know about the wider influences on the design of new products

## CULTURAL & FASHION TRENDS

**CULTURE** and **FASHION** trends can influence design greatly. For example: colour. Colour can signify different things in different cultures. The colour red, **Red** symbolizes excitement, energy, passion, action, love, and danger in Western **cultures**. It's also associated with communism and revolution in countries like Russia. In Asian **cultures red** is a very important **colour** — it symbolizes good luck, joy, prosperity, celebration, happiness, and a long life.

## ICONIC DESIGN

iPod Touch 2007

SONY WALKMAN Walkman TPS-L2 (1979 1979

SIR ALEC ISSIGONIS' ORIGINAL MINI 1959

STRATOCASTER GUITAR Electric Guitar Designed By Leo Fender, George Fullerton, and Freddie Tavares In 1954

SPITFIRE R.J. MITCHELL 1936

An iconic design is usually a design that is 'ground breaking' and one that sets new standards in its field. It is a design that other designers and manufacturers follow, as it becomes a bench mark for other similar products. Furthermore, an iconic design is one that stands up to the test of time, remaining a good design, despite the passing of years, decades and even centuries.

# MARKET PULL V'S TECHNOLOGY PUSH

The term '**MARKET PULL**', refers to the need/requirement for a new product or a solution to a problem, which comes from the market place. The need is identified by potential customers or market research. A product or a range of products are developed, to solve the original need. Market pull sometimes starts with potential customers asking for improvements to existing products. Focus groups are often central to this, when testing a concept design or an existing product.

The digital camera. Twenty years ago, there was a 'market' requirement for a camera that could take endless photographs, that could be viewed almost immediately. Market pull (market need) eventually led to electronics companies developing digital cameras, once miniature digital storage, processing power and improved battery performance was available. Market pull ensured that photo editing software also developed, in parallel with the development of digital camera technology.

**TECHNOLOGY PUSH** is when research and development in new technology, drives the development of new products.
Technology Push usually does not involve market research. It tends to start with a company developing an innovative technology and applying it to a product. The company then markets the product.

Touch Screen technology appeared as published research by E.A. Johnson at the Royal Radar Establishment UK, in the mid 1960s. The technology began to attract research and development funding. In the 1980s, Hewlett Packard introduced a touch screen computer. 1993 hand writing recognition introduced - Apple's Newton PDA. 1996, Palm introduced its Pilot Series. Touch screen technology now seen in smart phones.

# SUSTAINABILTY & SUSTAINABLE DESIGN

WHAT IS **SUSTAINABLE** DESIGN?
The intention of sustainable design is to "eliminate negative environmental impact completely through skilful, sensitive design". Manifestations of sustainable design require renewable resources, impact the environment minimally, and connect people with the natural environment.

**RENEWABLE RESOURCES**
Renewable energy is made from resources that Mother Nature will replace, like wind, water and sunshine.
Renewable energy is also called "clean energy" or "green power" because it doesn't pollute the air or the water.
EXAMPLES:
**WIND SOLAR HYDRO GEOTHERMAL BIOMASS**

**NON-RENEWABLE RESOURCES**
Fossil fuels are non-renewable because they will run out one day. Burning fossil fuels generates greenhouse gases and relying on them for energy generation is unsustainable. (finite).
EXAMPLES:
**COAL OIL GAS**

**6R'S OF SUSTAINABILITY?**
RE**DUCE**: is it possible to reduce the amount of materials used when making a product?
RE**USE:** could the product have another use? Could its parts be used in other products?
RE**CYCLE:** have recycled materials been used? Is it made from materials that are easy to recycle?
RE**THINK:** is there a better way to solve the problem that is less damaging to the environment?
RE**PAIR:** if the product breaks can it easily be fixed without throwing away?
RE**FUSE:** not accepting things that are not good for the environment. Is packaging needed?

# LIFE CYCLE ASSESSMENT

**CARBON FOOTPRINT**: This term is used to denote the amount of carbon dioxide produced by your daily activities and use of material goods. Since CO2 is the most common of the greenhouse gases, you can determine your personal participation in Global Warming. you can prevent global warming, simply by changing some of your habits.

**LIFE-CYCLE ASSESSMENT** (LCA, also known as life-cycle analysis, Eco balance, and cradle-to-grave analysis) is a technique to assess environmental impacts associated with all the stages of a product's life from cradle to grave. Each stage of the LCA is below...

**Raw** Materials → **Manufacturing** → **Transportation** → Installation → Use → **Maintenance** → Disposal → **Landfill** - Recycling

# NEW AND EMERGING TECHNOLOGIES – SMART MATERIALS

**THERMOCHROMIC** pigments are sensitive to temperature. They change colour when they are heated up or cooled down. This property is useful for indicating if the drink in a cup is hot, or if the water in a kettle is hot. Phosphorescent pigments glow in the dark. They are able to absorb light energy and store it.

**PHOTOCHROMIC MATERIALS** change reversibly colour with changes in light intensity. Usually, they are colourless in a dark place, and when sunlight or ultraviolet radiation is applied molecular structure of the material changes and it exhibits colour. When the relevant light source is removed the colour disappears

**POLYMORPH** is a thermoplastic material that can be shaped and reshaped any number of times. it is normally supplied as granules that look like small plastic beads. In the classroom it can be heated in hot water and when it reaches 62 degrees centigrade the granules form a mass of 'clear' material. When removed from the hot water it can be shaped into almost any form and on cooling it becomes as solid as a material such as nylon.

Although expensive, polymorph is suitable for 3D modelling as it can be shaped by hand or pressed into a shape through the use of a mould