Unconventional Forming

Unconventional Forming Methods

- The metals are formed and released by large amount of energy in a very short time interval.
- Used to form large parts, difficult to form metals with less expensive equipment and tooling
- Classification :
  - High Energy Rate Forming methods (HERF)
  - High Velocity Forming methods (HVF)

Comparison of HERF and HVF methods

HERF	HVF
The released energy is used directly to form the metals	The released energy is converted into mechanical energy which imparts high velocities to ram/die
Ex: Explosive forming, electro-hydraulic forming, electromagnetic forming etc.	Ex: Penumatic mechanical forming, petro-forge hammer dynapack forming etc.
The spring back is minimal *.	The spring back is more compared to HERF
There is no moving parts in it.	Ram/die moves with hydraulic press.
Deformation of metals in the form of flat sheet or tube	Deformation of metals in the form of solid billet. (Billet forming method)

* The high energy pressure waves produce high compressive stresses in the metal when it is forced against the die surface. Die is also undergoes elastic deformation which results in over forming of the workpiece. Due to this spring back is minimal in HERF.

High Energy Rate Forming (HERF)

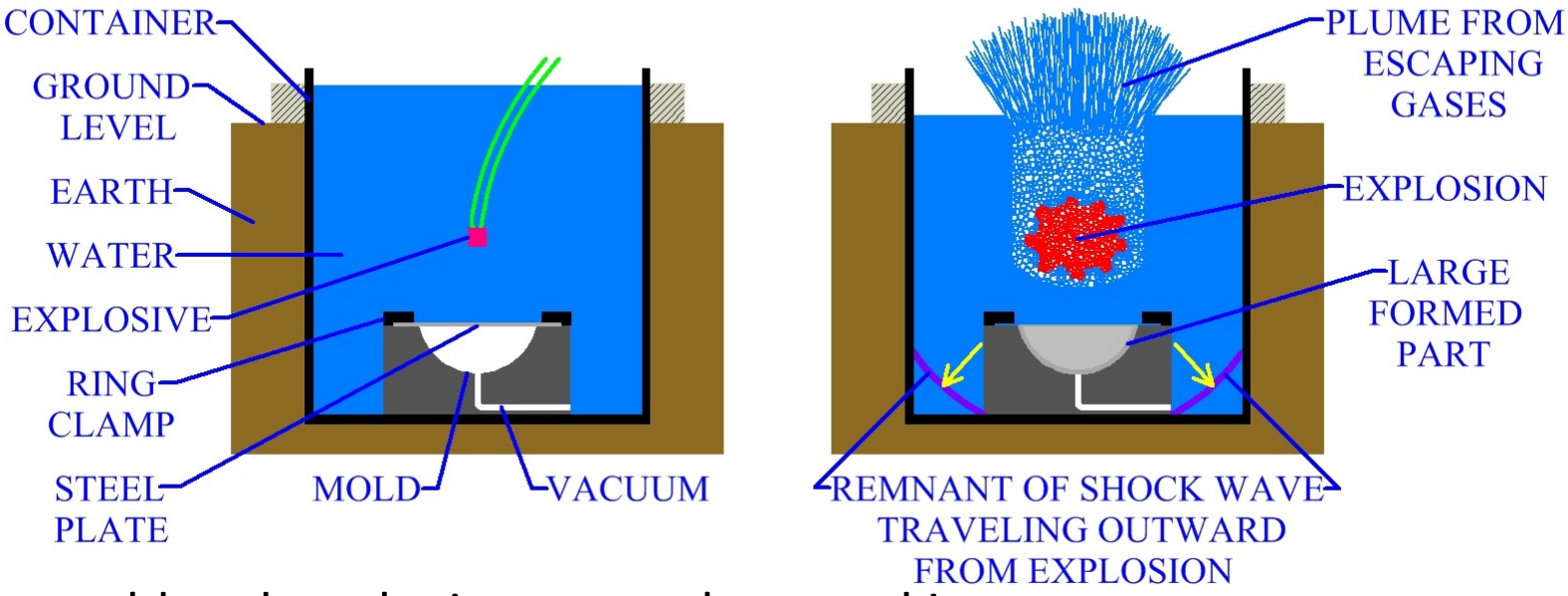
- HERF is the forming of sheet metal by high energy surge, delivered over a very short time.
- Forming occurs very shortly, desirable materials for HERF will be ductile at high deformation speeds.
- Example:
  - Explosive forming
  - Electrohydraulic forming
  - Electromagnetic forming

Explosive Forming

- The power from an explosive charge used to manufacture big parts.
- It is commonly used for the production of large parts is called a standoff system.
- Suitable for low quantity production of large, thick and unique parts.
- Capital cost is low
- For low volume production
- Production of prototype parts

- Classification:
  - Unconfined explosive forming
  - Confined explosive forming

UNCONFINED EXPLOSIVE FORMING

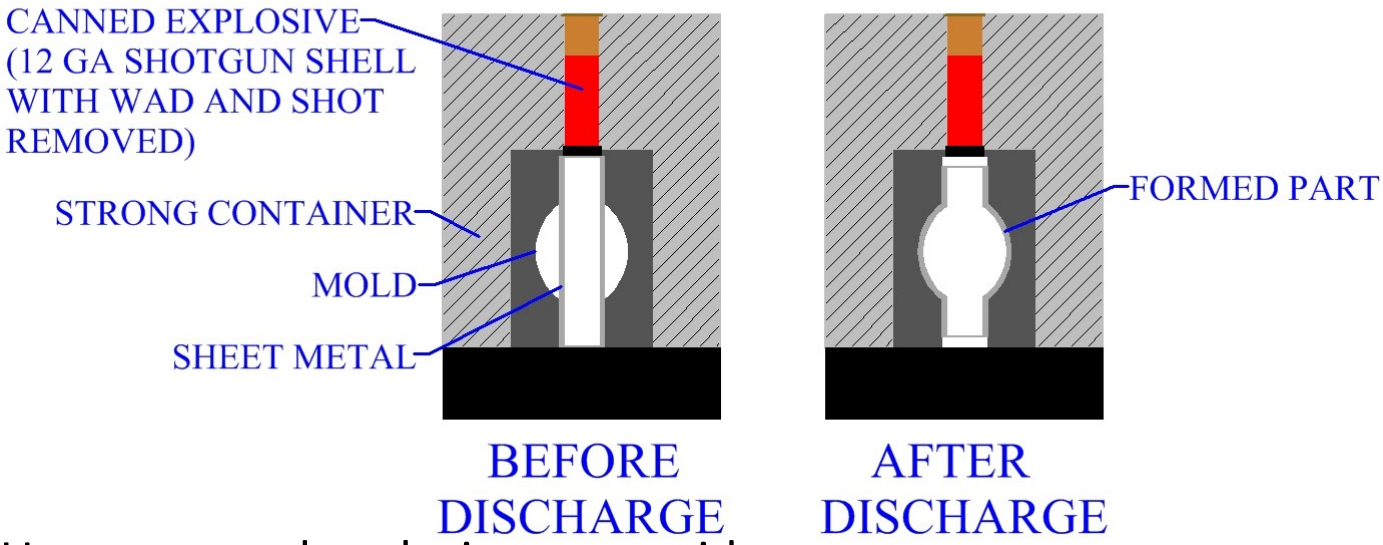


- The mold and work piece are submerged in water
- The sheet metal is secured over the mold by a ring clamp.
- Vacuum is created in the die cavity.
- The explosive itself is also deeply submersed in water.
- An explosive is placed above the work piece with a certain distance from the work. This distance is called the standoff distance.
- Standoff distance depends on the size of the work, for larger parts it is usually about half the diameter of the blank.
- Upon detonation, the shock wave travels through the water and delivers great energy to the work, forming it to the die cavity near instantaneously.

- Molds are made out of inexpensive or easy shape materials. It can be permanent. Ex: Al, wood, concrete, plastic, iron and steel
  - Concrete – Medium and pressure & large parts
  - Cast iron: high pressure & many parts
  - Concrete and epoxy resin – low pressure & large parts
  - Kirksite – low pressure and few parts.
  - Kirksite and fibreglass: low pressure and few parts
- The amount of explosive depends upon the type of system used and the amount of pressure needed to form the part.
- The shock wave generated by explosive travel along an expanding spherical front.
- All the energy from the shock wave is not absorbed by the work piece.
- Explosive materials: Dynamite, amatol, TNT (Tri-nitrotoluene), RDX, Research and Development explosive (Cyclotrimethyl-enetrinitramine), Tetryl and PETN (Pentaerythriol Tetranitrate) and their mixture.
- Deformation velocities range from 9 to 230m/s.

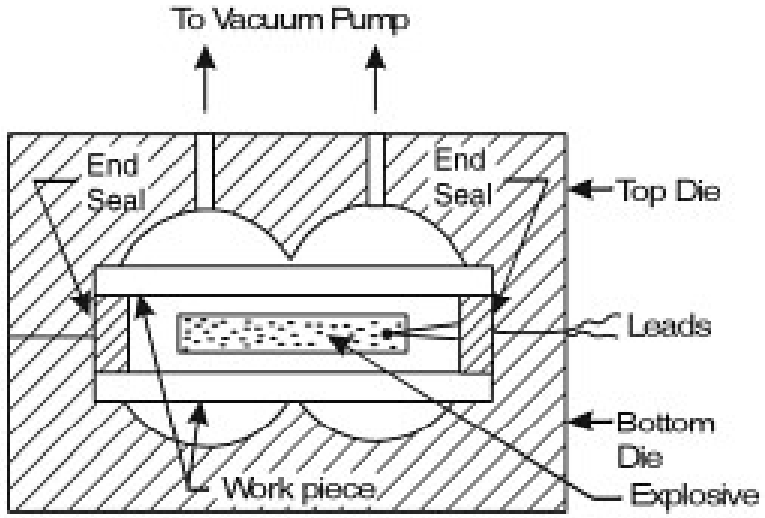
- Energy transmitting medium: water
  - With water, noise level of explosion is reduced
  - The damage of the workpiece from particle of explosion and donator is greated reduced.
- In explosive forming, spring back is minimised. Due to
  - The use of sheet explosive close to the workpiece
  - High claming forces on the hold down areas
  - The absence of lubricant
- Application: Aircraft, ship building, radar dishes, rocket motor cases

CONFINED EXPLOSIVE FORMING

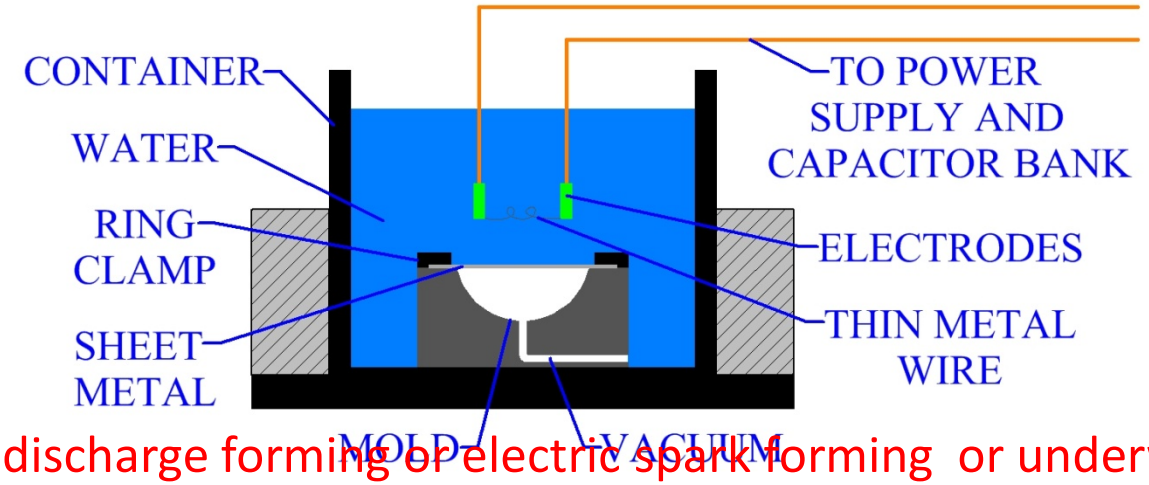


- Uses a canned explosive or cartridge.
- Used for relatively smaller parts than the standoff system.
- All of the energy is directed into a closed container, the walls of which contain the die cavity.
- The energy from the canned explosive forces the sheet metal into the walls of the mold, forming the part.
- Disadvantage: Safety is always is problem in explosive forming where die failure is a significant concern

- Energy transmitting medium: Air
- Vacuum should be created in between the die and the workpiece



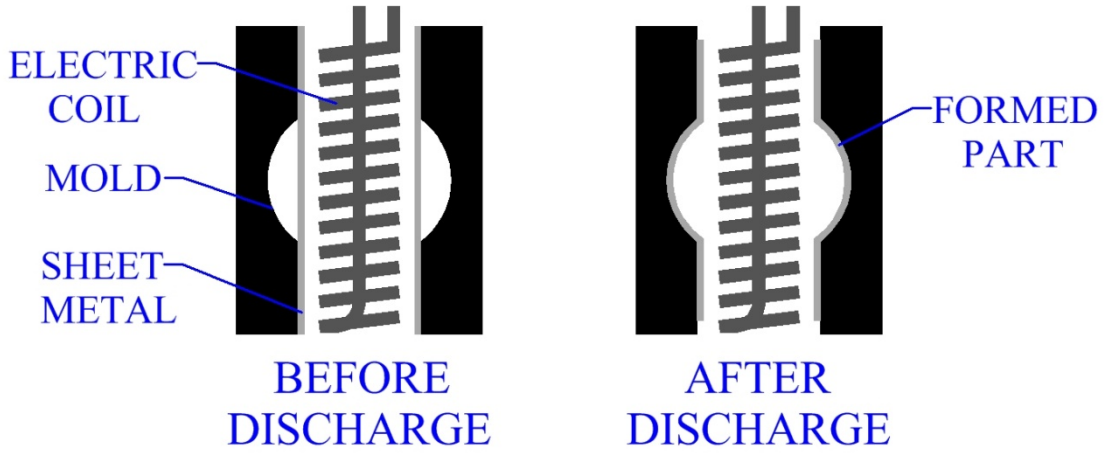
ELECTROHYDRAULIC FORMING



- Also called electric discharge forming or electric spark forming or underwater spark forming
- It is a unique high energy forming process for sheet metal.
- This manufacturing process uses the energy from the combustion of a thin metal wire.
- Two electrodes, with a wire connecting them, are submersed in liquid. The work is set up similar to explosive forming and this process is applicable to relatively smaller parts.
- A sheet metal blank is secured on top of the mold with a ring clamp and a vacuum is created in the die cavity under the blank. Electrical energy is stored in a capacitor bank. The electricity is discharged through the electrodes and the wire, instantly vaporizing the wire, creating a shock wave that travels through the water. This shock wave forms the sheet metal to the mold cavity.

- A potential difference of 50kV can jump a gap of about 25mm.
- Electrohydraulic forming produces a shock wave of relatively low magnitude and is best suited for thinner work.
- The wire needs to be replaced after every operation.
- Electrohydraulic forming may be considered to have a low production rate.
- Die material: Kirksite, epoxy, plaster of paris and steel
- Advantage:
  - The large amounts of energy can be directed to isolated areas of the workpiece.
  - Production rate is higher as compared to explosive forming
  - Low cost
  - Shapes impractical by conventional methods can be made by this method. Ex.: tubular and dished shapes
- Limitation: The critical impact velocity <30m/s are not suitable for this method.

ELECTROMAGNETIC FORMING



- Electromagnetic forming is a popular high energy rate forming process that uses a magnetic surge to form a sheet metal part.
- In the electromagnetic process, also called magnetic pulse forming.
- An electric coil is placed near a metal work piece. A capacitor bank is charged up and a large electrical surge is sent through the coil. The current creates a magnetic field. When a conductive material disrupts a magnetic field it produces a current in that material, this is called an eddy current. Due to the close proximity of the conductive sheet metal to the coil, the coil's magnetic field is disrupted and eddy currents are generated in the work piece. These currents in the sheet metal produce their own magnetic field that opposes the original magnetic field of the coil. The opposing forces push these fields apart and form the work.
- The coil may be placed inside or over the work, depending upon the desired effect.
- Many electromagnetic forming operations are used to bulge tubes, or form tubes over other parts such as rods and cables.
- Electromagnetic forming is used for relatively thinner sheet metal parts.