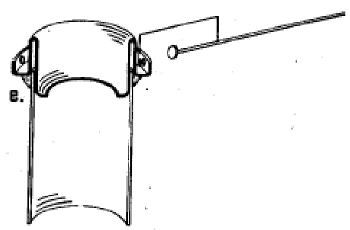
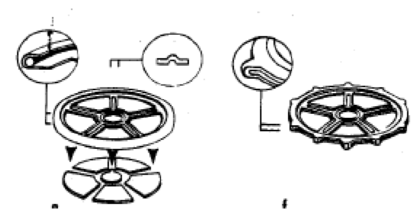
Outline

Historically

Sheet metal stamping was developed as a mass production technology for the production of bicycles around the **1890's**. This technology played an important role in making the system of interchangeable parts economical (perhaps for the first time).



Bicycle Hub



Bicycle Sprocket

Sheet Metalworking

- Cutting and forming operations performed on relatively thin sheets of metal which are produced by *rolling*
- Thickness of sheet metal = 0.4 mm (1/64 in) to 6 mm (1/4 in)
- Thickness of plate stock > 6 mm
- Operations usually performed as cold working (except when the stock is **thick** or the metal is **brittle** then warm working is performed)

Sheet and Plate Metal Products

- Sheet and plate metal parts for consumer and industrial products such as:
  - Automobiles and trucks
  - Airplanes
  - Railway cars and locomotives
  - Farm and construction equipment
  - Small and large appliances
  - Office furniture
  - Computers and office equipment

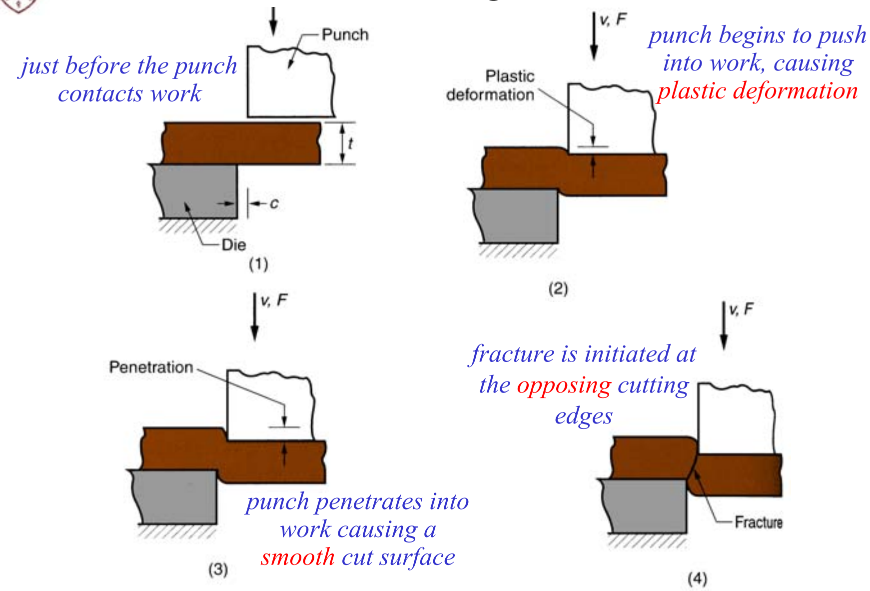
Sheet Metal Processes

1. Cutting
   - *Shearing to separate large sheets; or cut part perimeters or make holes in sheets*
2. Bending
   - *Straining sheet around a straight axis*
3. Drawing
   - *Forming of sheet into convex or concave shapes*

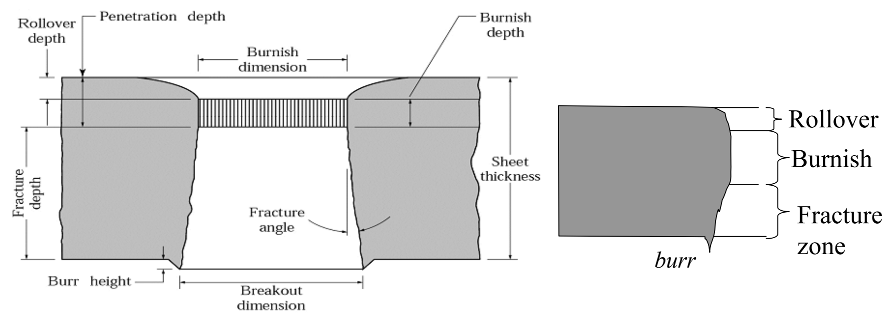
Advantages of Sheet Metal Parts

- High strength
- Good dimensional accuracy
- Good **surface finish**
- Relatively …………..
- For large quantities, economical mass production operations are available

Cutting



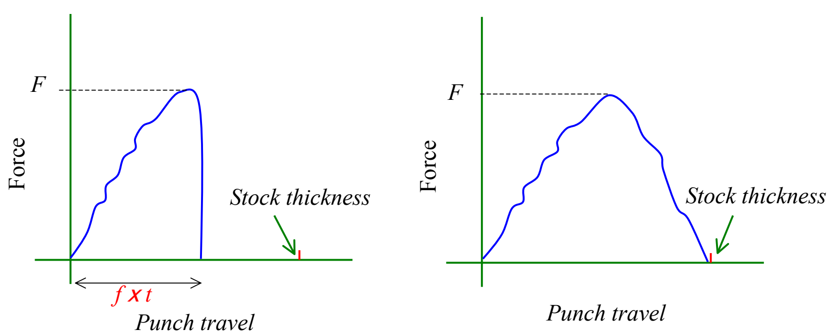
Quality of sheared edges



- Depends on process used
- Edges can be rough, not square, and contain cracks, residual stresses, and a work-hardened layer
- These are all *detrimental* to the ……………… of the sheet
- Quality can be improved by control of ………., tool and die design

Clearance in Sheet Metal Cutting

Force required for shearing:



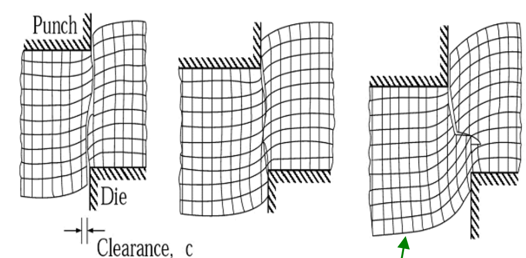
(a) Optimum clearance (b) Incorrect clearance

- *f* is the fraction of the thickness through which the punch has traveled

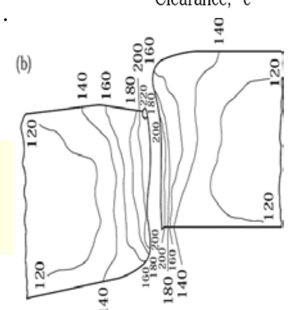
- Incorrect clearance requires higher ……………..
- and causes excessive burr.

Quality of sheared edges

- Low clearance
  - ………………
  - …………………
  - ……………………
- High clearance
  - ………………………
  - ……………………..
  - ……………………



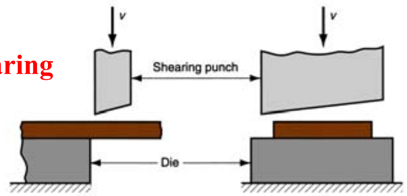
As clearance ***increases****, the material tends to be pulled into the die rather than be sheared*



Microhardness (HV) contours for a 6.4-mm thick 1020 hot-rolled steel in the sheared region

Cutting Operations

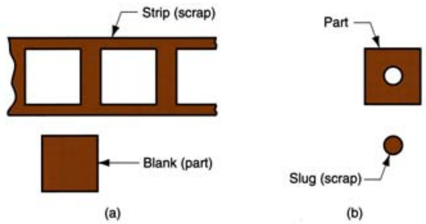
Shearing



side view *front view*

Typically used to cut large sheets into smaller sections for subsequent operations

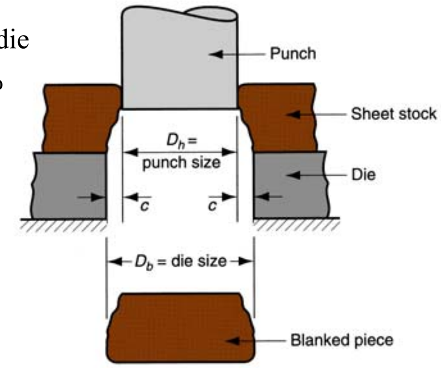
Blanking



Punching

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 = $D_b - 2c$
Blanking die diameter = D_b

where c = clearance

For a round *hole* of diameter D_h:
Hole punch diameter = D_h
Hole die diameter = $D_h + 2c$

Die size determines blank size D_b; punch size determines hole size

Clearance in Sheet Metal Cutting

- Recommended clearance can be calculated by:

  $c = at$

  where c = clearance; a = allowance; and t = stock thickness

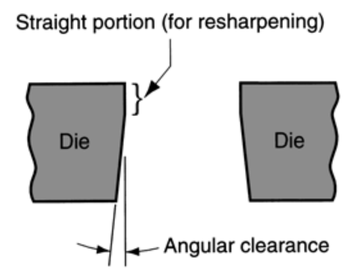
- Allowance a is determined according to type of metal

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

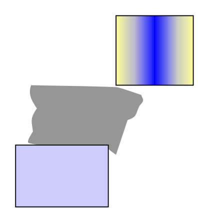
- *Low "c" for soft materials*
- *High "c" for hard materials*

Angular Clearance

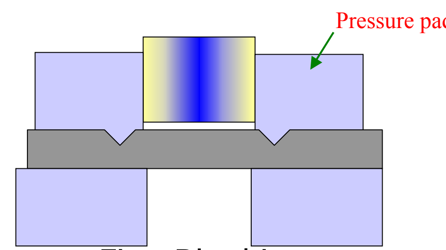
- Purpose: allows slug or blank to drop through die
- Typical values: 0.25° to 1.5° on each side



Other Cutting Operations



Shaving



Fine Blanking

Cutting Forces

$F=S*t*L$

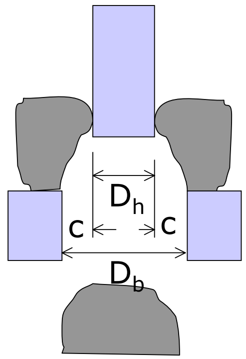
Where:
S= Shear strength
t=thickness
L=length of cutting edge

Important to determine the press capacity (tonnage)

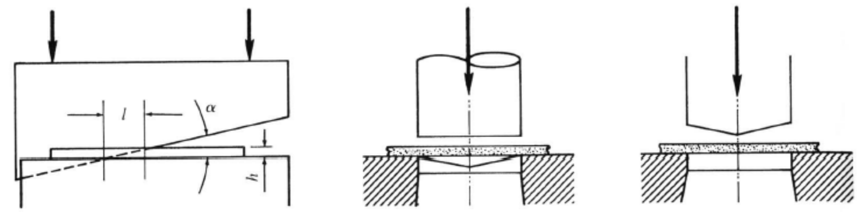
If shear strength is not known cutting force can be estimated as:

$F=0.7*TS*t*L$

Where TS =Ultimate tensile strength



Cutting Forces

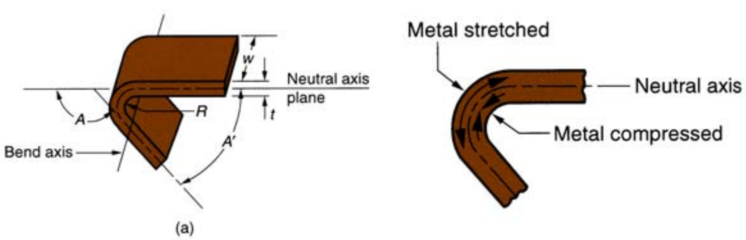


Shearing *blanking* *piercing*

- Shearing forces can be reduced by ……….. cutting tools
- This is analogous to the action of hand scissors, in which the blades close at an angle rather than parallel to each other.
- Angled cutting tools reduce the instantaneous sheared ……… thus reduce the ………. required.

Bending

- Straining sheetmetal around a straight axis to take a permanent bend



Bending of sheet metal (b)

- Metal on inside of neutral plane is compressed, while metal on outside of neutral plane is stretched

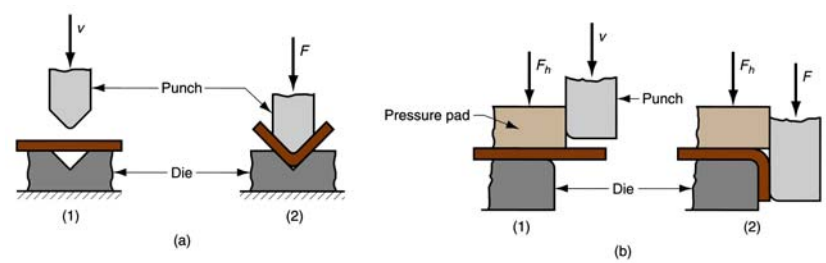
Types of Sheetmetal Bending

V-Bending

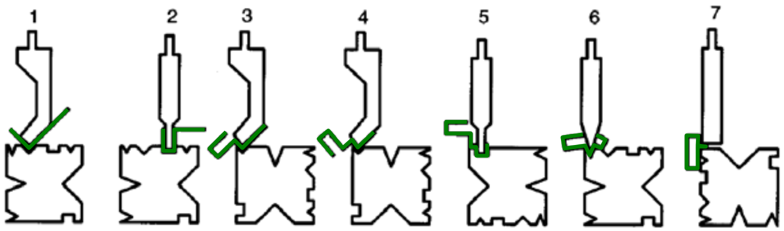
- For low production
- Performed on a *press brake*
- V-dies are simple and inexpensive

Edge Bending

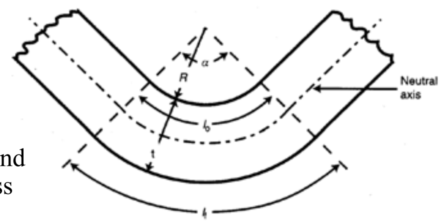
- For high production
- For angles . .. .
- Pressure pad required
- Dies are more complicated and costly



Types of Sheetmetal Bending



$$\frac{l_f}{l_o} = \frac{R+t}{R+\frac{t}{2}}$$



- With intelligent design and multiple press strokes even complex shapes can be produced.
- To successfully design the tooling for operation such as this, it requires a knowledge of the major parameters associated with bending.
- These parameters include: minimum bend radius, the spring back angle and the press force.

Stretching during Bending

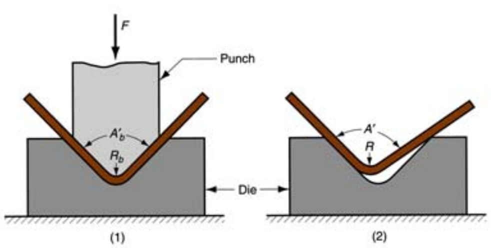
- If bend radius is small relative to stock thickness, metal tends to stretch during bending
- Important to estimate amount of stretching, so that final part length = specified dimension
- Problem: to determine the length of neutral axis of the part before bending

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

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

Where,
BA = bend allowance
A = bend angle
R= bend radius
t = stock thickness
and K_{ba} is factor to estimate stretching

Springback in Bending

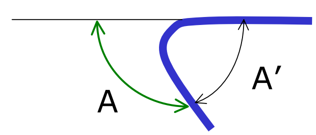


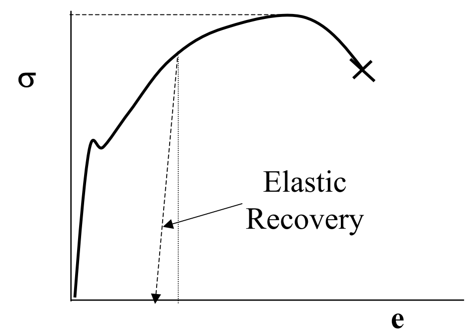
To compensate for SB:

- *Overbending* – ………… punch angle and ………… punch radius
- *Bottoming* – plastically deform with additional punch pressure

- *Springback* = increase in included angle of bent part relative to included angle of forming tool after tool is removed
- Reason for springback:
  - When bending pressure is removed, elastic energy remains in bent part, causing it to recover partially toward its original shape

Analysis of Bending





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

A' = included angle of the sheet metal part

A_b' = included angle of the bending tool

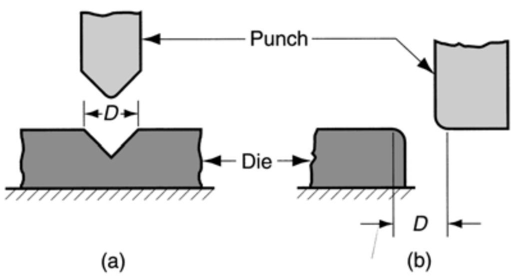
Bending Force

Maximum bending force estimated as follows:

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

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

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



Next Topic:

Deep Drawing