Modul 2: Sheet Metal Forming

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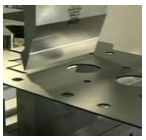
Sheet metal forming works with thin sheet stock material. It is a rapid operation and its primary application includes the body panels and frame components of most automobiles, truck bodies, railway cars, farm and construction equipment, office furniture, metallic beverage cans, and office staples, brackets inside PCs, and aircraft fuselage skins, frames, stiffeners and wings panels.



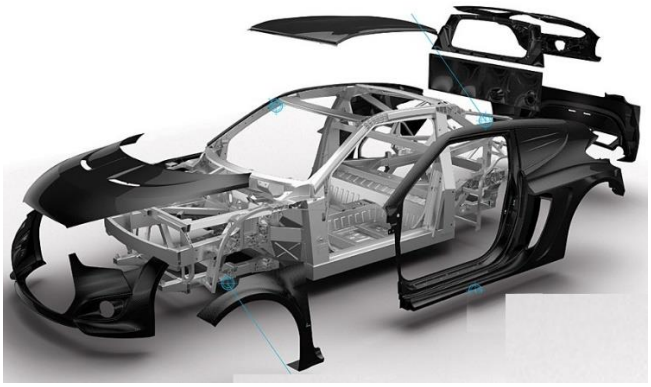


Image Source: http://autocomponentsindia.com/lightweighting-lies-heavy-on-automotive-industry/

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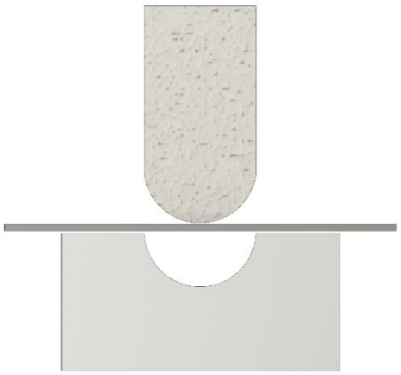
This Module Objective:

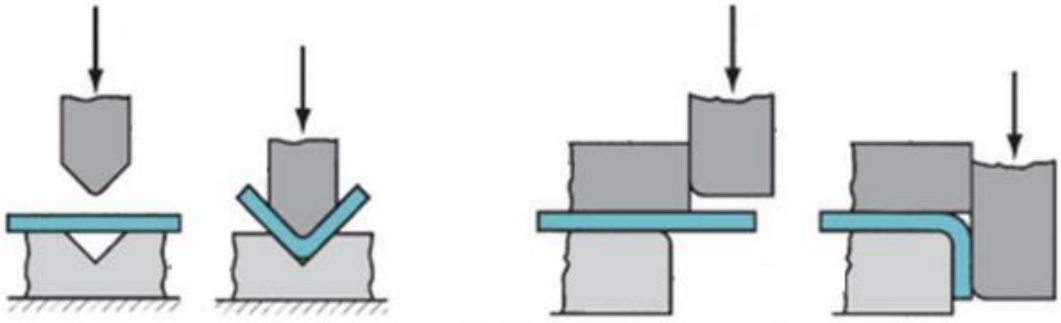
- To be able to identify parts that are produced using sheet metal forming process.
- Basic engineering analysis of bending and shearing.

The two most common operations of sheet metal forming are shearing and bending. Shearing (also known as cutting and blanking) refers to cutting and may be performed with an automated press or even with handheld shears. Bending can be done by deforming sheet metal around an edge or in case of automotive body panels with a complex three-dimensional shape by stretching and bending the metal between two mold halves (it is also called dies). Many sheet metal parts are made by both shearing and bending, simultaneously.

The bending operations are performed on machine tools called “Stamping Press”.

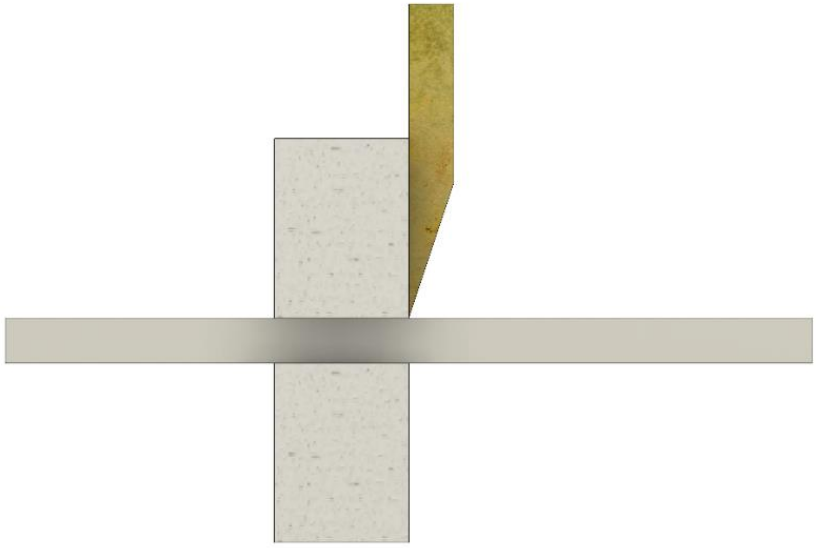


Two most common bending operations are V-bending, and Edge-bending.



Stamped part vs. Formed parts

Cutting is accomplished by a shearing action between two sharp cutting edge. Cutting process can be parallel (all at once), or serial (locally). For example, punching is all at once, but scissors cut locally.



The three most common sheet metal cutting operations are:

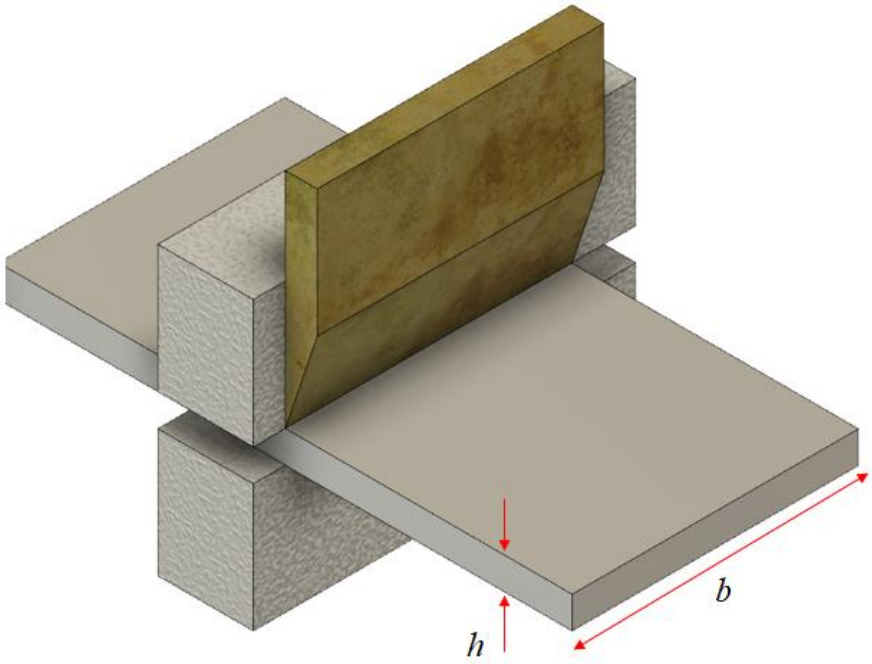
- Shearing
- Blanking
- Punching

Engineering Analysis of Sheet Metal Cutting:

Shearing like machining require local failing/breaking the material. In machining, the metals usually fail along the shear plane, while in a shearing operation, a crack may form due to initial shearing and end in tearing.

Models that approximate the shearing force typically utilize the Ultimate Tensile Strength for the measure of stress required to fail the material.

The force required in sheet metal cutting operation can be estimated as follows, where T*S* is the ultimate tensile strength, b is the width of the sheet, and h is the thickness of the sheet.

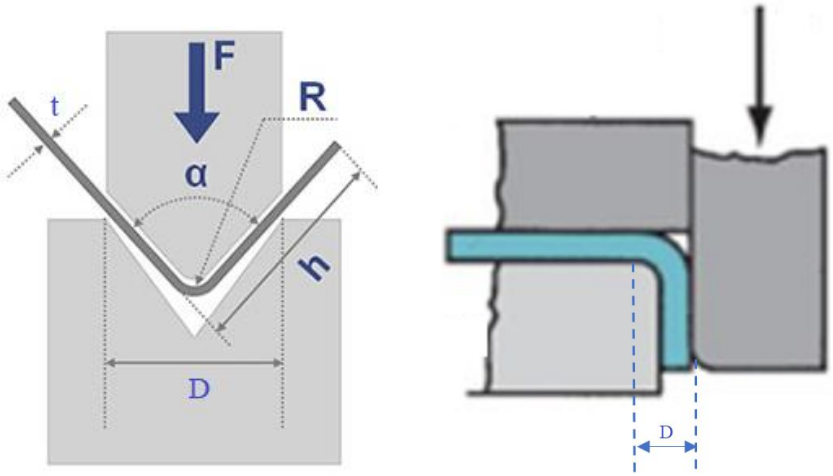


Engineering Analysis of Sheet Metal Bending:

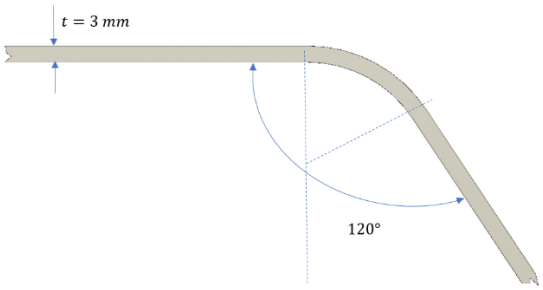
In order to form a sheet, it must reach to its plastic deformation. The minimum radius without tearing the sheet can be estimated by:

$$r_{min} = \frac{E\frac{h}{2}}{TS}$$

The required force for V and Edge bendings:

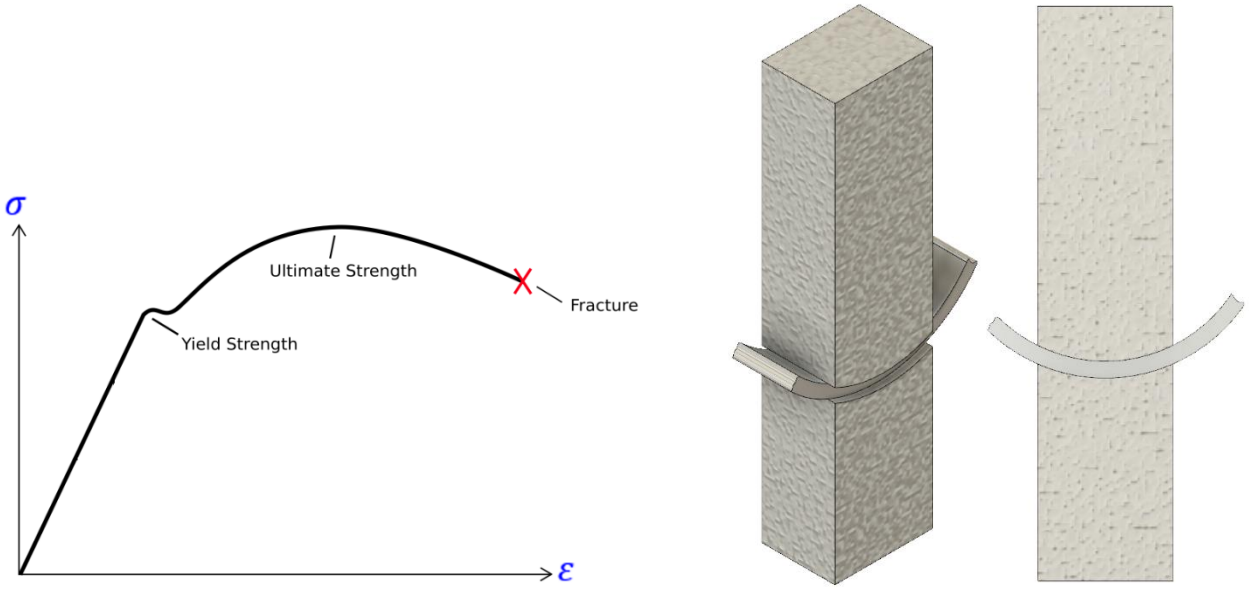


Example 1) Determine the required force to form a sheet-metal blank to be bent as shown using a V-die with die opening $D = 25mm$. The width of the sheet is $w = 45mm$

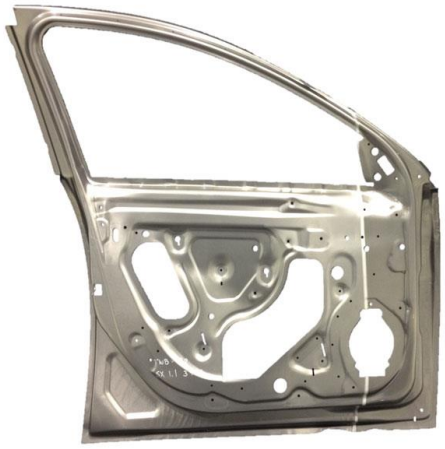


Spring Back

When the bending pressure is removed at the end of deformation operations, the elastic energy causes the metal to recover partially toward its original shape. This elastic recovery is called spring-back. Eliminating or minimizing the elastic spring back of a sheet is typically done by stretch forming, where the sheet is loaded in tension prior to bending such that all material elements (above and below the neutral axis) are strained above the tensile yield strain. This results in a uniform stress profile equal to the material yield stress. This balanced stress profile effectively gives rise to no elastic moment in the sheet, and therefore no spring back when unloaded.



Example 2) Car doors, among much of the automotive body are typically formed by stamping and then shearing sheet metal stock. Consider two material options for a car door frame as:



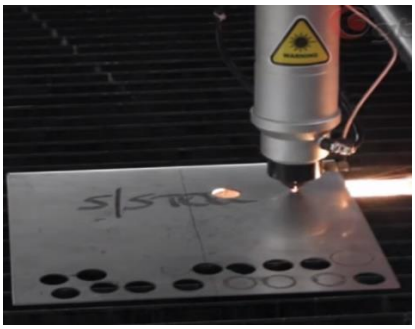
Steel:	**Aluminum:**
$\rho = 7600\frac{kg}{m^3}$	$\rho = 2700\frac{kg}{m^3}$
$E = 200GPa$	$E = 69GPa$
$\sigma_y = 520MPa$	$\sigma_y = 400MPa$
$TS = 860MPa$	$TS = 455MPa$

For analysis, let's model the complex features on a car door as simple curvatures. Tooling to press a simple curvature involves a male and female die and a clamping assembly that can place the sheet in tension before the die press is closed.

For a sheet metal stock with $2.4mm$ thickness, determine the minimum tool radius for both the steel and aluminum alloys that will not tear the material. Assume the sheet of material is in pure bending. If the sheet is formed using a tool with a 32 cm radius of curvature, what is the final radius of curvature of the sheet? Assume the sheet is not stretched before forming.

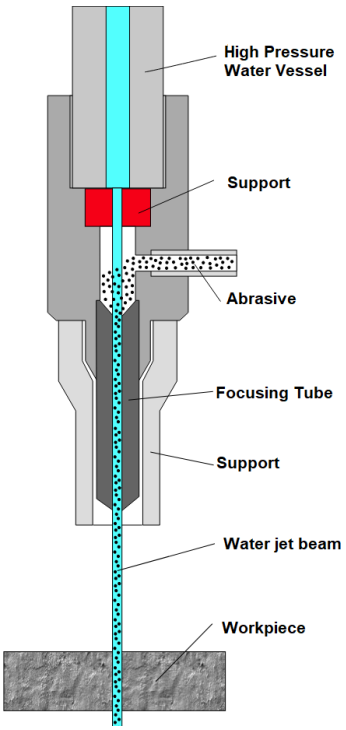
Other methods of cutting (*self-study*):

- Abrasive water jet
- High power photon laser



Video, *https://www.youtube.com/watch?v=G-p6C1Gd9q0*

Source: *https://www.youtube.com/watch?v=pbXoJKzSs28*



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