Electromagnetic Forming (magnetic pulse forming)

8.1 Process description:

The EMF process uses a capacitor bank, a forming coil , a field shaper , and an electrically conductive workpiece to create intense magnetic fields that are used to do the useful work. This very intense magnetic field, produced by the discharge of a bank of capacitors into a forming coil, lasts only a few microseconds. The resulting eddy currents that are induced in a conductive workpiece that is placed close to the coil then interact with the magnetic field to cause mutual repulsion between the workpiece and the forming coil. The force of this repulsion is sufficient to stress the work metal beyond its yield strength, resulting in a permanent deformation.

8.2 speed of forming:

The conductivity of the workpiece and the eddy currents which interact with the magnetic field of the coil result in a net pressure on the surface of the workpiece. As the workpiece surface moves inward under the influence of this pressure, it absorbs energy from the magnetic field. To apply most of this available energy to forming, and to reduce energy loss due to permeation of the workpiece material (which wastes energy by resistance heating), the forming pulse is kept short. In most forming applications, pulses have duration of between 10 and 100 second.

8.3 formation methods:

Electromagnetic formation can usually be applied to three forming methods: compression, expansion, and counter forming. As shown in figure (8-1 a), a tubular workpiece is compressed by an external coil, usually against a grooved contoured insert, plug, tube or fitting inside the workpiece. A tubular workpiece is expanded by an internal coil as shown in figure (8-1 b), usually against a collar or other component surrounding the workpiece .flat stock is almost always contour-formed against a die as seen in figure (8-1 c).

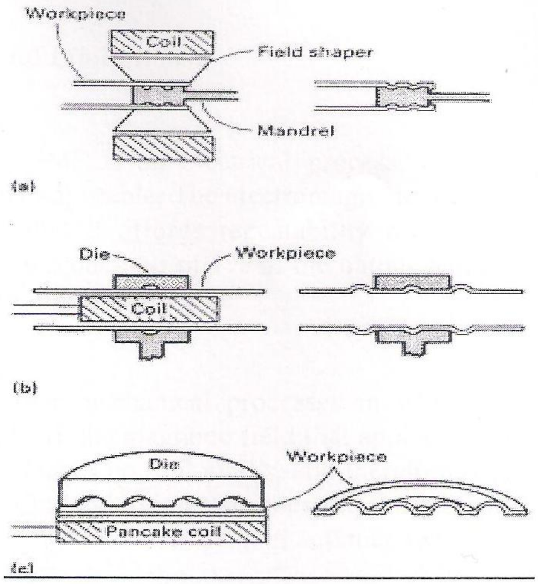

Figure (8-1) Three basic methods of EMF. (a) Compression. (b) Expansion. (c) Contour forming.

This process is primarily applied in the forming of good conducting materials such as: copper, aluminum, silver and low carbon steel. It can also be used to form a poor conductor like stainless steel. T he efficiency of the magnetic pulse forming depends upon the resistivity of metal being formed. For good results the resistivity of the material should be less than 15 micro-ohm-centimeters.

8.4advantages and limitations:

1. It gives a high rate of production
2. Non contact: unlike other mechanical processes in which a tool contacts a workpiece, in EMF the magnetic field that applies the pressure requires no lubrication, leaves no tool marks and therefore requires no cleanup after forming. One exception that does require lubrication is when the workpiece is driven against a mandrel and then removed.
3. Springback: the material is loaded into its plastic region , resulting in permanent deformation, so that the springback often associated with mechanical processes is virtually eliminated , because there is no mechanical contact.
4. Strength: joints made by this process are typically stronger than the parent material.
5. The EMF process allows increased ductility for certain aluminum alloys because of the lack of mechanical stress and friction normally encountered with mechanical processes.

6. Tooling: the tooling for process is relatively inexpensive .the machine and the work coils can be viewed as general –purpose tooling.

General limitations

The speed of joining or formation also represents one of the limitations of the process. Because forming take place in such a short period, the material does not lend itself to deep drawing of materials. The process is also limited to those materials that are electrically conductive .materials with an electrical resistivity of 0.15 micro –ohm- meter or less are ideal candidates for the process. Included in this group are such materials as copper, aluminum, brass, and mild steels.

Pressure limit:

The maximum pressure that can be applied by standard compression coils is approximately 340 Mpa, thus the process is restricted to relatively thin –wall tube or sheet products.

8.5 Applications:

Electromagnetic forming is chiefly used to expand, compress, or form tubular shapes. It is occasionally used to form flat sheet, and it is often used to combine several forming and assembly operations into a single step.

8.6 die materials:

The die used in electromagnetic process should be made of low electrical conductivity to minimize the magnetic cushion effect. Dies are generally made of the following materials: **Steel or epoxy resin**. Steel dies have longer life .but the disadvantage of steel dies is that magnetic cushion effect is not entirely prevented. Air is often evacuated from the die to ensure good reproduction of detail, and prevent distortion caused by entrapped air, which is particularly likely to occur with thin gauge material.