Latest Forming Techniques For BIW

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Abstract

The purpose of this paper is to know more about the forming process, the material which can be formed, stresses coming on sheet metal during forming and defects of the sheet metal in forming operation.

Sheet metal is produced by reducing the thickness of a long work piece by compressive forces applied through a set of rolls. Sheet metals are generally sheets less than 6 mm and sheets above 6mm are known as plates.

There are many different metals that can be made into sheet metal, such as aluminium, brass, copper, steel, tin, nickel and titanium. For each material type or class of material there are large numbers of alloys and heat treatments which effect material properties and "formability". Which metal is chosen for a particular application depends on the requirements of the part, the cost of manufacturing it, and the availability of the metal. Requirements of parts vary as per the applications. The primary consideration for one part may be strength; for another it may be surface appearance.

These sheets, after undergoing cutting, bending, stamping and welding operations it takes on useful engineering forms. Sheet metal has become a significant material for automotive bodies and frames.

In forming operation, Stresses are below the ultimate strength. Material is not removed, only the contour of the work piece is changed to the desired product. The surface-area-to-thickness-ratio of the products made is high and material is subjected to shape changes by various dies; thickness variations are usually not desirable as they can lead to part failure during manufacturing.

In typical sheet metal forming operations primary deformation imposed is tensile. The major devices used are presses and dies. There are three basic types of operations in sheet metal forming processes: shearing, bending and drawing. The shape and dimensions of the parts obtained correspond fairly well to those of the active elements of the pressing device, for example, the punch shape is reproduced on the blank. There are differences in shape due to material spring back when the part is removed from the punch-die and to other less drastic effects.

There are many defects involved such as cracking, splitting, thinning, wrinkles and surfaces defects like scoring lines, deformations etc. To rectify the above defects we need to either modify the dies or the panels. And to modify the dies it takes huge amount of time and also involves huge amount of cost. Same is also applicable to the panels. The implications of this paper would be that it would certainly help to minimize the time and the cost involved in rectifying the panels if wrongly done and adopt correct process.

Keywords: Sheet Metal Forming, Anisotropy, Strain hardening.

1. Introduction

In typical sheet metal forming operations primary deformation imposed is tensile. The major devices used are presses and dies. There are three basic types of operations in sheet metal forming processes: shearing, bending and drawing. The shape and dimensions of the parts obtained correspond fairly well

to those of the active elements of the pressing device, for example, the punch shape is reproduced on the blank. There are differences in shape due to material spring back when the part is removed from the punch-die and to other less drastic effects.
Compared to other manufacturing processes (e.g., casting, forging and machining), forming has several technical-economic advantages:

- Parts may be formed whose complex shapes are difficult or even impossible to obtain by other techniques;
- In most instances formed parts do not require additional mechanical processing;
- The dimensional accuracy of parts ensures their exchangeability in assembly, the exception is the change in sheet thickness on transition section where thinning is likely to occur;
- Strain hardening increases the mechanical properties of formed parts;
- Formed parts can be very light because complex shapes including strengthening features such as ribs can be produced;
- Presses allow high production rates by fast operation and the use of sequential forming steps.

2. Materials Commonly used in Forming

There are many materials which can be formed. We will concentrate here on only the most commonly used ones. For each material type or class of material there are large numbers of alloys and heat treatments which effect material properties and "formability." Steel, copper, aluminium and their alloys are most frequently used materials for formed parts. Which metal is chosen for a particular application depends on the requirements of the part, the cost of manufacturing it, and the availability of the metal. Requirements of parts vary. The primary consideration for one part may be strength; for another it may be surface appearance.

2.1Steel

Steel is composed primarily of iron with carbon as the major alloying element. The greater the percentage of carbon, the stronger and stiffer the steel. High-carbon steels are generally infeasible for use as work piece materials in sheet metal forming because of their high resistance to permanent or plastic deformation. Most automotive stampings are produced from low-carbon steel, containing less than 0.15% carbon.

Cold Rolled Steel As with most metals the alloy composition, heat treatment and any mechanical processing (rolling in this case) are all important in determining material behaviour. The "drawing quality" steels are processed to produce uniform deformation up to large deformations (deformation and uniform deformation is discussed in detail below). Steels are available in 1/4 hard, 1/2 hard and full hard conditions.

Spring Steel has a high "elasticity," that is, a large amount deformation can be imposed before the material takes on a permanent set or plastic deformation is produced.

Stainless Steels contain alloying additions of nickel and chromium. Their cost is high, but because of their fine surface appearance and resistance to corrosion, they are used in forming special parts.

2.2. Copper and Copper Alloys

Copper and copper alloys are generally used for sheet forming where the advantages of their special properties justify their higher cost. The ductility of copper and its alloys reduces cracking and wrinkling problems compared to other metals. Also, copper has unique advantages in high electrical and thermal conductivities. It is used in forming radiator grids to dissipate auto engine heat, and in electrical switches, relays, etc. Copper alloys usually have excellent corrosion resistance. They are costly and have low strength.

Cartridge Brass is 70% Cu, 30% Zn and in its soft temper state is very ductile. Its name suggests the possibility of large deformation as in the drawing (in which a punch pulls or draws material into a die) of cartridges.

Phosphor Bronze with a composition of 95% Cu and 5% Sn is commonly available in a spring temper. The increased hardness and "elasticity" of this material makes it suitable for parts which must remain elastic, e.g., springs and electrical contacts. **Leaded Brass** such as 65% Cu, 33% Zn, 2% Pb "clock brass" is soft and easily worked.

2.3.Aluminum

Aluminum has achieved importance in virtually all segments of the world economy; its principal uses are in transportation, construction, electrical

applications, beverage cans, cooking utensils and mechanical equipment. A number of unique and attractive properties account for the engineering significance of aluminum: formability, light weight, corrosion resistance, and good electrical and thermal conductivity. Aluminum has a specific gravity about one third that of steel.
1100-O Aluminum is the "dead soft" temper of this alloy.
1100-H14 has higher strength due to the heat treatment but is still soft and easy to form.
2024-O Aluminum is an alloy designed to have higher strength. In its heat treated **2024-T3** form it is extensively used for aircraft components.
3003-O Aluminum is an alloy which when heat treated properly, e.g., **3003-H14** has good "workability" or is "formable" and so finds use in cooking utensils and building siding.
5000 series Aluminium's poses good corrosion resistance and can be easily welded. An alloy such as **5052-H34** which has limited cold-workabiliy finds use where the extent of deformation imposed in forming large curvature panels is small, e.g., boat hulls.
6061-O Aluminum is the not heat treated version of a widely used series of aluminium's can have excellent strength.
6061-T6 is used in many machined parts since its mechanical properties are such that it is strong and also is easily machined in the sense of good surface finish.
7075-O Aluminum is the soft state of the **7000 series** aluminium alloys which have very high strengths and find their way into many airframe structures and highly stressed parts.

The most serious drawback of aluminium from an engineering viewpoint is its relatively low modulus of elasticity, roughly one third of that of steel. Aluminum alloys have much higher strength than pure aluminium yet retain the advantages of light weight, good thermal conductivity and corrosion resistance. But their thermal conductivity is lower than pure aluminium.

3. Mechanical Properties of Metals

The most common material deformation processes used in all sheet-forming processes are stretching, shearing, and bending, material mechanical needed for describing these processes are presented.

3.1.Elasticity

Elasticity, roughly defined, is the ability of a metal to return to its original shape after being deformed. The elasticity of any metal is limited and the elastic range is followed by plastic or permanent deformation and fracture. The resilience of a material is the amount of energy absorbed in the elastic range of deformation.

3.2.Malleability

Malleability is a qualitative term describing the ability of a metal to withstand plastic deformation without fracturing. It refers particularly to deformation under compressive loading. As with elasticity, there is a definite limit to the malleability of a given metal. After a certain amount of deformation the material will fracture.

3.3.Ductility

It is also a measure of the ability of a metal to withstand plastic deformation without fracturing. Ductility, however, is the reaction of metal to tensile stresses. Thus work material ductility is important in such metalworking operation as drawing and bending.

The ductility of a given metal is measured by the amount of elongation and reduction in cross section that occur under measured loads.

3.4.Strength

In general, strength is the stress acting at a particular deformation condition of the material. The stress needed to cause permanent deformation is called yield strength. The ultimate strength of a material is the maximum stress that the material can support. Fracture strength is the stress at fracture.

The amount of force necessary to cause blank deformation will be related to the strength of the material, the amount of deformation imposed and the size of the part being produced.

3.5. Strain Hardening

Ductile metals strain hardens with deformation and a useful quantity for describing this is "flow stress" of the metal. Flow stress is the stress necessary to cause continued deformation and so can also be thought of as the strength of the metal at any instant in a deformation process. Since work material flow stress varies during forming, the force necessary to form a blank increases due to strain hardening.

3.6.Hardness

Hardness is another property of interest. It is the ability of a metal to resist penetration or abrasion. The hardness of a metal has a definite relationship to the ability of the metal to be plastically deformed, and to the amount of instantaneous load required for deformation to take place.

4. Sheet Metal Forming

Forming is the process in which the shape of the punch and die is directly reproduced in the metal with little or no metal flow. Forming, Bending or drawing actions may be combined in a die and is classified as Form die or Draw die depending on the dominant action of process. The decision to use a form die instead of a Draw die will depend largely on the complexity of the shape & geometrical criteria. The use of draw die may be indicated, if the form die would cause the metal to tear because of excessive tensile strain (stretch) or form objectionable wrinkles because of excess crowding of metal etc defects. Most problems in sheet metal forming come from a bad control of holding, restraining and spring back.

5 Metal Behaviours in Sheet Forming

5.1.Strain hardening

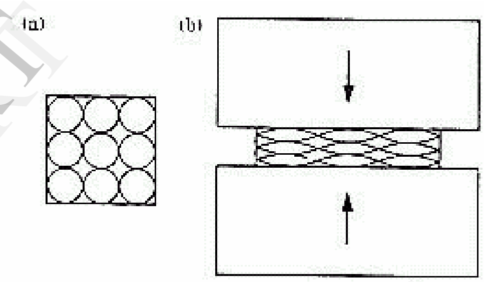
Work hardening or stain hardening refers to the fact that as a metal deforms the material undergoes changes in its atomic and crystalline structures resulting in increased resistance of the material to further deformation. Thus, additional strain increase requires more stress increment and the strain is spread throughout the sheet. Strain hardening then results in more uniform deformation. In shearing operations, the punching force depends on the material, the amount of work hardening during deformation, the thickness of the sheet metal and the punching speed.

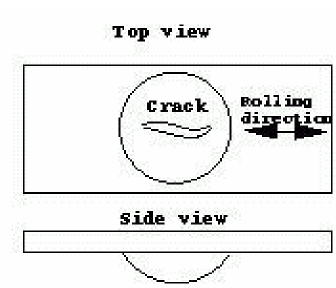
5.2.Necking

At some point in the deformation, the strain suddenly localizes and necking, or localized thinning, begins. When this occurs, little further overall deformation of the sheet can be obtained without its fracturing in the necked region.

5.3.Anisotropy

Anisotropy is differences in behavior in different directions. Wood is a common anisotropic material due to its structure. Along grain and cross grain behaviours are distinctly different. Metals are composed of many individual, randomly oriented crystals or grains. If a piece of metal with uniform equiaxed grains (having equal dimensions in all directions, as shown in the Figure) is subjected to plastic deformation, changes in grain structure occur which depends on the amount of deformation in different direction. In the example of compression, the grains have elongated in one direction and contracted in the other. This piece of metal has become anisotropic, and its properties in the vertical direction are different from those in the horizontal direction.





Anisotropy is of interest in sheet metal forming. For example, if the circular blank used in drawing of an aluminum beverage can is anisotropic, the circular punch will produce different deformation around the periphery of the blank. A symmetric process will produce asymmetric parts. In contrast to inherent anisotropic material behavior, anisotropy can be produced by the processes used to form sheet stock. Sheet metal was produced in other processes (rolling for example) which probably left a deformation pattern in the sheet, e.g., different amounts of deformation in the rolling direction and the direction perpendicular to the rolling direction. Forming process design and sheet stock specification must account for this anisotropy. Another example is shown in the second figure.

5.4.Springback

In the tensile test unloading occurs along a line parallel to the elastic deformation line. Analogously, when a part being formed is unloaded when it is removed from the die, elastic recovery or springback occurs. Elastic recovery results in the final shape of the part being different from the die shape or part shape in the die. If the elastic recovery is relatively large compared to the deformation needed to form the part, large deviations from desired part shape result. Shallow or large curvature parts such as some automobile body panels can be difficult to form. The solution to springback problems is to over bend the parts.

5.5.Wrinkling

Although in sheet forming the metal is generally subjected to tensile stresses, the method of forming may be such that compressive stresses are developed in the plane of the sheet. We can imagine a circular blank being drawn into a circular die by a circular punch to form a can.

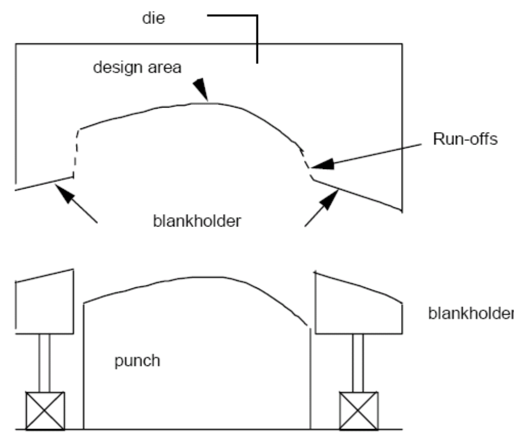
Tensile stresses are produced in the can wall during drawing and compressive stresses in the blank flange as its length is being decreases as it moves toward the die cavity.

6.Stamping operation

A sheet formed part is usually obtained through a number of operations (phases). Each operation can be decomposed in several phases.

- Gravity fall
- Holding
- Forming
- Trimming, flanging
- Spring back

Typical stamping tool

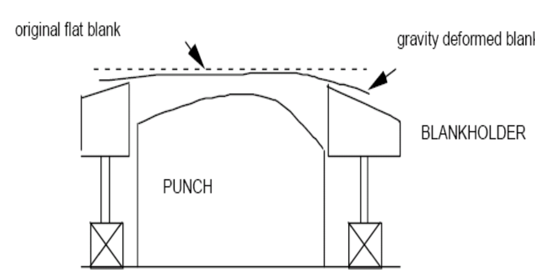


GLOSSARY:

Design surface:- Part as designed to fit in the car (after trimming)
Blank holder surface:- Surfaces that hold the blank before the forming operation, including the restraining
Production surface/run-offs:- Junction between the two former surfaces, protecting the design surface and controlling material flow.
Die face:- Run-offs + blank holder

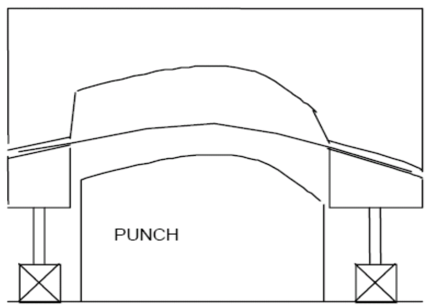
Gravity fall

The blank adapts to the blank holder shape



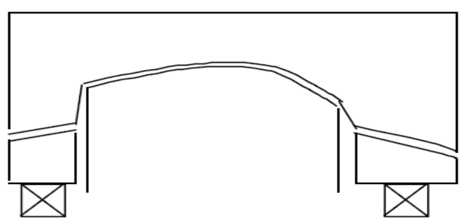
Holding

The die pushes on the blank holder and squeezes the blank. Holding controls the shape of the blank and the contact between the blank and the punch.



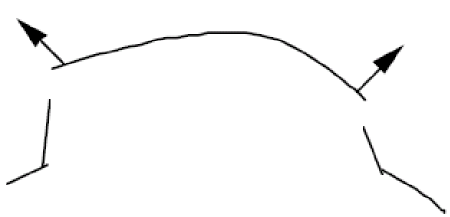
Forming

The die goes down until it squeezes the blank onto the punch



Trimming and spring back

Plastic deformation leaves some stresses locked through metal thickness. After the extraction from the tools these stresses are released originating a different shape than that of the tools.

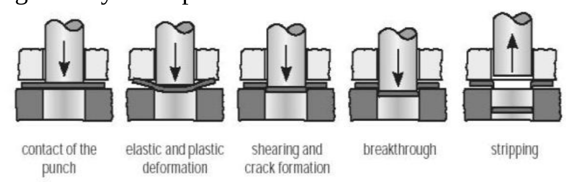


Spring back before trimming is sometimes important for the design of the tools and robots of the press. Spring back after trimming may change the shape of the part to the point that it is impossible to assemble.

7 Forming operations

7.1. Blanking:-

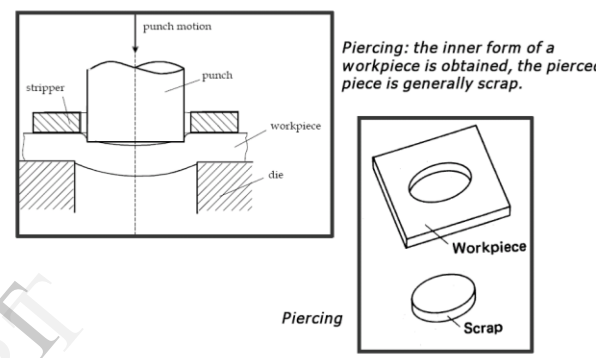
Outside/surrounding material is cut off a smaller piece and discarded. In blanking operation the pierced piece is generally work piece.



Phases of the Blanking Process

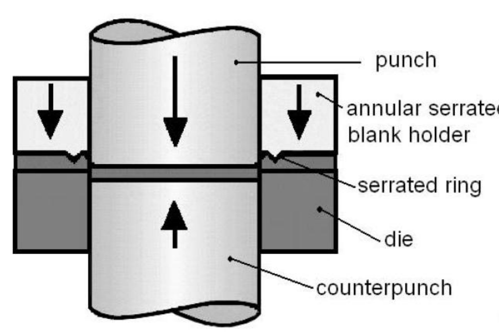
7.2. Piercing:-

A small section of material is sheared out of a larger piece and discarded.



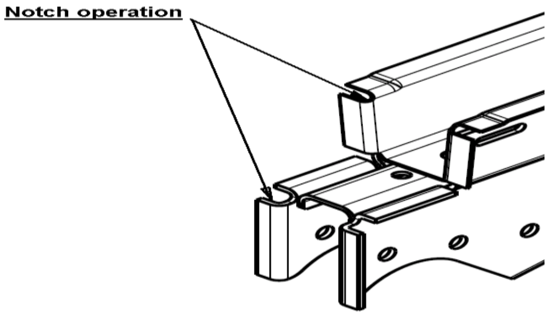
7.3. Fine blanking:-

Dies are designed that have small clearances and pressure pads that hold the material while it is sheared. The final results are blanks that have extremely close tolerances.



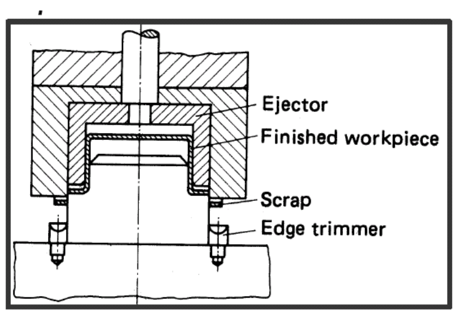
7.4.Notching:-

Notching is a shearing process during which a metal scrap piece is removed from the outside edge of a metal work piece. During a notching operation, the metal work piece has an outside edge removed by the use of multiple shear blades that are set at right angles to each other.



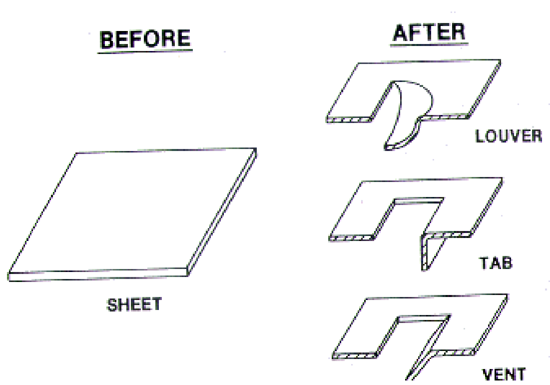
7.5. Trimming:-

Trimming is defined as to shear from a work piece a particular portion which is not required on a final product.



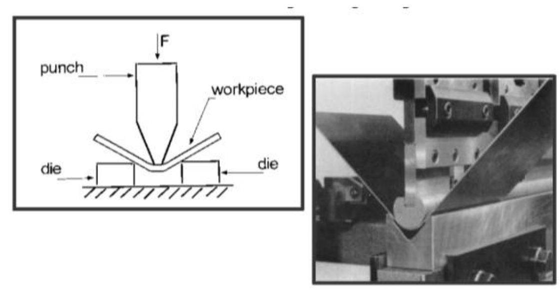
7.6.Lancing:-

Lancing is a piercing operation in which the work piece is sheared and bent with one strike of the die. A key part of this process is that there is not reduction of material, only a modification in its geometry. This operation is used to make tabs, vents, and louvers.



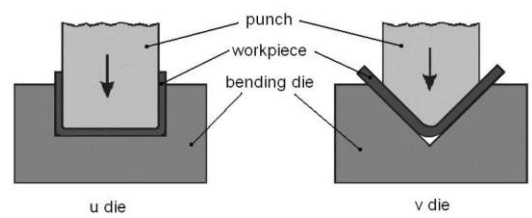
7.7.Sheet bending:-

Forming of some finite curvature on (usually) flat sheet metal along a straight edge.



7.8. Die bending:-

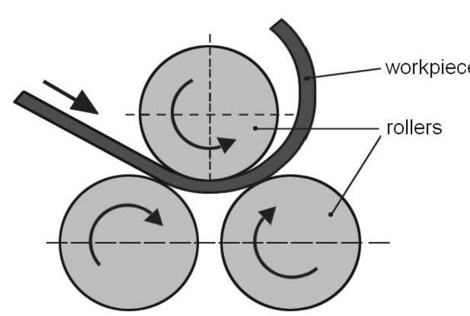
Press brake machine is generally used for this operation.



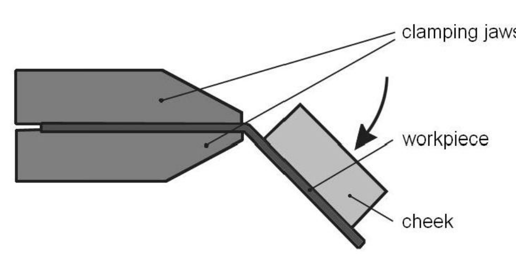
Die Bending

7.9.Roll bending:-

Also spelled **roll forming** is a continuous bending operation in which a long strip of metal (typically coiled steel) is passed through consecutive sets of rolls until the desired cross-section profile is obtained. Roll forming is ideal for producing parts with long lengths or in large quantities.

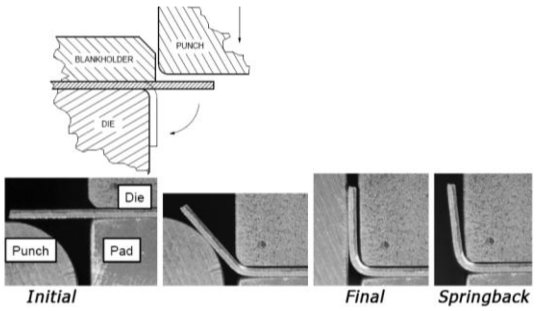


7.10. Swivel bending:-

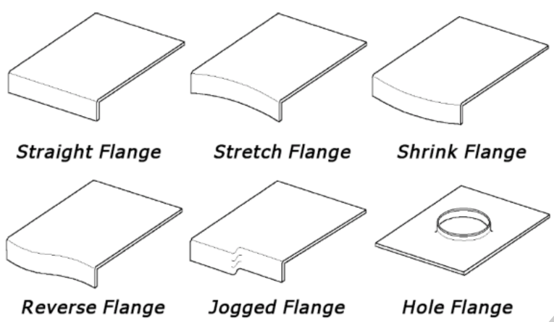


7.11. Flanging:-

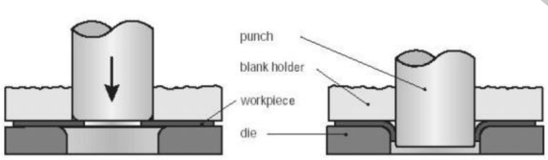
Flanging is an operation that creates a bent edge that curves inward in the centre.



Types of flanging:-



7.12. Hole flanging:-

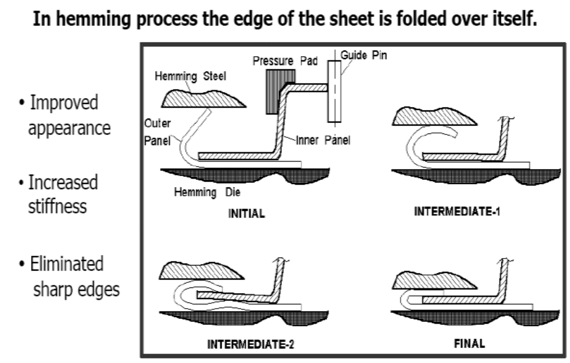


7.13.Hemming:-

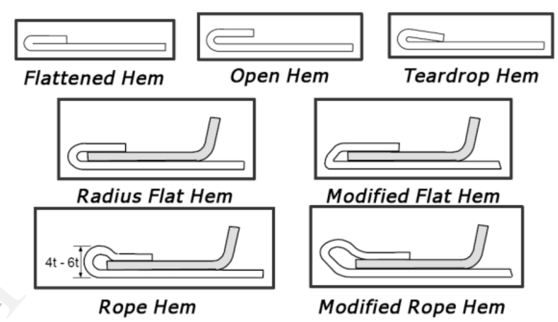
Hemming and seaming are two similar metalworking processes in which a sheet metal edge is rolled over onto itself. A hem is when the edge is rolled flush to itself, while a seam joins the edges of two materials.

Hems are commonly used to reinforce an edge, hide burrs and rough edges, and improve appearance.

- It improves the rigidity of the edge
- It facilitates joining of two parts as in the case of Bonnet assembly /Door assembly

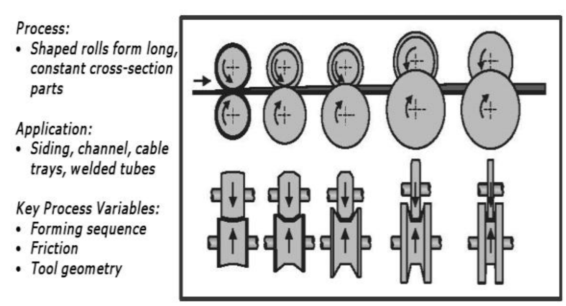


Types of hemming:-



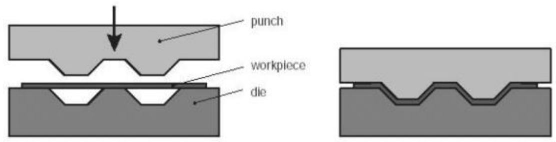
7.14.Roller forming:-

Forming a flat strip of sheet metal through pairs of rolls gradually without changing the thickness. Roll Forming is a progressive bending operation



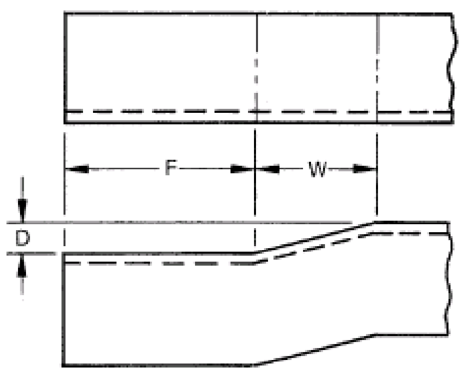
7.15.Embossing:-

Embossing is a process for producing raised or sunken designs or relief in sheet metal. This process can be made by means of matched male and female roller dies, or by passing sheet or a strip of metal between rolls of the desired pattern.



7.16.Joggling:-

Joggling, also known as joggle bending, is an offset bending process in which the two opposite bends are each greater than 90°, and are separated by a neutral web less than 5 work piece thicknesses apart.



Joggle bend in sheet metal

8Conclusion:-

After understanding the above forming operation and the deformation involved in material forming along with the mechanics behind the forming operation it is very critical to design the formed panels as it involves huge amount of cost in making the same and also rectifying the panels if any defects are present in the panels or rectifying the tools.

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