**Electroforming - basic principles**

What is electroforming?

Described quite simply it is a method of manufacturing articles by electrodeposition rather than by mechanical techniques.

It is a technology that is completely unrecognised by many people including trained scientists and engineers. The reason for this is that almost all electroformed products are intermediate devices used in the manufacture of other articles. Many of the final products in which the electroforming process an essential part of the manufacturing process are, however, extremely familiar to members of the general public.

The principals of electroforming are discussed below.

The basic principles of both the electroforming and electroplating are, to all intents and purposes, identical. Two electrodes, an anode and a cathode, are immersed in a suitable electrolyte containing a dissolved salt of a metal (for example nickel sulphate) in an appropriate container. A direct current is applied between these electrodes causing the electrode connected to the positive pole of the current source, the anode, to dissolve. This produces positively charged metallic ions, for example Ni$^{2+}$, in solution which migrate towards the negatively charged electrode, the cathode. At the cathode surface the positively charged metallic ion is reduced to the elemental metallic state by electrons supplied from the direct current source. This causes the cathode to become coated with whatever metal is being deposited by the process.

The basic principles of the electroforming process are demonstrated in the schematic diagram below, using nickel metal as an example.
Nickel metal is electrodeposited onto the surface the cathode, known in the industry as a mandrel. This is a suitably shaped former designed to ensure that the electroformed product conforms precisely to the shape, dimensions and surface detail that is required.

There are a number of critical differences between nickel electroforming and nickel electroplating. The first is that in electroforming the surface of the mandrel must be prepared using a process, or processes, that ensures that electrodeposited does NOT adhere to the cathode surface.

It is for this reason that stainless steel is cited as the mandrel material in the example above. A passive oxide naturally forms on the surface of stainless steel which allows the passage of current to ensure that metal deposition can take place. However this oxide layer also ensures that there is no adhesion between the cathode surface and the metal being deposited.

In electroplating processes, however, where the objective is to coat the surface of one metal, for example, mild steel with another, more corrosion resistant, one then preparation processes must be applied to the surface of the substrate material to ensure that the deposit adheres firmly to it.

The other major difference relates to the deposit thickness. With electroforming the thickness of metal deposited is generally much greater than that for electroplating since once the electroform has been removed from the mandrel it becomes a free standing object and needs to be thick and rigid enough to be used in that form.
Essential plant components, as illustrated above, are as follows:

- A tank to contain the process solution.
- The process solution.
- Two electrodes - an anode and a cathode.
- A controlled source of direct current between the electrodes.
- Heaters and thermostats to control solution temperature.
- Solution pumping to provide supply agitation to the solution and also to filter the solution continuously.

(Note: the tank may also contain a secondary source of solution agitation, such as pumped air as shown above. Unfortunately air agitation increases the evolution of solution spray from the process tank thus reducing the cleanliness of the process equipment and surrounding area. Therefore, it is now considered best available technology to boost the effect of the solution flow using the filtration system with devices called ‘eductors’ attached. These devices increase the effectiveness of the agitation to the extent that additional processes are unnecessary.)

The plant shown below is a piece of all-purpose equipment of the type that could be used for multiplicity of electroforming operations.

However, for many specialised applications - such as some of the examples cited in the electroformed products sections - purpose designed and dedicated plant is required in which only one type of electroform can be manufactured.