Electrochemical Metalworking

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Introducing electrochemical metalworking into school allows children to use metal in a creative fashion. When designing small scale decorative metalwork projects, thought can be given to the various different ways of creating pattern, texture and the use of colour. Because these techniques can be used in any workshop area and don't have to take place in a metalworking environment, they may be a useful step in moving away from the idea that working with metal is synonymous with heavy machinery and oily white coats! It is also relevant that some electrochemical processes such as electroplating afford a useful insight into important industrial technology.

The amount of space required is minimal although some time is necessary to set up the equipment and make up the chemical solutions. If an area of the workshop is set aside for such purposes and the equipment is readily available for use, then these processes can be easily incorporated into many existing projects, making them more exciting and varied. Any such area definitely needs to be next to a sink because of the chemicals and acids which will need to be rinsed from the work.

Prior to introducing one or more of the following techniques into the CDT curriculum, teachers may wish to experiment themselves and find out the potential of the processes. Results are easy to achieve, but a little experimentation will be crucial if good and predictable results are to be obtained.

This is not intended to be a detailed guide but a brief look at four techniques which could be used successfully with both lower and upper school pupils. In some instances, extra information may be deemed necessary and some references are given at the end of the article.

CHILDREN NEED TO BE WELL INSTRUCTED IN THE SAFE USE OF ANY CHEMICALS. GOGGLES AND RUBBER GLOVES SHOULD ALWAYS BE WORN AND WORK SHOULD BE CARRIED OUT IN A WELL VENTILATED AREA TO SAFEGUARD AGAINST ANY FUMES THAT ARE GIVEN OFF. IF IN DOUBT, ASK AN EXPERT.

Anodising

There is a natural oxide film which forms on the surface of aluminium when it is exposed to the atmosphere. This film protects the metal giving it resistance to corrosion. The process of anodising increases the thickness of the oxide film and so increases the protection of the base metal. The film is porous and so can be dyed using either the recommended dyes or Dylon fabric dyes. The results will differ depending on the dye used. The purer the aluminium, the better the results tend to be. As a general rule, extruded aluminium is purer and so better results will be achieved with this rather than sheet material.

The process of anodising is carried out in a glass tank containing a solution of around 10% sulphuric acid, 90% water. Tap water can be used though distilled water is recommended. An approved power supply of between 12-22 volts is needed. The bath is set up with the article being anodised forming the anode and the lead plate the cathode. Once the circuit has been connected, the process takes between 20-30 minutes. If a deep colour is required, the film should be allowed to increase in thickness for about 40 minutes.

The aluminium should be suspended in the tank using aluminium wire as the acid will react with other metals. Wax can be used as an effective stopping out agent for areas where no oxide coating is required. Hydrogen gas is emitted during this operation and so work should be carried out in a well ventilated room. It is advisable to put some sort of cover over the tank as the solution may spray out slightly.

The stages of the operation are as follows:

1. degrease the aluminium
2. rinse in cold water
3. anodise
4. rinse in cold water
5. dye in warm (60°C) dye. The colour is altered by changing the concentration of the dye solution, not by increasing the immersion time. The metal should be boiled in the dye solution for about 5 minutes to seal the colour.

Etching

Etching is a metalworking technique where areas of metal are exposed to an acid and are eaten away. Protected areas remain untouched and so surface decoration can be produced.

The corrosive action of the acid is called the 'bite' and the acid-proof material used for stopping out various areas, the 'resist'. Nail polish, wax and stopping out varnish are examples of suitable resists. Once applied, the resist should be left to dry out thoroughly before being submerged in the acid bath. Any chips or gaps in the resist will also be eaten away so it is important to check that the cover is a good one.

As the metal is etched, tiny bubbles stick to the surface and prevent the acid from making good contact. These bubbles need to be dispersed by stroking the workpiece with a feather or by using an agitator. The work should be removed from time to time to check progress. Once sufficient depth has been etched, the stopping out medium can be dissolved using turps or thinners.

For etching copper or brass a solution of 1 part ferric chloride to 1 part water can be used. When etching aluminium the solution is weaker, usually 1 part ferric chloride to 3 parts water — which etches quicker if the solution is heated. When making up a solution, acid should always be added to water to prevent a dangerous reaction.

Electroplating and electroforming

Electroplating is a method of coating a conductive surface with a thin layer of metal. Electroforming is similar but the time involved is greater, the idea being to build up a thicker layer of metal. This is done by plating onto a model or mandrel which is made from either a conductive material or a non-conductive material which has been treated to make it conductive.

When a direct current is passed through an appropriate electrolyte between two metal plates or partially conductive materials — one connected to the positive side and one to the negative side of a power supply — charged metal particles (ions) are released into the solution migrating from positive to negative. The cathode is made the workpiece and so through this process receives a film of metal.

Most of the information available about electroplating and electroforming is largely related to industry and is very detailed. This sort of detail is

Right: This copper decoration was grown onto a wax model.

inappropriate if the techniques are to be used in school workshops.

Copper plating is the most suitable because the necessary materials are readily available and because good results are easy to achieve. The copper plating solution (electrolyte) is made up as follows:

2½ litres water
30 grammes alum powder
550 grammes copper sulphate
65 grammes sulphuric acid

The anode is a copper sheet and the cathode is the workpiece. A variable direct current supply of between 2-12 volts is required. This could be a number of HP2 battery cells placed in series or an approved power pack of the type often found in schools. The simplest application of the plating technique and a good one to test if the operation is working satisfactorily, is to plate copper onto brass sheet, areas of which have been stopped out with varnish to make them non-conductive and therefore unable to plate. In this fashion surface decoration can be developed. The plating process should be carried out as follows:

1. clean the brass with metal polish
2. stop out the areas which are to remain brass
3. connect the workpiece into the circuit (by means of a crocodile clip or metal tongs) and suspend in the electrolyte
4. remove after a few seconds to check that plating is taking place
5. leave to plate until required thickness has grown
6. rinse in cold water and clean off varnish.

A non-conductive surface such as acrylic sheet can be made conductive by applying conductive paint. A copper layer can then be grown onto the plastic. Most materials can be treated to make them conductive and can then be used as a mould on which to grow a copper coating. This can either be left as a permanent decoration on the surface or can be peeled away from the material on which it was grown. Wax can be used to make 3 dimensional moulds if graphite powder is melted into it to make it conductive. The graphite powder should also be dusted over the surface to improve conductivity. Once a sufficient thickness of copper shell has developed, the wax can be melted out.

Electroforming, where an article may have to stay immersed in a tank for up to 6 hours, is not a process which can be used throughout a lower school group but may provide interesting ideas for work with smaller upper school groups and GCSE candidates. Lower school work may be more limited to simpler plating techniques but even within these confines interesting jewellery and decorative designs can be developed.

Metal colouring

Metals have been chemically coloured throughout history and a recent revival of interest has been partly due to the Hughes and Rowe 1984 exhibition and the subsequent Crafts Council publication. The book is full of recipes and techniques many of which are suitable for use with copper and brass. There are many colour plates which show the range of exciting results which can be achieved. Recipes for interesting mottled effects, green, black and many other colours can be found which use harmless chemicals and so would be ideal for CDT projects. The colouring is carried out by using a variety of methods some of which involve leaving the workpiece in sawdust which has been dampened with chemical solution for a few days, other results can be achieved more immediately by applying the solution to a heated metal surface.

Any surface colouring will rub off in time if the piece is to be handled regularly, therefore any colouring in recessed areas is going to be more permanent. For this reason, the colouring of metals compliments the effects achieved through electroforming and etching.

The four processes outlined above can be used together in a number of interesting ways. Colouring aluminium by anodising can be made more varied if the surfaces are textured first by etching and electroformed copper can be coloured using a chemical recipe. Because the results are rarely predictable, the introduction of electrochemical metalworking into CDT will help children to work in an exploratory fashion. Often the unintended 'mistakes' will be as interesting as the original design idea.

For further information:

The British Anodising Association, Broadway House, Calthorpe Road, Five Ways, Birmingham B15 1TN. Tel: 021 455 0311

The Colouring, Bronzing and Patination of Metals, *Hughes and Rowe,* The Crafts Council, 1984.

Electroplating and Electroforming on a Small Scale, send an SAE (A4) and £2 postal order or cheque made payable to N. Johns to Waltheof School, Beaumont Close, Sheffield, S2.