Manufacturing Processes
UTA026

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Introduction to Metal Forming

METAL FORMING

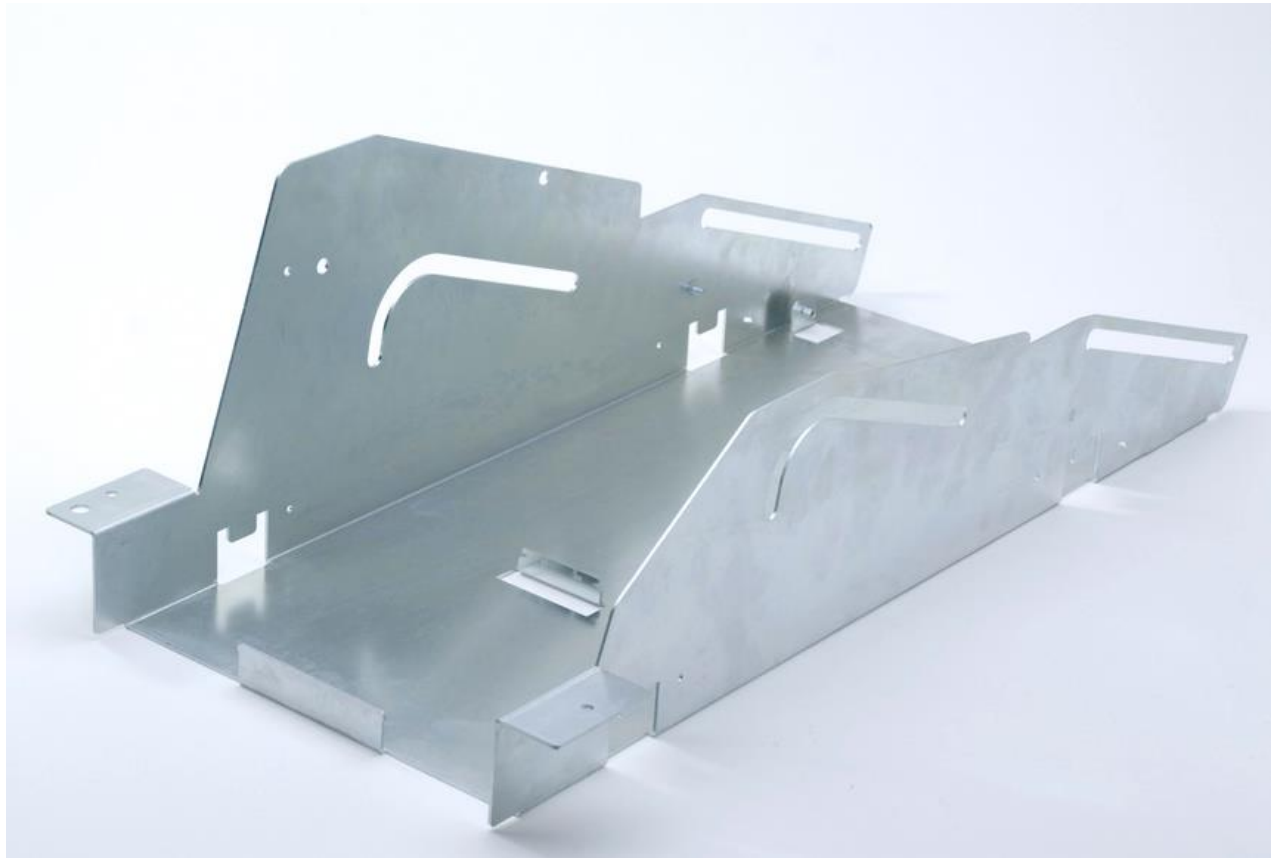
- ***Metal forming*** includes a large group of manufacturing processes in which ***plastic deformation*** is used ***to change the shape*** of metal workpieces.
- Deformation results from the use of a tool, usually called a ***die*** in metal forming, which applies stresses that ***exceed the yield strength*** of the metal.
- The metal therefore ***deforms*** to take a shape determined by the ***geometry of the die***.

METAL FORMING

- Stresses applied to ***plastically deform*** the metal are usually ***compressive***.
- However, some forming processes ***stretch*** the metal, while others ***bend*** the metal, and still others apply ***shear*** stresses to the metal.

METAL FORMING

METAL FORMING



Remembering stress strain diagram

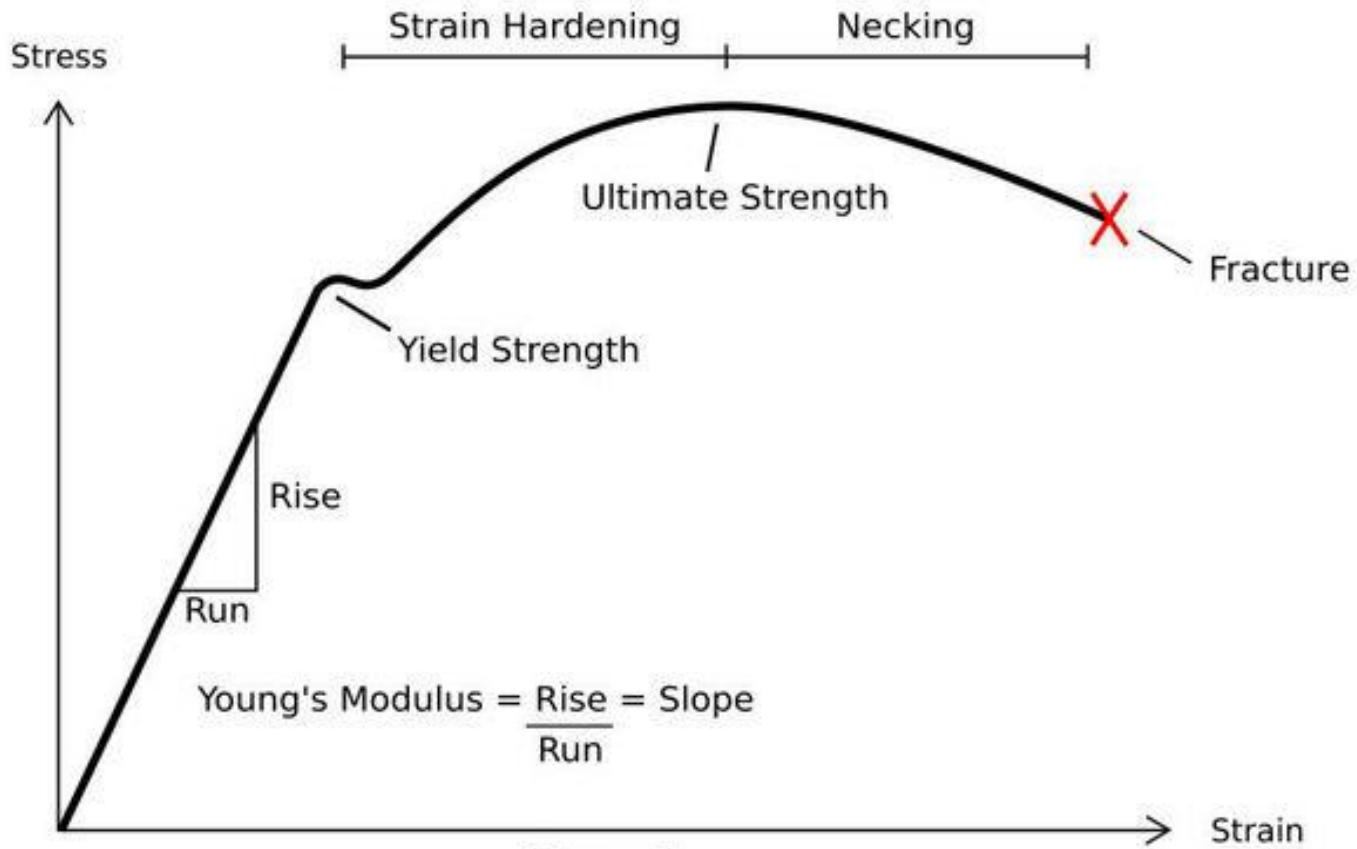
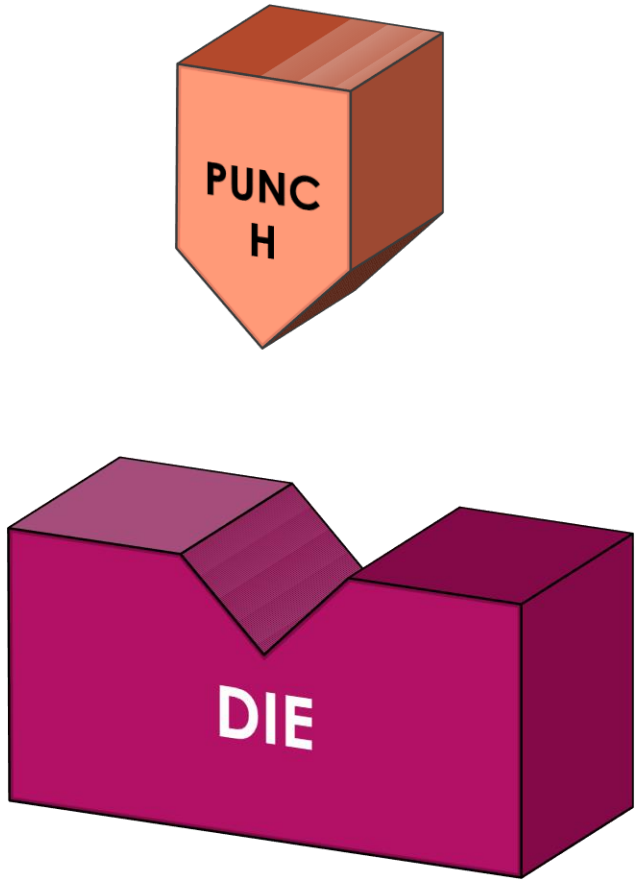


Figure 1

PUNCH AND DIE



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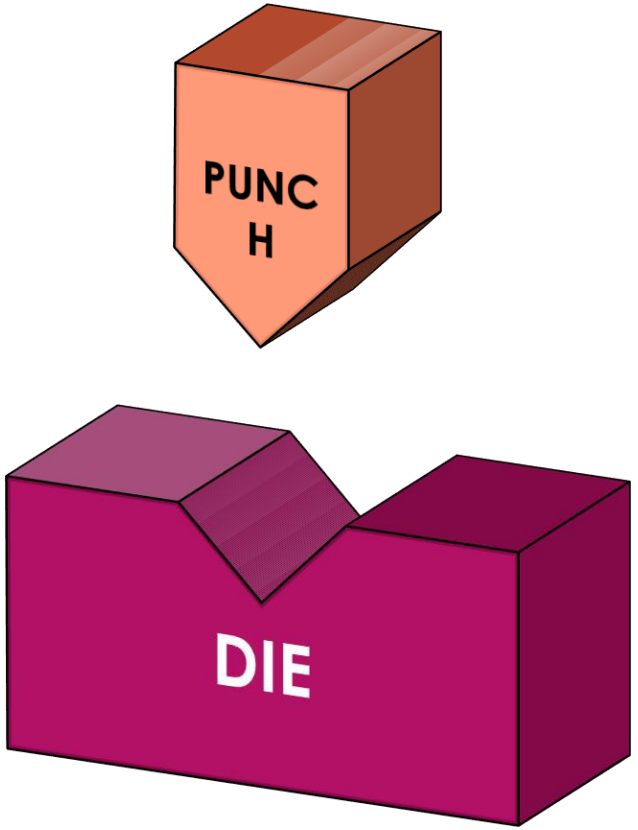

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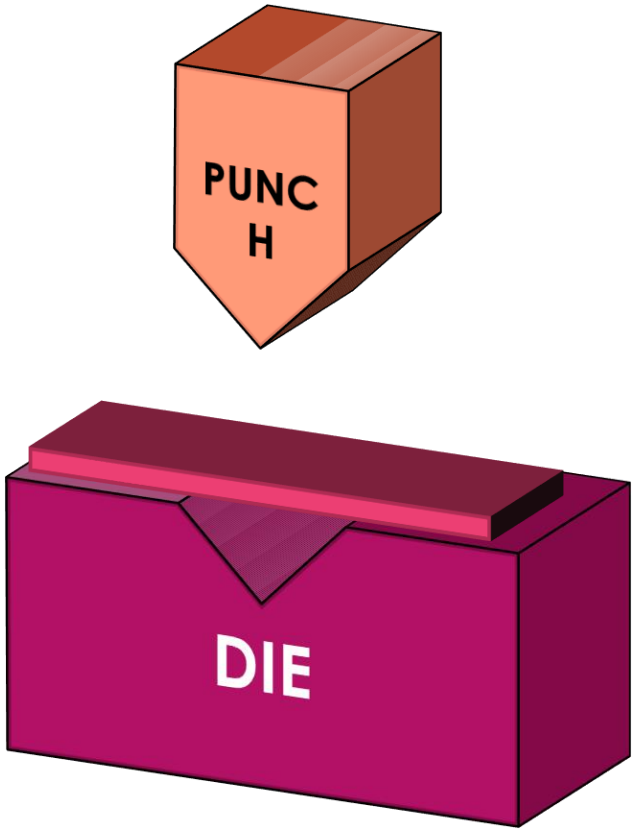

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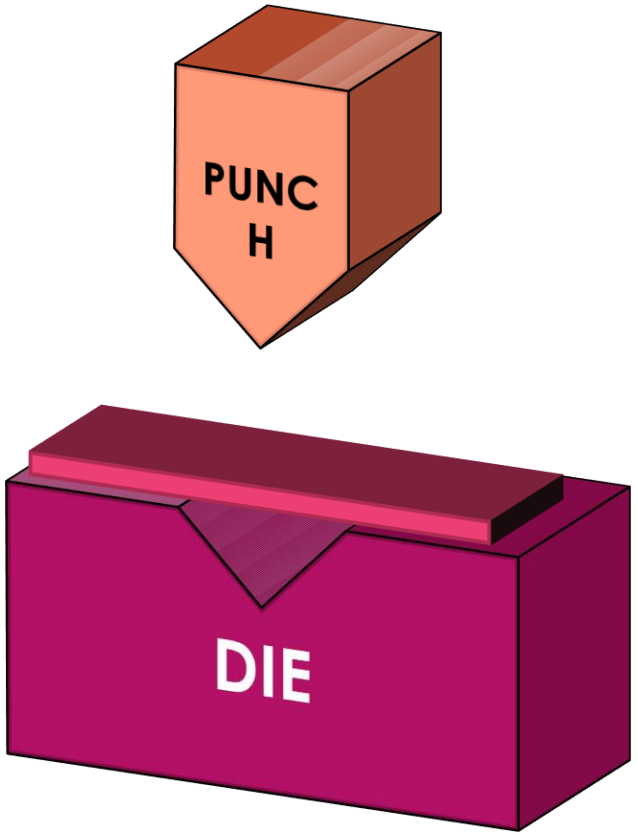

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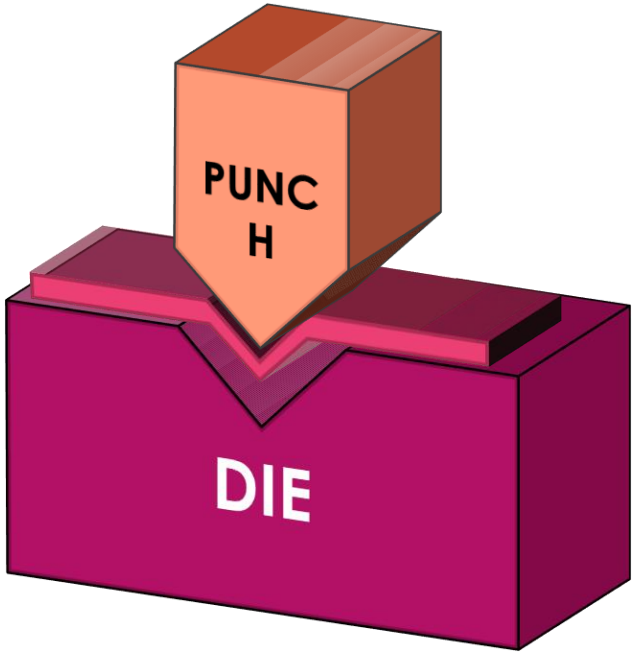

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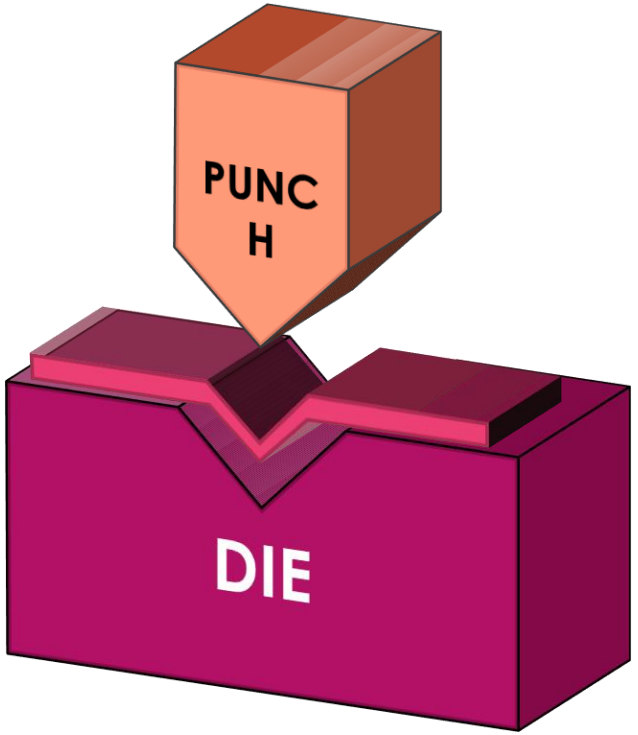
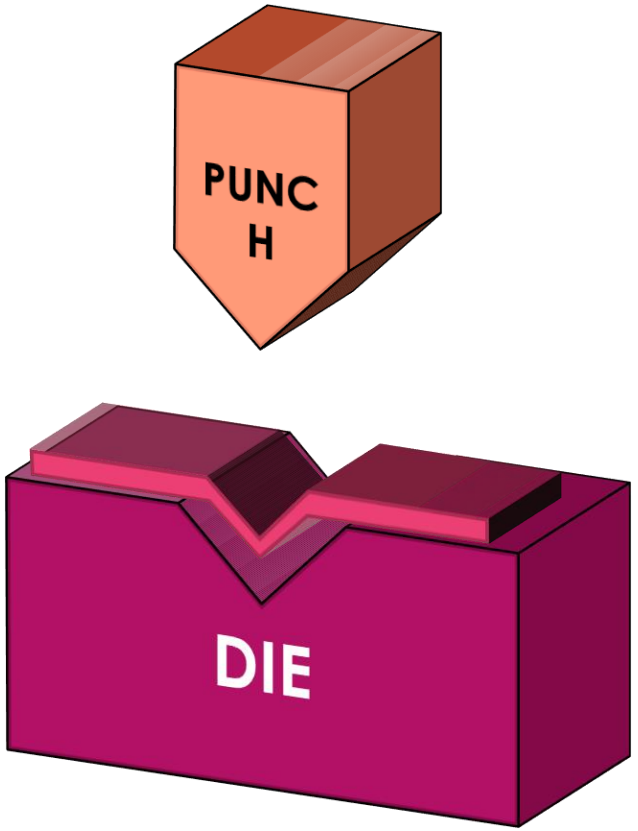


METAL FORMING



METAL FORMING

- Since the material is ***simply moved*** (or ***rearranged***) to produce the shape, as opposed to cutting away unwanted regions, the amount of ***waste can be substantially reduced***.
- Unfortunately, the ***forces required*** are often ***high***.
- Machinery and tooling can be quite expensive for metal forming operations.

METAL FORMING

- To be successfully formed, a metal must possess certain properties.
- Desirable properties include
  - ***low yield strength*** and
  - ***high ductility***.
- These properties are affected by ***temperature***.

EFFECT OF TEMPERATURE

- In metalworking operations, workpiece ***temperature*** can be one of the ***most important process variables***.
- In general, an ***increase*** in ***temperature*** brings about a ***decrease in strength***, an ***increase in ductility***, and a ***decrease in the rate of strain hardening***—all effects that would tend to promote ***ease of deformation***.

EFFECT OF TEMPERATURE

- Forming processes tend to be classified as
  - ***Cold Working***
  - ***Warm Working***
  - ***Hot Working***

COLD WORKING

- The plastic deformation of metals ***below the recrystallization temperature*** is known as cold working .
- Here, the deformation is usually performed at ***room temperature***, but ***mildly elevated*** temperatures may be used to provide increased ductility and reduced strength.

COLD WORKING ADVANTAGES

1. No heating is required.
2. ***Better*** surface finish is obtained.
3. ***Superior*** dimensional control is achieved since the tooling sets dimensions at room temperature.
4. Products possess ***better*** reproducibility and interchangeability.
5. Strength, fatigue, and wear properties are all improved through ***strain hardening***.
6. ***Contamination*** problems are ***minimized***

COLD WORKING DISADVANTAGES

1. ***Higher forces*** are required to initiate and complete the deformation.
2. ***Heavier*** and more powerful equipment and stronger tooling are required.
3. ***Less ductility*** is available.
4. Metal surfaces must be clean and scale-free.
5. Intermediate anneals(heating) may be required to compensate for the loss of ductility that accompanies strain hardening.
6. ***Undesirable residual stresses*** may be produced.

WARM WORKING

- Because plastic deformation properties are normally enhanced by increasing workpiece temperature, forming operations are sometimes performed at temperatures somewhat ***above room temperature*** **BUT** ***below the recrystallization temperature.***
- The term warm working is applied to this second temperature range.

WARM WORKING

- The dividing line between cold working and warm working is often expressed in terms of the melting point for the metal.
- The dividing line is usually taken to be ***0.3 T_m***
- ***T_m*** = is the melting point (absolute temperature) for the particular metal.

WARM WORKING

- The lower strength and strain hardening at the intermediate temperatures, as well as higher ductility, provide warm working with the following advantages over cold working:

1. lower forces and power,
2. more intricate work geometries possible,
3. need for annealing may be reduced or eliminated

HOT WORKING

- ***Hot working*** (also called hot forming) involves deformation at temperatures above the recrystallization temperature.
- The recrystallization temperature for a given metal is about one-half of its melting point on the ***absolute scale (Kelvin or Rankine)***.
- In practice, hot working is usually carried out at temperatures somewhat ***above 0.5 T_m*** .
- In some books it has been given ***above 0.6 T_m*** .

HOT WORKING

- ***Scale*** *(a coating of oxide formed on heated metal)* on the work surface is accelerated at higher temperatures.
- Accordingly, hot working temperatures are usually maintained with in the range ***0.5 T_m*** to ***0.75 T_m*** .

HOT WORKING ADVANTAGES

1. The shape of the workpart can be ***significantly*** altered
2. ***Lower forces*** and power are required to deform the metal
3. Metals that usually fracture in cold working ***can be hot formed***
4. No strengthening of the part occurs from work hardening.

HOT WORKING DISADVANTAGES

1. Lower dimensional accuracy
2. Higher total energy required (due to the thermal energy to heat the workpiece),
3. Work surface oxidation (scale),
4. Poorer surface finish, and
5. Shorter tool life.

References:

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- Degarmo, E. P., Kohser, Ronald A. and Black, J. T., Materials and Processes in Manufacturing, Prentice Hall of India (2008) 8th ed.
- Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, Dorling Kingsley (2006) 4th ed.

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