RTU SYLLABUS- High Velocity Forming Methods: Definition; Hydraulic forming,Explosive forming, Electro-hydraulic forming, Magnetic pulse forming.

UT - V

High Velocity Forming

In conventional metal forming operations, we usually apply force to the metal to be worked upon using some form of a tool that could be a simple hammer blow or a power press impulse such as that used in drop forging. But today we will talk about an innovative method which is used in metal forming and can be said to be equivalent to hitting the work-piece onto the hammer rather than the other way round.

As the name itself hints, HVF or high velocity forming refers to a set of techniques which are used for metal forming. These techniques could include methods such as explosive forming, electromagnetic forming and so forth. All these techniques involve imparting a high kinetic energy to the work piece by accelerating it to a highly velocity, before it is made to hit the appropriate die or made to undergo the process of plastic the formation.

One main advantage of using HVF techniques is that very complex shaped parts can be formed in a single operation, rather than carrying out a series of operations to achieve the same results via conventional forming techniques.

A wide variety of operations which are conventionally carried out using traditional methods can be done using highly velocity techniques, and these processes include those of extrusion, die-forging, punching, joining and so forth. The list of materials which can be formed using high velocity methods contains a wide variety of materials including magnesium, aluminium, zirconium, stainless steel, alloys steel etc.

Advantages of HVF

Highly velocity forming techniques have several advantages over conventional forming techniques, apart from reducing the number of processes required in manufacturing.

The strain distribution is much more uniform in a single operation of HVF as compared to conventional forming techniques. This results in making it easy to produce complex shapes without inducing unnecessary strains in the material.

Since the basic principle of a highly velocity formation technique is quite opposite to that of a conventional forming technique, the tools and other equipment used in the process has quite lightweight compact relatively speaking.

Hydroforming

Hydroforming is a metal fabricating and forming process which allows the shaping of metals such as steel, stainless steel, copper, aluminum, and brass. This process is a cost-effective and specialized type of die molding that utilizes highly pressurized fluid to form metal.One of the largest applications of hydroforming is the automotive industry, which makes use of the complex shapes made possible by hydroforming to produce stronger, lighter, and more rigid unibody structures for vehicles. This technique is particularly popular with the high-end sports car industry and is also frequently employed in the shaping of aluminium tubes for bicycle frames.

Hydroforming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die. To hydro form aluminium into a vehicle's frame rail, a hollow tube of aluminium is placed inside a negative mold that has the shape of the desired result. High pressure hydraulic pumps then inject fluid at very high pressure inside the aluminium tube which causes it to expand until it matches the mold. The hydro formed aluminium is then removed from the mold. Hydroforming allows complex shapes with concavities to be formed, which would be difficult or impossible with standard solid die stamping. Hydroformed parts can often be made with a higher stiffness-to-weight ratio and at a lower per unit cost than traditional stamped or stamped and welded parts. Virtually all metals capable of cold forming can be hydroformed, including aluminium, brass, carbon and stainless steel, copper, and high strength alloys.

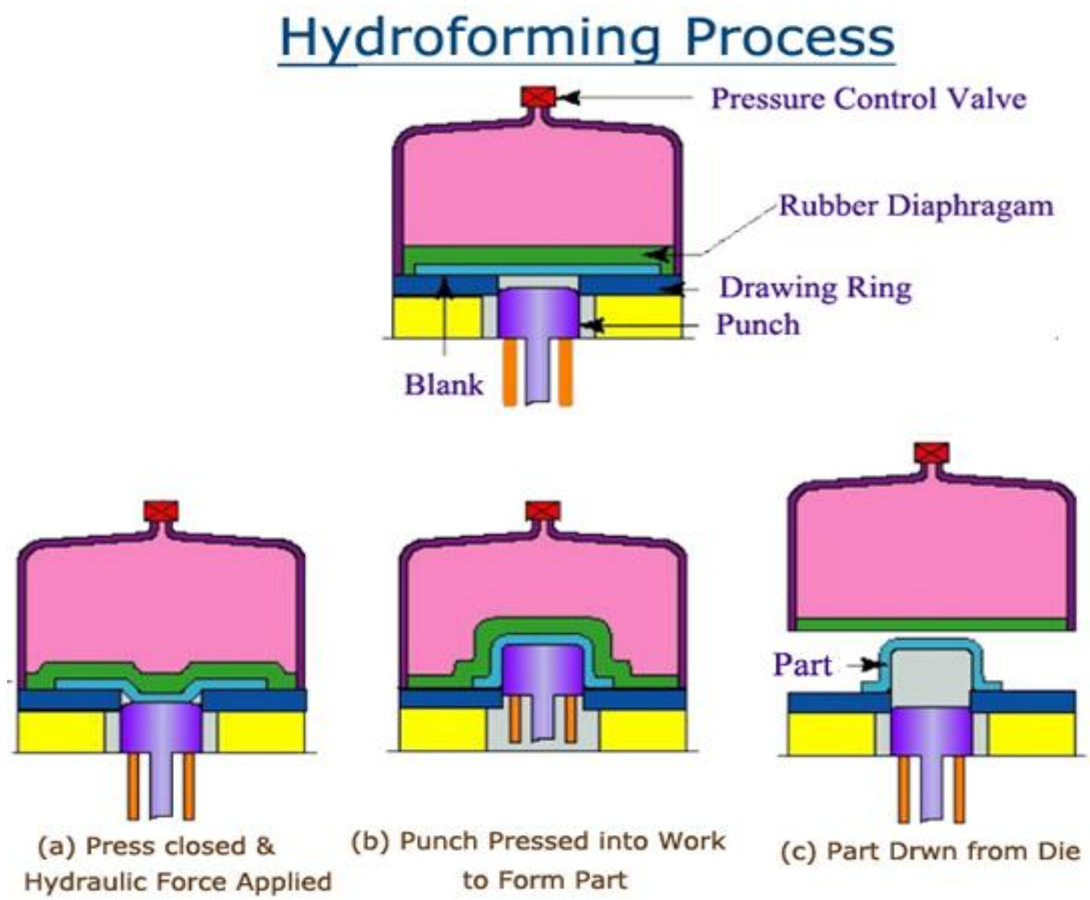

Fig.Hydroforming Process

Explosive forming

A punch in conventional forming is replaced by an explosive charge. Explosives used can be:

• High energy chemicals like TNT, RDX, and Dynamite.

• Gaseous mixtures

• Propellants.

Types of explosive forming:

1) Unconfined type or Stand off technique

2) Confined type or Contact technique

Principle:

The work is firmly supported on the die and the die cavity is evacuated. A definite quantity of explosive is placed suitably in water medium at a definite stand off distance from thework. On detonation of the explosive charge, a pressure pulse (or a shock wave) of very high intensity is produced.

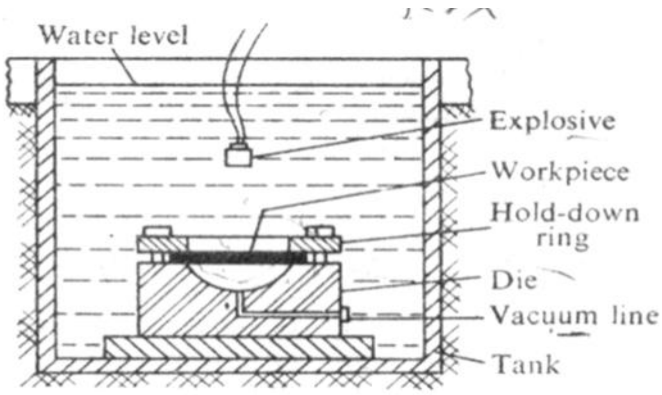

Fig.Unconfined Type Explosive Forming

A gas bubble is also produced which expands spherically and then collapses. When the pressure pulse impinges against the work (plate or sheet0, the metal is deformed into the die with a high velocity of around 120 m/s (430km/h).

The vacuum is necessary in the die to prevent adiabatic heating of the work which may lead to oxidation or melting.

Role of water

i. Acts as energy transfer medium

ii. Ensures uniform transmission of energy

iii. Muffles the sound of explosion

iv. Cushioning/ smooth application of energy on the work without direct contact.

Process Variables

i. Type and amount of explosive: wide range of explosive sis available.

ii.Stand off distance – SOD- (Distance between work piece and explosive): Optimum SOD must be maintained.

iii. The medium used to transmit energy: water is most widely used.

iv. Work size:

v. Work material properties

vi. Vacuum in the die

Advantages

i. Shock wave is efficiently transmitted through water and energy is transmitted effectively on the work

ii. Less noise

iii. Less probability of damage to work.

iv. Large and thick parts can be easily formed

v. Economical, when compared to a hydraulic press

Limitations

i. Optimum SOD is essential for proper forming operation.

ii. Vacuum is essential and hence it adds to the cost.

iii. Dies must be larger and thicker to withstand shocks.

iv. Not suitable for small and thin works.

v. Explosives must be carefully handled according to the regulations of the government.

Applications

i. Ship building,

ii. Radar dish,

iii. Elliptical domes in space applications

2. Confined System (or Contact Technique)

Principle

The pressure pulse or shock wave produced is in direct contact with the work piece (usually tubular) and hence the energy is directly applied on the work without any water medium.

The tube collapses into the die cavity and is formed. It is used for bulging and flaring operations.

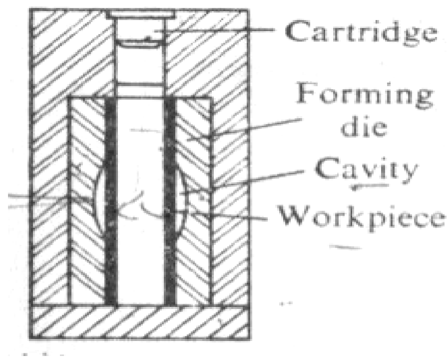

Fig. Confined (Contact) type Explosive forming

Advantages

i. Entire shock wave front is utilized as there is no loss in water.

ii. More efficient as compared to unconfined type.

Disadvantages

i. More hazard of die failure

ii. Vacuum is required in the die

iii. Air present in the work piece (tube) is compressed leading to heating.

iv. Not suitable for large and thick plates.

Applications

Bulging and flaring of tubes

Electro-hydraulic forming

Principle

A sudden electrical discharge in the form of sparks is produced between electrodes and this discharge produces a shock wave in the water medium. This shock wave deforms the work plate and collapses it into the die.

The characteristics of this process are similar to those of explosive forming. The major difference, however, is that a chemical explosive is replaced by a capacitor bank, which stores the electrical energy.

The capacitor is charged through a charging circuit. When the switch is closed, a spark is produced between electrodes and a shock wave or pressure pulse is created. The energy released is much lesser than that released in explosive forming.

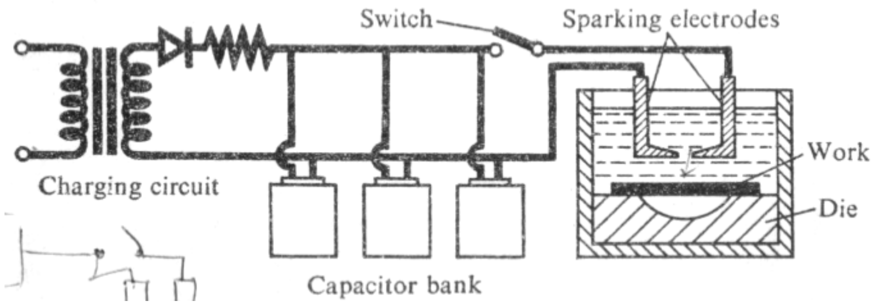

Fig. Electro Hydraulic Forming

Process Characteristics:

i.Stand off distance: It must be optimum.

ii. Capacitor used: The energy of the pressure pulse depends on the size of capacitor.

iii. Transfer medium: Usually water is used.

iv. Vacuum: the die cavity must be evacuated to prevent adiabatic heating of the work due to a sudden compression of air.

v. Material properties with regard to the application of high rates of strain.

Advantages:

i. Better control of the pressure pulse as source of energy is electrical- which can be easily controlled.

ii. Safer in handling than the explosive materials.

iii. More suitable if the work size is small to medium.

iv. Thin plates can be formed with smaller amounts of energy.

v. The process does not depend on the electrical properties of the work material.

Limitations:

i. Suitable only for smaller works

ii. Need for vacuum makes the equipment more complicated.

Applications:

They include smaller radar dish, cone and other shapes in thinner and small works.

Electromagneticforming

The electrical energy stored in a capacitor bank is used to produce opposing magnetic fields around a tubular work piece, surrounded by current carrying coils. The coil is firmly held and hence the work piece collapses into the die cavity due to magnetic repelling force, thus assuming dieshape

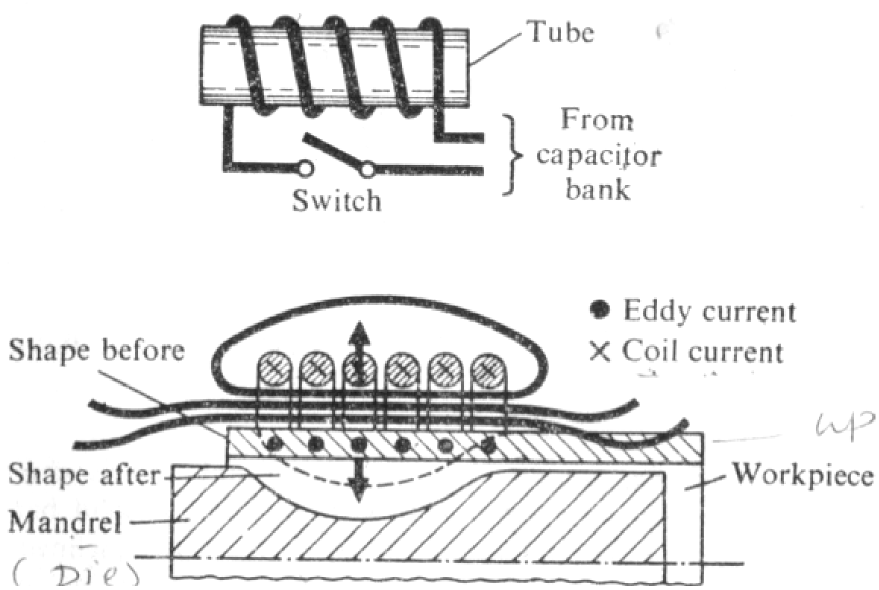

Fig. Electro Magnetic Forming

Process details/ Steps

i. The electrical energy is stored in the capacitorbank
ii. The tubular work piece is mounted on a mandrel having the die cavity to produce shape on thetube.

iii. A primary coil is placed around the tube and mandrelassembly.

iv. When the switch is closed, the energy is discharged through thecoil

v. The coil produces a varying magnetic field aroundit.

vi. In the tube a secondary current is induced, which creates its own magnetic field in the opposite direction.

vii. The directions of these two magnetic fields oppose one another and hence the rigidly held coil repels the work into the diecavity.

viii. The work tube collapses into the die, assuming itsshape.

Process parameters

i. Work piecesize

ii. Electrical conductivity of the workmaterial.

iii. Size of the capacitorbank

iv. The strength of the current, which decides the strength of the magnetic field and the forceapplied.

v. Insulation on thecoil.

vi. Rigidity of thecoil.

Advantages

i. Suitable for smalltubes

ii. Operations like collapsing, bending and crimping can be easilydone.

iii. Electrical energy applied can be precisely controlled and hence the process is accurately controlled.

iv. The process is safer compared to explosiveforming.

v. Wide range ofapplications.

Limitations

i. Applicable only for electrically conducting materials.

ii. Not suitable for large workpieces.

iii. Rigid clamping of primary coil iscritical.

iv. Shorter life of the coil due to large forces acting onit.

Applications

i. Crimping of coils, tubes, wires

ii. Bending of tubes into complexshapes

iii. Bulging of thin tubes.