

AS LEVEL Section A

FACT FILES

Technology & Design

For first teaching from September 2011

For first award in Summer 2012

Methods of
Joining Materials



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Learning Outcomes

Students should be able to:

- Demonstrate knowledge and understanding of permanent and semi-permanent methods used to join materials to include:
 - Soldering, brazing, welding;
 - Riveting;
 - Selection of adhesives;
 - Nut, bolt and washer and self tapping screws;
 - Knock down fittings.



Course Content

Different materials can be joined in many different ways depending on whether the joint needs to be permanent or semi-permanent.

- **Permanent:** once this type of joint has been constructed, it can not be reversed without causing damage to the material/product.
- **Semi-permanent:** this type of joint is a method of joining that is designed to be permanent; however, it can be disassembled without damaged the materials.

Permanent methods:

Welding

The main method of permanently joining metals is by welding. There are many variations of welding including MIG and TIG, oxyacetylene welding, electric arc and spot and seam welding. All involve permanently joining metals by the use of heat, causing the 2 main pieces of metal to become molten and using a joining material to mix them before they solidify, forming a permanent, strong joint.

Welding can be repetitive and because of this robots can be used to weld in particularly unpleasant environments or when mass production is required, e.g. car industry.



MIG and TIG: these types of welding can be used to join thin sheets of metal by adjusting the settings on the main machine unit. MIG (Metal Inert Gas) and TIG (Tungsten Inert Gas) welding use a gas jet around a filler wire. This prevents oxidation of the joint, ensuring optimum strength. Different gases are used with different materials, e.g. Argon with aluminium.

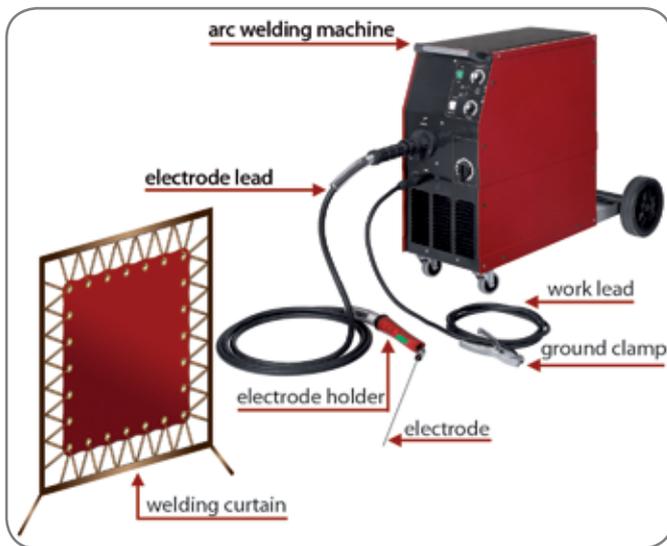


Oxy-acetylene: For this method acetylene is burned with oxygen to produce a heat source of approximately 3500°C. Fine adjustment of the gases can be made by the user altering the gas feed on the handle of the torch.

Excess oxygen gives the hottest flame; however, a neutral flame has equal volumes of both gases and is the most commonly used setting.

The gases levels are also adjusted depending on the thickness of the materials that are to be joined. During this process, a molten pool of the metal is made before a filler rod (of the same metal) is dipped into the pool and melts, filling the joint. Fluxes are not used with steels but are with a range of other metals.

Electric arc welding: This type of welding generates enough heat to melt the joint edges by creating an electric current through an arc between the materials being joined and the filler rod (electrode).



The process uses a low voltage and high current (10-120 amps) to produce the arc. The electrode carries the current and is a flux coated filler rod.

At each end of the arc there is intense heat. This melts the filler rod and the metals to form the weld bead. The flux coating on the filler rod prevents oxidation on the joint occurring.

Spot and seam: Spot and seam welding use an electric current as a heat source. Spot welding uses a spot to fuse the metals together and is mainly used in the production of car bodies because it is a quick and clean process.

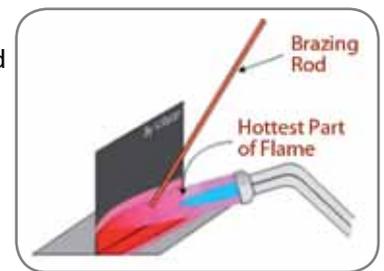


Seam welding: Seam welding passes an electrical current through the edges of two sheets of metal as they pass through rollers. Food and drinks cans are manufactured in this way.



Brazing

Brazing is used to join metals such as copper and steel. Brazing is similar to soldering but uses much higher temperatures (870 – 880°C). The rod used to fuse the two pieces together is called the brazing spelter and is composed of an alloy of copper and zinc. When the correct temperature is reached, the spelter melts and fills the joint by capillary action. The joint is allowed to cool and harden before the excess flux is removed.



Soldering

The two main types of soldering are:

- Hard soldering.
- Soft soldering.

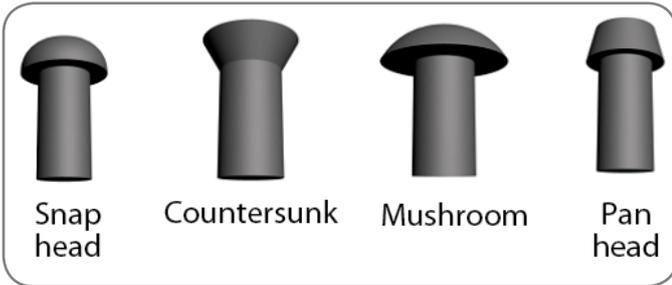
The principle of the two methods is the same; however, the lowest melting point in hard soldering is 625°C, whereas in soft soldering the melting point is approximately 200°C.

The stages in the soldering process are:

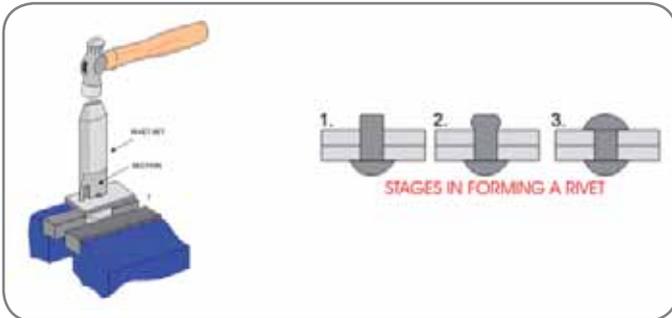
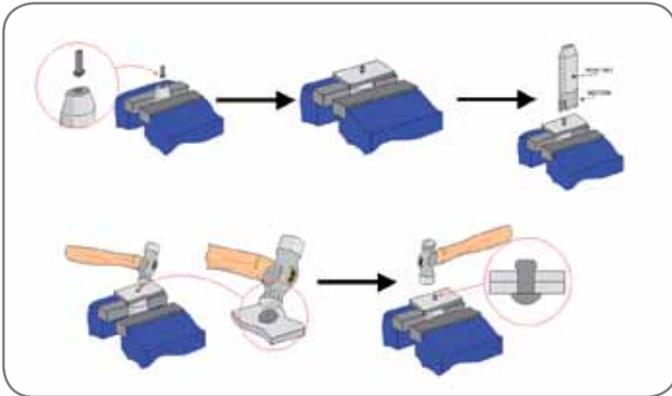
1. Materials are cleaned and degreased. The surfaces of the two materials can be kept clean by use of a flux.
2. The surfaces must fit together without gaps and must be held together securely while being heated.
3. A heat source such as a blow torch is used to heat the materials around the joint to make sure that both pieces are evenly heated. The solder filler rod is rested on the joint and as it starts to melt, capillary action will allow the solder to run between the joint.
4. Once filled, the joint will be left to cool and harden.

Riveting

Rivets are used to join two sheets or plates of metal together. There are four main types of rivets:



Process of riveting:



1. The snap head rivet is placed into a tool called a dolly that is held in a vice.
2. The plates are then placed over the rivet.
3. The rivet set is then placed over the rivet and pressed down to ensure that there are no gaps between the sheets/plates of metal.
4. The rivet set is tapped with a ball peen hammer. This closes any gaps and starts to form the rivet joint.
5. The ball peen hammer is then reversed to form the head of the rivet.
6. The final stage is using a rivet snap to form a similar shaped dome on both sides of the joint.

Adhesives

The main advantage of using an adhesive over other methods of joining is that it is generally invisible. Unlike other methods of joining, adhesives do not damage or change the materials being joined.

| Type | Use | Advantages | Disadvantages |
|---------------------------------|---|---|---|
| Synthetic resin glue (casamite) | Joining wood. It is a powder that is mixed with water to form a thin paste. | <ol style="list-style-type: none"> 1. Stronger than PVA. 2. Heat and water resistant. 3. Economical. 4. Durable. 5. Non-staining. | <ol style="list-style-type: none"> 1. Takes 4-6 hours to set. 2. Hard on tools. |
| PVA (Polyvinyl acetate glue) | Joining wood. It is a white liquid sold in various sizes of containers. | <ol style="list-style-type: none"> 1. Strong and water resistant. 2. Non-staining. 3. Sets quickly (2-3 hours) 4. Excess glue can be removed by a damp cloth. | <ol style="list-style-type: none"> 1. Not waterproof. |
| Contact (impact) adhesive. | Joining different types of materials, e.g. plastic laminates/metallic strips to wood and other materials. Each surface is coated with the adhesive and left for 10-15 minutes until touch dry. The surfaces are then lined up before being pressed together. | <ol style="list-style-type: none"> 1. Clean. 2. Quick. 3. Economical. | <ol style="list-style-type: none"> 1. Little or no time for repositioning. 2. Good ventilation required. |
| Epoxy resin. | Araldite is the main example of this adhesive. It is used to form a rigid bond with most unlike materials with the exception of silicon rubber, polythene or thermoplastic. The resin and hardener are mixed and spread over surfaces and left to set for 24 hours. | <ol style="list-style-type: none"> 1. Good water resistance. 2. Insulation and gap filling properties. | <ol style="list-style-type: none"> 1. Expensive because it needs to be spread over a larger area to be permanent. 2. High cost prevents large-scale work. |

Other adhesives include:

- Tensol 12 and tensol 70 for joining thermoplastics.
- Tensol 53 for joining PVC.
- Rigid polystyrene cements.
- Special DIY all-purpose adhesives, e.g. UHU. Used for many materials.
- Special industrial adhesives, e.g. superglues.
- Double-sided tape.
- Latex adhesive, e.g. Copydex. This is suitable for fabrics, paper and card.
- Hot-melt glue used in hot glue guns.

Nuts, bolts and washers

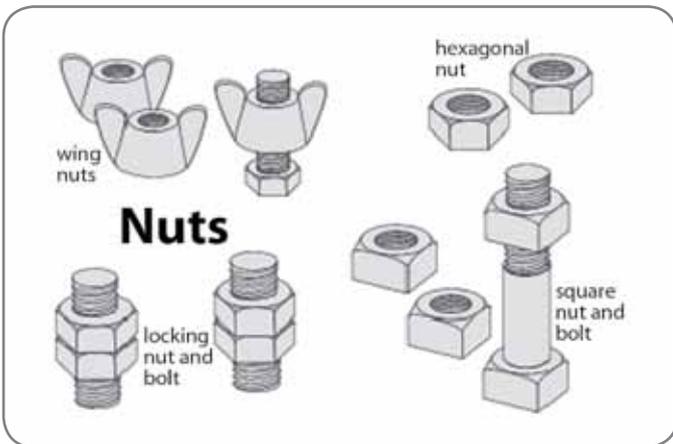
Nuts and bolts are used to hold two or more pieces of materials together in a semi-permanent method of joining.

Bolts tend to be made from high tensile steel and are threaded (square or hexagonal threaded) for all or part of the length of the shaft.



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Nuts used with bolts must have matching diameter and thread form. They come in various forms, from wing nuts (made for easy removal by hand) to hexagonal nuts and special locking nuts that resist coming loose.



Types of washers: Washers are used to protect the surface when nuts are tightened. They spread the load applied to the surface and prevent loosening that can be caused by vibrations.



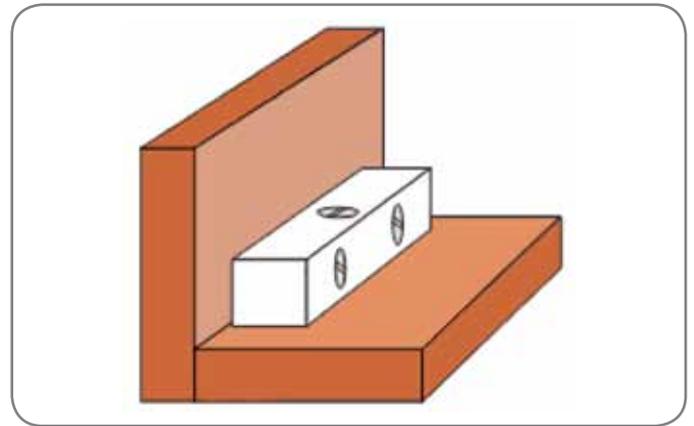
Self-tapping screws: Self-tapping screws are used for thin sheet metal and plastic. They are made from hardened steel and they cut their own thread as they are screwed in to the material.

A clearance hole and pilot hole (equal to the screw's core diameter) are required prior to insertion.

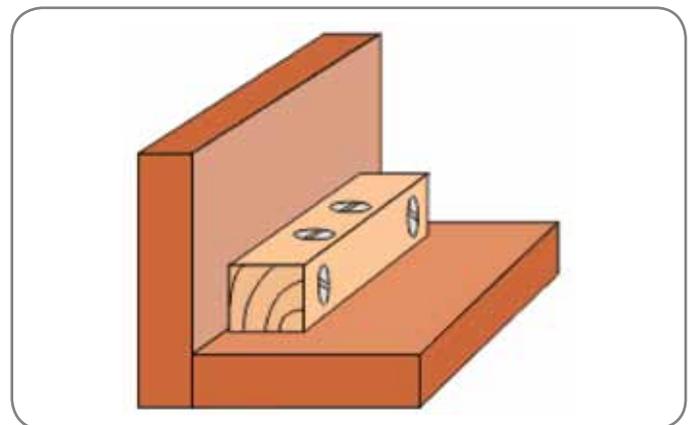
Knock-down fittings

Knock-down fittings are predominantly used in self-assembly products that might be such as items of furniture found in the kitchen, bedroom and living room. This type of furniture tends to be supplied in flat-pack form.

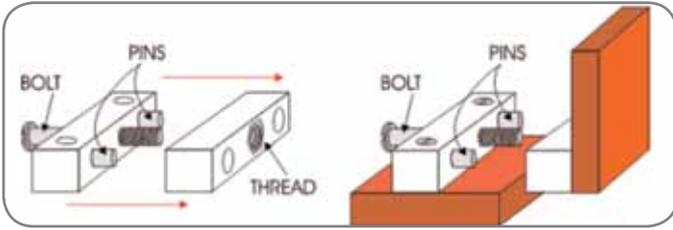
Corner blocks comprise of one or two piece plastic block joints that assist with the assemble of products such as shelving units or attaching to top of a piece of furniture such as a table top or kitchen worktop to units.



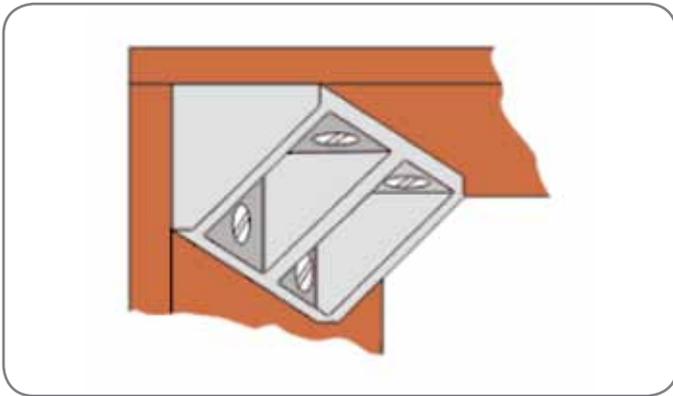
Natural wood fitting is an inexpensive form of knock-down fitting that uses a softwood such as pine in the same way that a corner block is used. Two set of perpendicular countersunk holes are drilled to guide the screws into the two pieces of material that is to be joined.



Two block fittings are made from plastic. A bolt passes through the first fitting into the thread of the second. By tightening the bolt, the two fittings pull together, while the two guide pins help keep the fitting straight. This provides a very strong joint and it can be dismantled using a screwdriver.



Rigid joints are moulded from plastics making them strong. There are four holes that guide the screws into the two piece of material and as the screws are tightened the rigid joint pulls the two pieces of material together ensuring a tight joint and 90° angle.



Revision questions

1. Machine screws, self-tapping screws and knock down fittings are considered semi-permanent methods used for joining materials.
 - a. Identify **two** permanent methods that could be used to join materials.
 - b. Briefly explain the difference between each of the semi-permanent methods stated below:
 - ii. Machines screws
 - iii. Self tapping screws
 - iv. Knock down fittings.
2. Riveting and knock down fittings are used to join materials. With the aid of annotated sketches, briefly explain how each of these is used to join materials.
3. Distinguish between permanent and semi-permanent methods used in joining of materials.
4. Brazing and welding are widely used methods in the joining of metals. Briefly outline **two** main characteristics for each of the methods above.