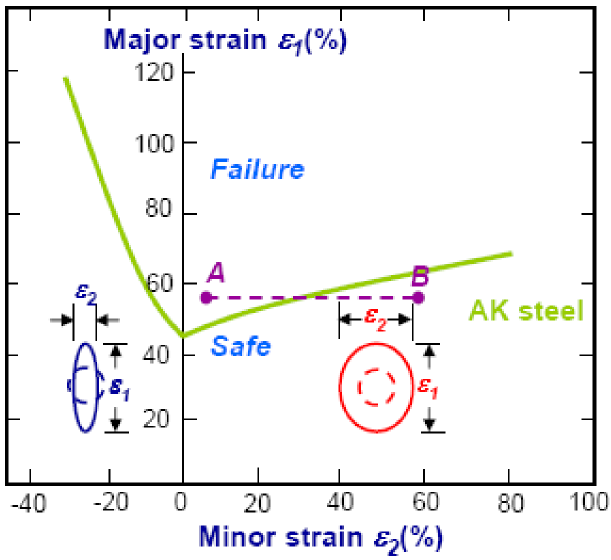
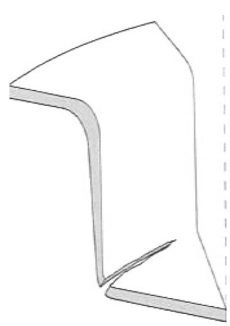
DEFECTS IN FORMING AND FORMING LIMIT CRITERIA

Forming limit criteria

Tensile test only provides ductility, work hardening, but it is in a uniaxial tension with frictionless, which cannot truly represent material behaviours obtained from unequal biaxial stretching occurring in sheet metal forming. Sheet metal formability tests are designed to measure the ductility of a material under condition similar to those found in sheet metal forming.

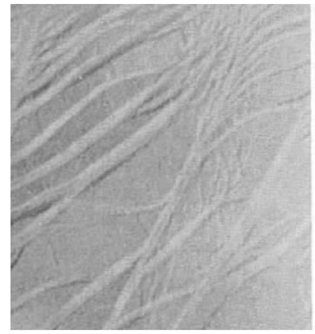


Defects in Forming



Cracks

Edge Forming



Strain on surface

- Radial cracks in the flanges and edge of the cup due to not sufficient ductility to withstand large circumferential shrinking.
- Wrinkling of the flanges or the edges of the cup resulting from buckling of the sheet (due to circumferential compressive stresses) solved by using sufficient hold-down pressure to suppress the buckling.
- Surface blemishes due to large surface area. EX: orange peeling especially in large grain sized metals because each grain tends to deform independently use finer grained metals.
- Mechanical fibering has little effect on formability.
- Crystallographic fibering or preferred orientation may have a large effect. Ex: when bend line is parallel to the rolling direction, or earing in deep drawn cup due to anisotropic properties.

Simple Calculation Formulas:

Clearance in Sheet Metal Cutting

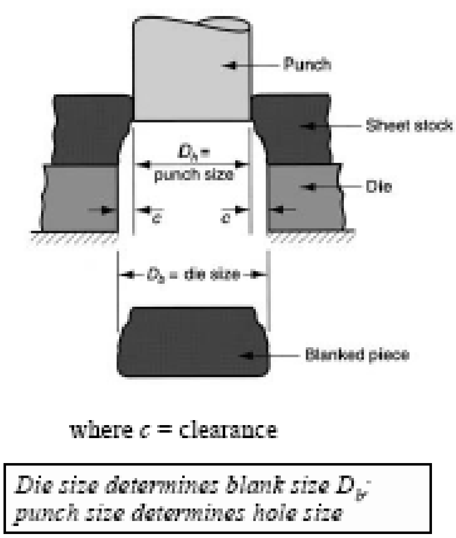
• Distance between the punch and die

• Typical values range between 4% and 8% of stock thickness

– *If too small, fracture lines pass each other, causing double burnishing and larger force*

– *If too large, metal is pinched between cutting edges and excessive burr results*

For a round *blank* of diameter D_b:



Blanking punch diameter = D_b - 2*c*

Blanking die diameter = D_b

For a round *hole* of diameter D_h:

Hole punch diameter = D_h

Hole die diameter = $D_h + 2c$

- Low "c" for soft materials
- High "c" for hard materials

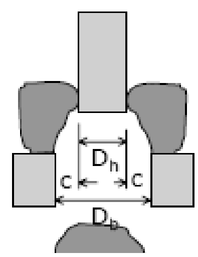
• Recommended clearance can be calculated by: c = *at;* where c = clearance; *a* = allowance; and *t* = stock thickness

• Allowance *a* is determined according to type of metal

Metal group	*a*
1100S and 5052S aluminum alloys, all tempers	0.045
2024ST and 6061ST aluminum alloys; brass, soft cold rolled steel, soft stainless steel	0.060
Cold rolled steel, half hard; stainless steel, half hard and full hard	0.075

Cutting Forces

*F=S*t*L; Where: S= Shear strength; t=thickness; L=length of cutting edge; Important to determine the press capacity (tonnage)If shear strength is not known cutting force can be estimated as: F=0.7*TS*t*L Where TS =Ultimate tensile strength*



Stretching during Bending

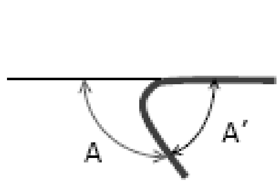
$$BA = 2\pi \frac{A}{360}(R + K_{ba}t)$$

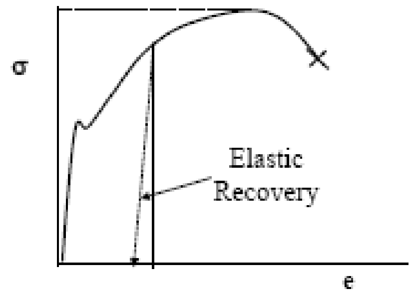
- If $R < 2t$, $K_{ba} = 0.33$
- If $R \geq 2t$, $K_{ba} = 0.50$

• If bend radius is small relative to stock thickness, metal tends to stretch during bending

• Important to estimate amount of stretching, so that final part length = specified dimension

• Problem: to determine the length of neutral axis of the part before bending Where, *BA* = bend allowance; *A* = bend angle; *R*= bend radius; *t* = stock thickness and *Kba* is factor to estimate stretching





$$SB = \frac{A' - A'_b}{A'_b}$$

A' = included angle of the sheet metal part

A'_b = included angle of the bending tool

Bending Force

Maximum bending force estimated as follows:

Where,

F = bending force

TS = tensile strength of sheet metal

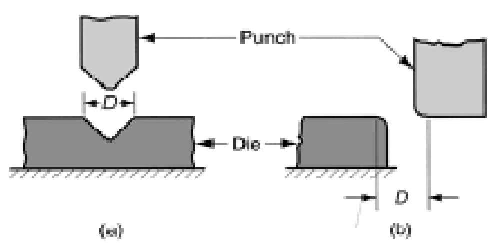
w = part width in direction of bend axis

t = stock thickness

D = die opening dimension

$$F = \frac{K_{bf} TS w t^2}{D}$$

- For V- bending, K_{bf} = 1.33
- For edge bending, K_{bf} = 0.33



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