

### Electro hydraulic forming

**Electro hydraulic forming** is a type of metal forming in which an electric arc charge is used to convert electrical energy to mechanical energy and change the shape of the work piece. A capacitor bank delivers a pulse of high current across two electrodes, which are positioned a short distance apart while submerged in a fluid (water or oil). The electric arc discharge rapidly vaporizes the surrounding fluid creating a shock wave. The work piece, which is kept in contact with the fluid, is deformed into an evacuated die.

The potential forming capabilities of submerged arc discharge processes were recognized as early as the mid 1940s. During the 1950s and early 1960s, the basic process was developed into production systems. This work principally was by and for the aerospace industries. By 1970, forming machines based on submerged arc discharge, were available from machine tool builders. A few of the larger aerospace fabricators built machines of their own design to meet specific part fabrication requirements.

Very large capacitor banks are needed to produce the same amount of energy as a modest mass of high explosives. This makes electro hydraulic forming very capital intensive for large parts. On the other hand, the electro hydraulic method was seen as better suited to automation because of the fine control of multiple, sequential energy discharges and the relative compactness of the electrode-media containment system. The process can be achieved by two methods as follow:

- 1- Capacitor discharge through a gap processes.
- 2- Capacitor discharge through a wire processes.

In the first method the voltage of 50000 volt used through a gap of 1 inch in the air between two electrodes , when this gap is submerged in the fluid , its length for cause the discharge will be depend on the electrical conductive capability of the fluid , the used electrodes shape , and the used discharge value. In general the discharge used in this method between 10000 to 30000 volt , this method is called also as a Spark discharge method.

The second method give more possibility for controlling than the first , because the way for the electrical discharge can be fixed previously , and also the transfer of the electrical energy to mechanical will be more efficiency and the used voltage is less than the first, also the used gap to produce the discharge will be more. The disadvantages of this method are necessity of changing the used wire after each of forming process , which needs to extra time and cost increasing specially when the forming parts need more than one stage for forming, but this can be decreasing by used more efficiency wires for energy changeable and decreasing the used voltage.

The electrical energy available in chargeable capacitor can be expressed according to following equation:

$$U = \frac{1}{2} cv$$

Where  $U$  = Electrical energy (watt-sec) or (Joule)

$c$  = Electrical capacitor (farad)

$v$  = Voltage (volt)

From the equation we find that  $U$  proportional with  $V$ , this means that we must increase the value of voltage when we need to increase the energy value for forming. Fig. (1) shows the principle elements for this method, the voltage has a value of 115 to 220 volt and the energy has a value of 40000 to 60000 Joules

Fig.(1) Schematic shows the electro hydraulic forming process

The force needed for forming a certain shape depend on several factors like the work piece size, type of metal, work piece thickness, and the value of fixing force of the work piece. In general the mathematical relationship for estimating force can be shown as follows:

$$S = pr/t \quad \text{then} \quad P = st/r$$

Where  $S$  = yield strength of the material

$r$  = initial radius of part

$t$  = thickness of material

$p$  = pressure

The equation gives lowest pressure demanded to do the permanent forming pipe shape of diameter for certain metal and certain thickness. Normally the demand pressure for permanent forming in metal is more than this value.

It is possible to use the method for several applications like:

Bulging, Forming, Drawing, Blanking, and Piercing.

These processes can be done with conventional methods , but because its limitation and the electro hydraulic method is cheaper in cost ,so this method always used than the others.