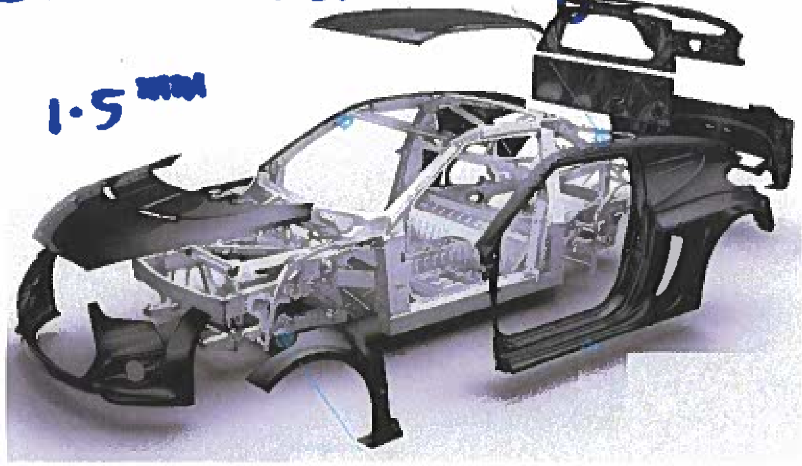
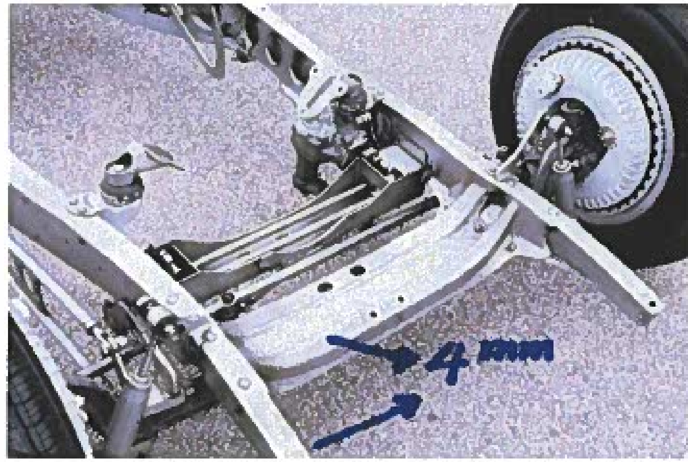
Sheet metal working

1.5 mm





6mm

0.25 mm

1mm

2.5 mm

Image Source https://www.sciencedirect.com/science/article/pii/B978012401698900015X

Sheet metal working:

- { Cutting
- { Forming

shape
{ - geometry
{ - strength

Small I ← weak (moment of Inertia) Strong ✓ increasing I

Application for: 0.1 mm – 10 mm ← sheet

if t >> 10 → plate

4 Attributes

Cost	Rate	Quality	Flexibility
low	fast	Surface: good Dim acc: mid → good	low

Dimension accuracy →

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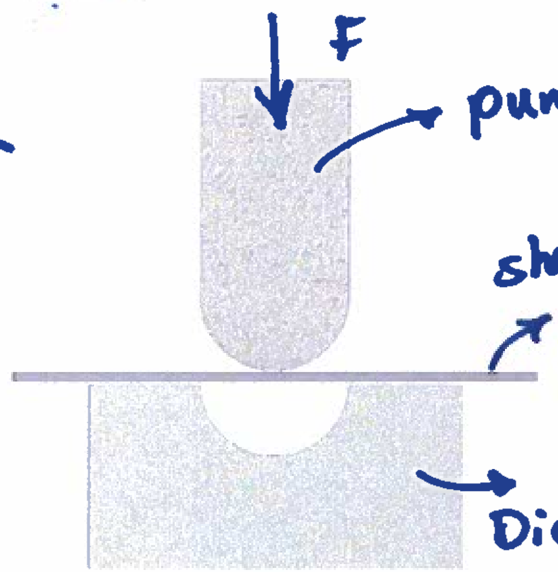
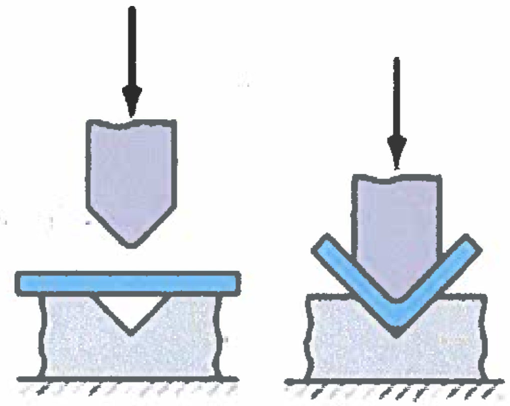
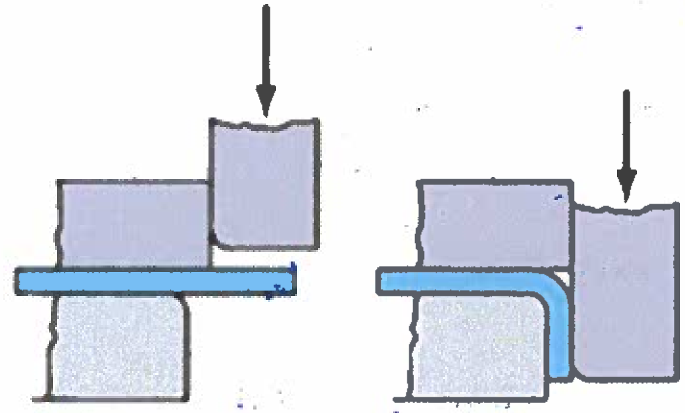
1992 Lexus ES Commercial

Stamping Press / press

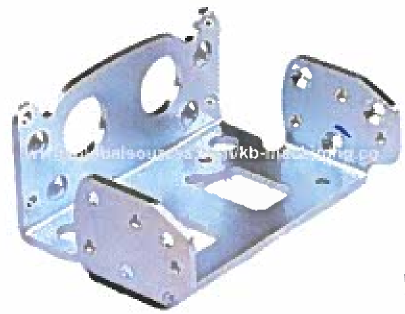


V-bending, and Edge-bending.





Stamped part vs. Formed parts

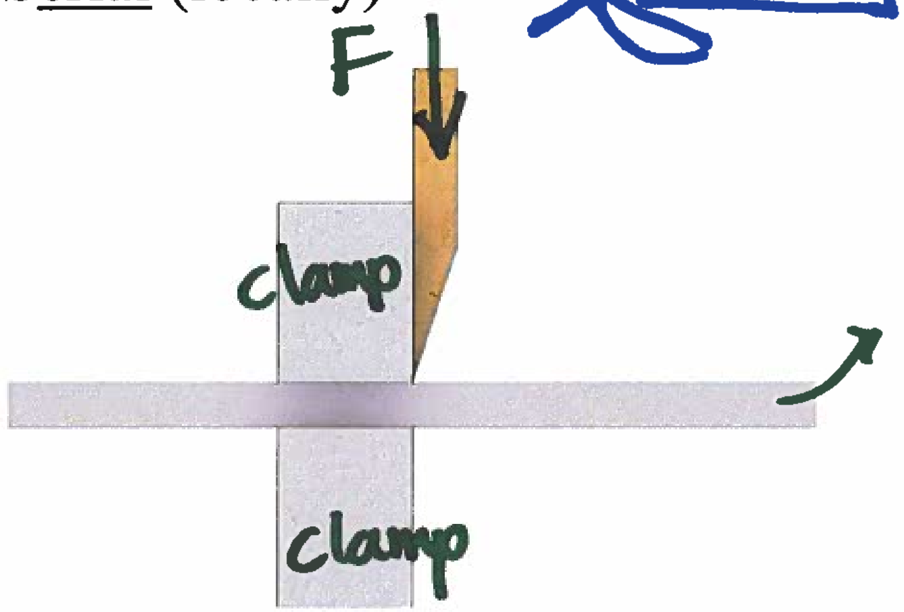


- all at once
- curved edge

- multiple steps
- straigh edge

Cutting

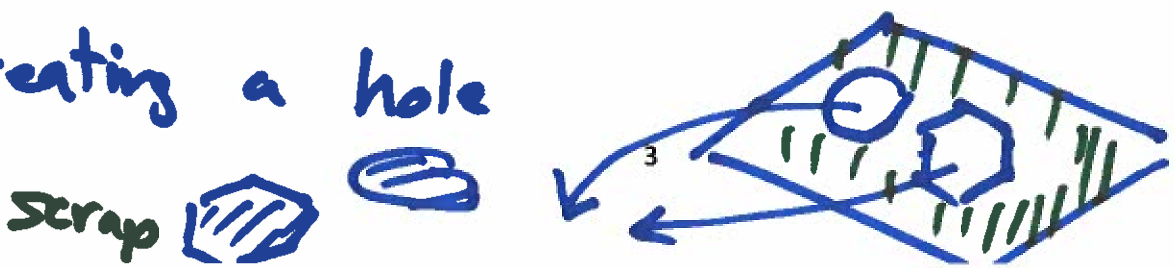
- Parallel (all at once)
- Serial (locally)

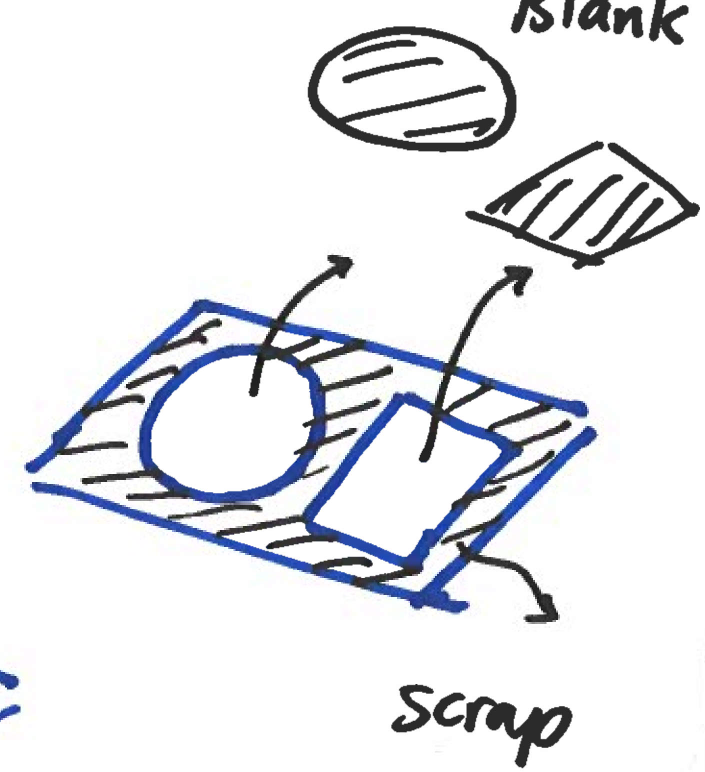


punching a hole

The three most common sheet metal cutting operations are:

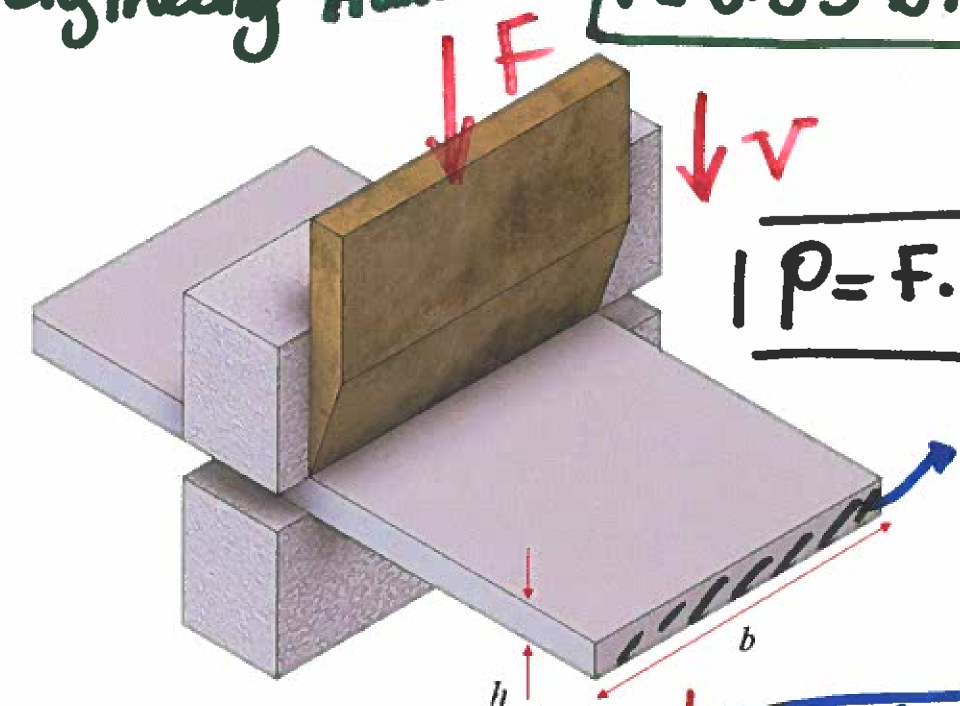
- Shearing : cut along a straight line
- Blanking : 〃 〃 ~~a~~ closed out line
- Punching : creating a hole





Engineering Analysis of Sheet Metal Cutting:

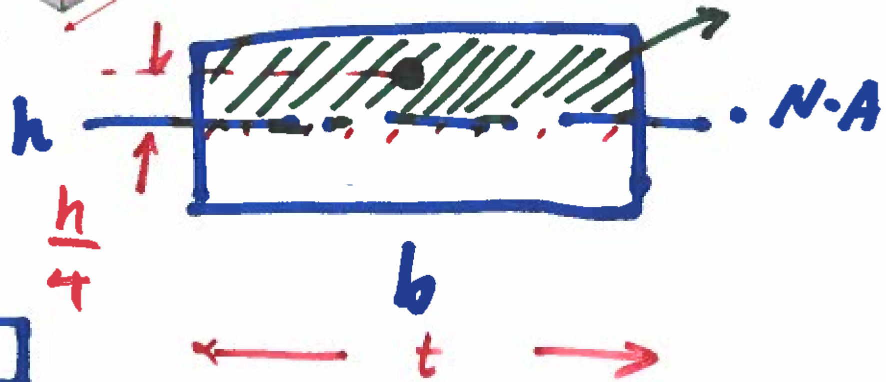
Engineering Hand Book $\boxed{F = 0.35\, bh\, (TS)}$



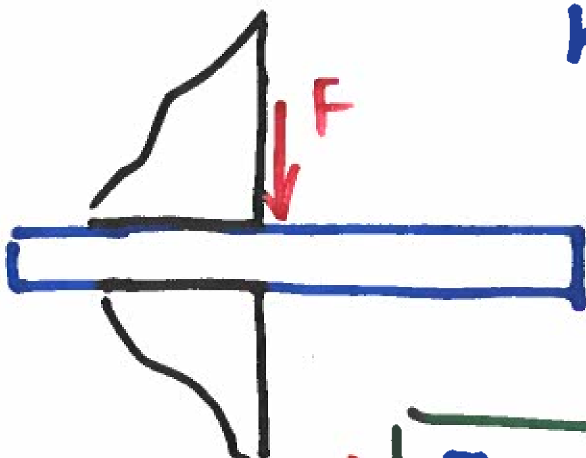
$\boxed{P = F \cdot V}$

$$\tau_{max} = \frac{VQ}{It} = \frac{(F)\left(b\frac{h}{2} \times \frac{h}{4}\right)}{\frac{1}{12}bh^3 \times b} = \frac{3}{2}\frac{F}{bh}$$

shearing TS $= 0.5$ TS → Tensile strength



$$Q = \left(b\frac{h}{2}\right)\left(\frac{h}{4}\right)$$



for cutting →

τ_{max} = shearing TS

$$\frac{3}{2}\frac{F}{bh} = 0.5\, TS \rightarrow$$

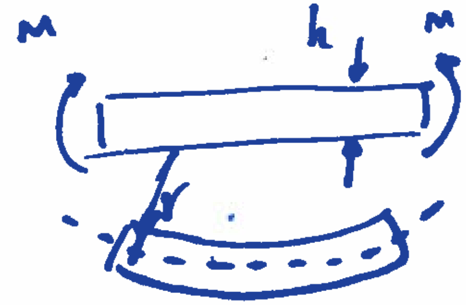
→ * $\boxed{F = \frac{1}{3}(bh)(TS)}$

Engineering Analysis of Sheet Metal Bending:

The minimum possible radius without tearing the sheet:

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

The required force for V and Edge bendings:



$$\sigma = \frac{Mc}{I}$$

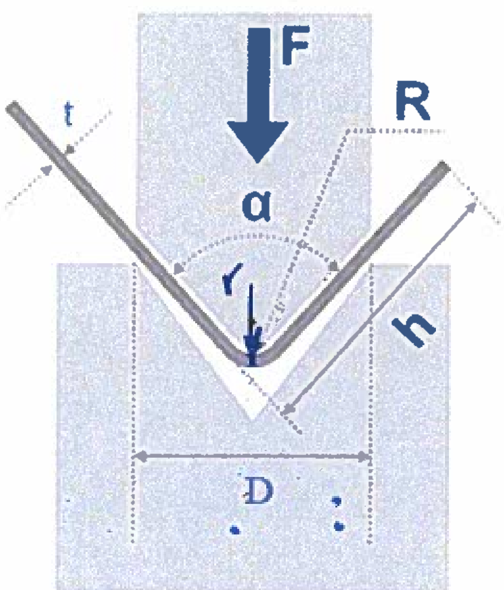
$$\frac{1}{r} = \frac{M}{EI}$$

$$\sigma = \frac{E\frac{h}{2}}{r}$$

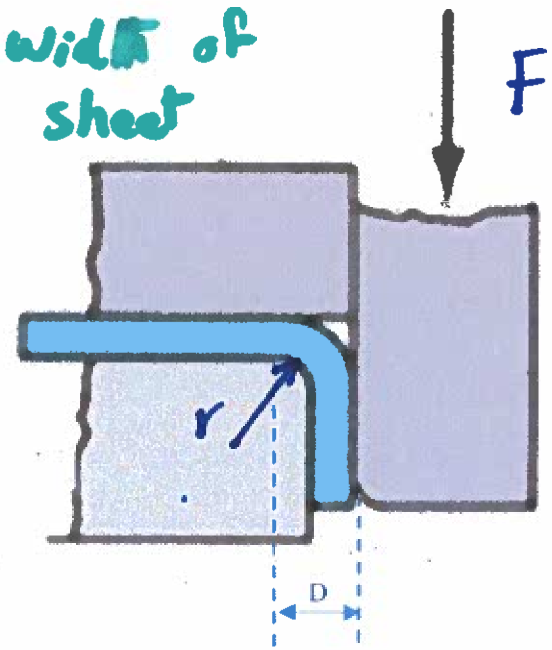
failure if $\sigma = \sigma_u$

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

w: width of sheet

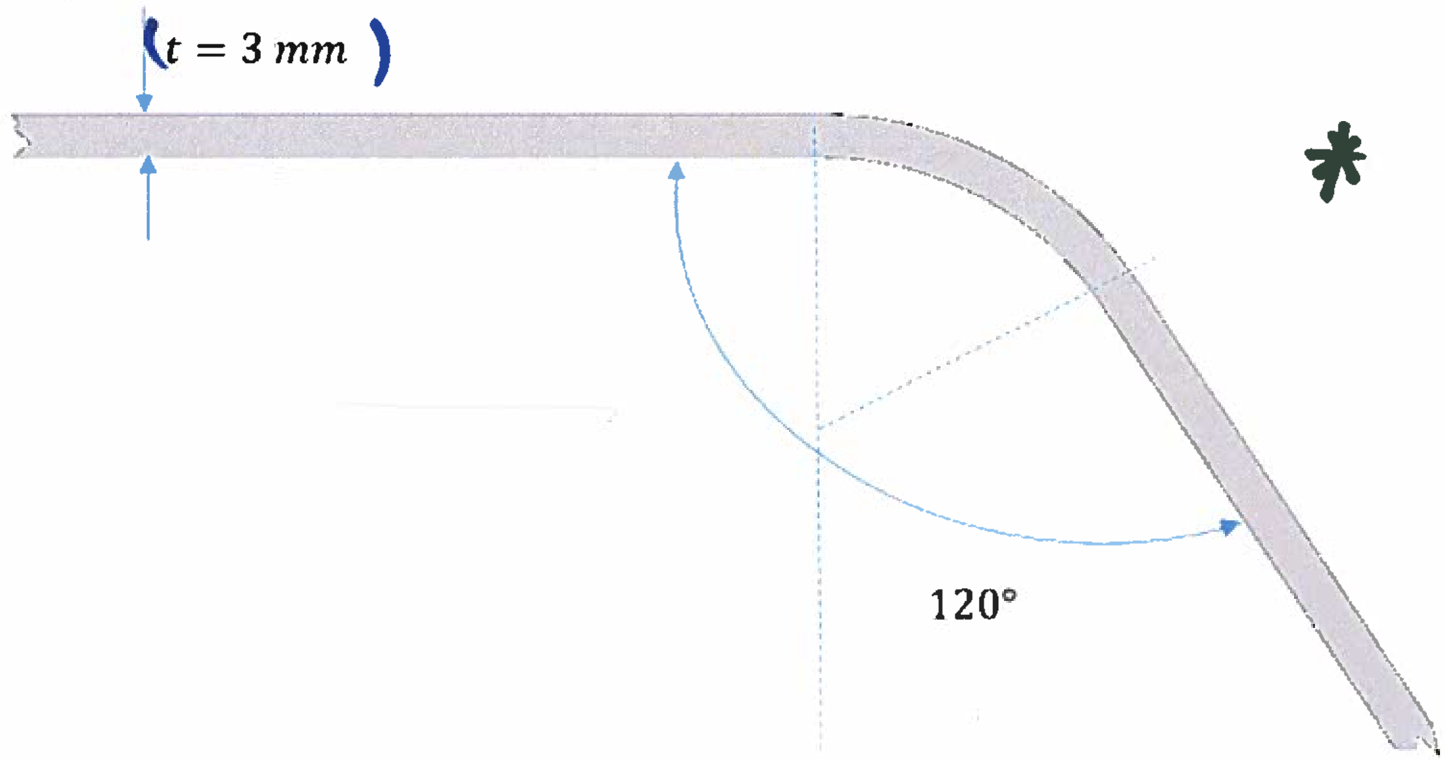


$$F = \frac{4(TS)wt^2}{3D}$$



$$F = \frac{(TS)\,wt^2}{3D}$$

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 $w = 45mm$



$$* \quad F = \frac{4(TS)(wt^2)}{3D}$$

TS → St. 850 MPa

TS → Al. 450 MPa

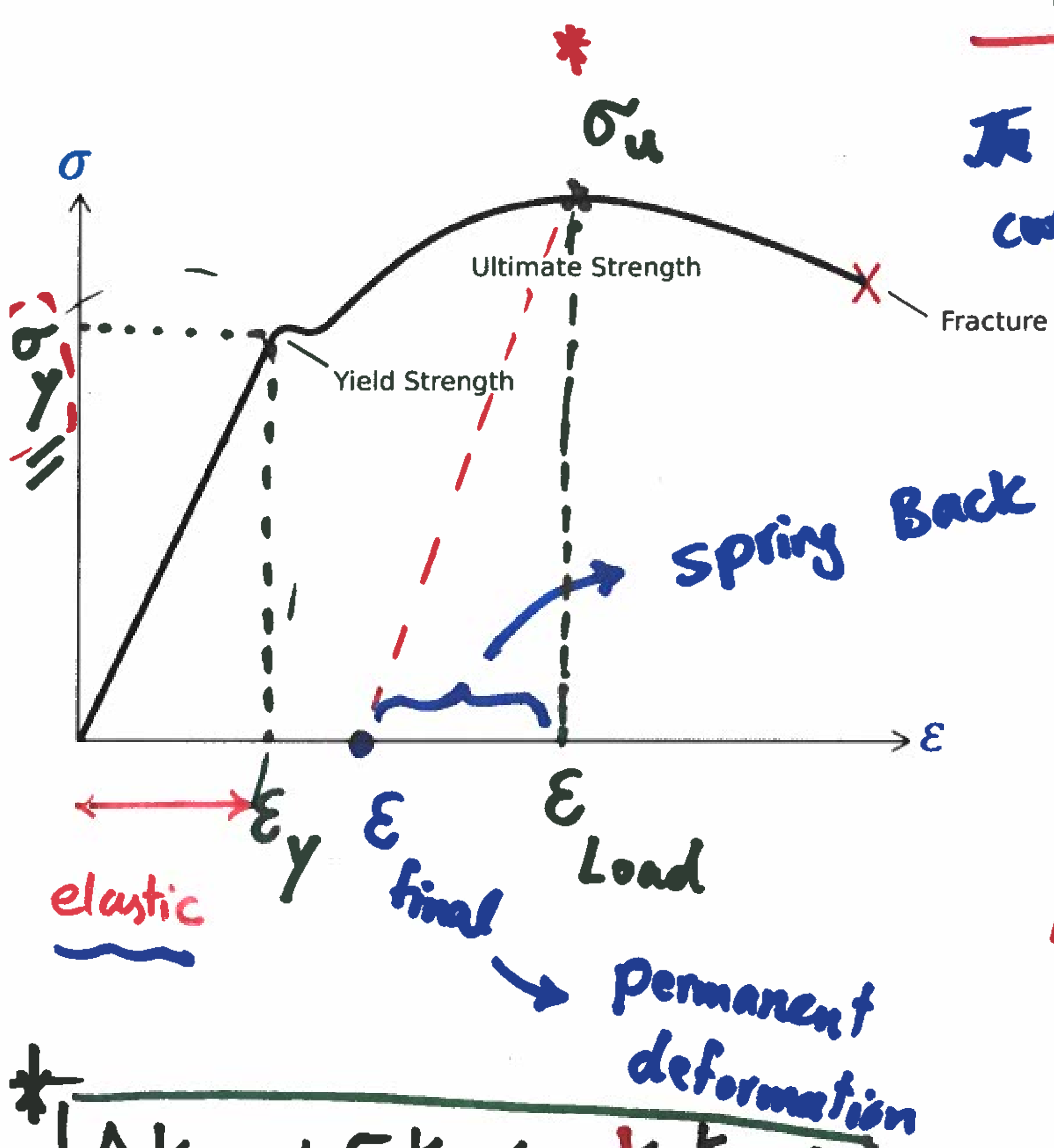
Power = F. V

V → Speed

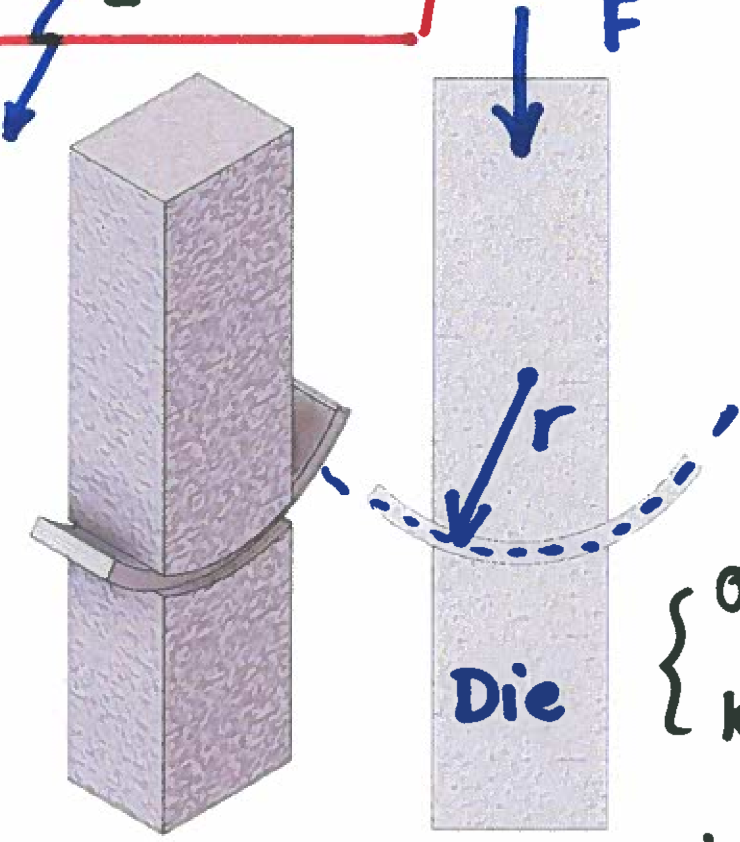
Spring Back

$$\boxed{K_{final} = K_L - \Delta K}$$

The mold curvature



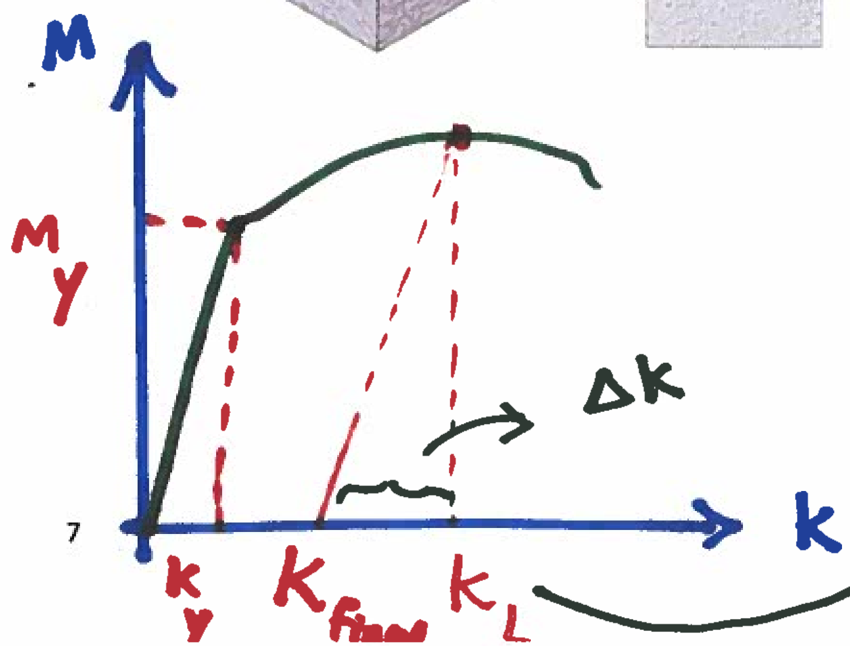
$$\boxed{\Delta k = 1.5 K_y \left(1 - \frac{1}{3}\left(\frac{k_y}{k_L}\right)^2\right)}$$



$$k = \frac{1}{r}$$

$$\begin{cases} \sigma = \dfrac{MC}{I} \\ k = \dfrac{M}{EI} \end{cases}$$

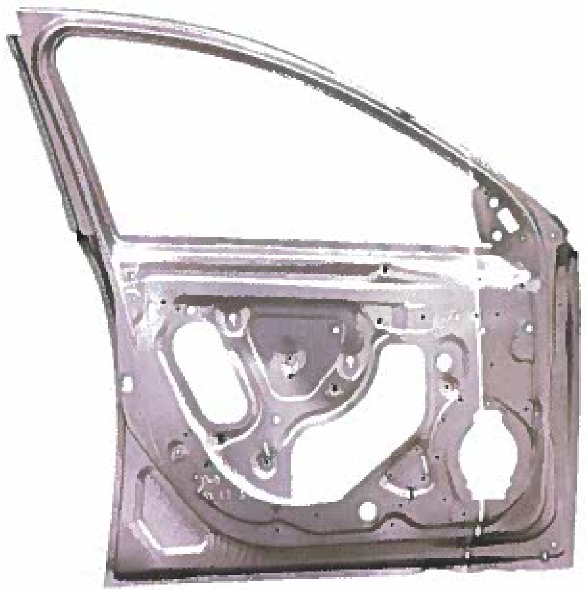
$$k = \frac{\sigma}{EC}$$



$$\boxed{k_y = \frac{\sigma_y}{EC}}$$

The mold curvature

Example 2) Sheet metal stock with 2.4mm thickness, Two options:



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

Q1. The minimum tool radius that will not tear the material?

Q2. If the sheet is formed using a tool with a 32 cm radius of curvature, what is the final radius of curvature of the

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

$$k_L = \frac{1}{320}, \quad k_y = \frac{\sigma_y}{E\frac{h}{2}}, \quad \Delta k = 1.5\, k_y \left(1 - \frac{1}{3}\left(\frac{k_y}{k_L}\right)^2\right) = \cdots$$

$$k_{final} = k_L - \Delta k = \cdots \quad r_{final} = \frac{1}{k_{final}}$$

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