Tool Materials

- **Ferrous materials**
  - Tool steel, alloy steel, carbon steel, cast iron
- **Non-ferrous materials**
  - Aluminum, Zinc, Lead, Bismuth
- **Non-metallic materials**
  - Plastics, rubbers, epoxy resins

Physical and Mechanical Properties

- Weight
- Thermal and electrical conductivity
- Melting point
- Strength
  - Tensile
  - Compressive
  - Shear
  - Yield
Physical and Mechanical Properties

- Hardness
  - Rockwell
  - Brinell
- Wear resistance
- Toughness
- Plasticity
- Ductility
- Britteness
- Malleability

Ferrous Tool Materials

- Conditions
  - Hot rolled
  - Cold rolled
  - Ground

Ferrous materials

- Carbon steels
  - Low carbon 0.05% to 0.30% C
    - Soft,
    - Tough,
    - Easily machined, and
    - Welded
  - Case hardened
    - Used for tool bodies, handles, die shoes, where strength and wear resistance is not required.
Ferrous materials

• Carbon steels
  – Medium carbon 0.30 to 0.70% C
  • Great strength and toughness
  • Normal heat treatment can be given
  – Used for tool parts such as studs, pins, axles and nuts
  – High carbon 0.70 to 1.50% C
  • Wear resistance is required
  – Used for Drill bushings, locators, and wear pads

Alloy steels

• Carbon steels with additional alloying elements
• Expensive
Tool steels

- W – water hardening tool steels
  - Plain carbon (W1) and carbon vanadium (W2)
  - Low cost
- O – oil hardening tool steels
  - Manganese oil hardening steels
  - Better wear resistance
- A – Air hardening die steels
  - Better wear resistance

Heat treatment for ferrous materials

- Normalizing
- Spheroidizing
- Stress relieving
- Annealing
- Hardening
- Tempering
- Case hardening

Hardening consists of three operations

1. Heating
   - Preheating
   - Austenitization
   - Quenching
2. Quenching
   - Hardening the heated metal in a liquid
   - Cooling in air/gas
3. Tempering
   - Heating the quenched metal to a lower temperature
   - Cooling in air/gas
Fig. 62. TTT diagram for UH2 (AISI W1). Austenitising (hardening) temperature 720°C.

Fig. 71. Hardness and toughness of Stavax after tempering at different temperatures. Tempering at 250°C gives a good combination of hardness and toughness.
Fig. 66. TTT diagram for Art (95) & Zn. Austenitizing (hardening) temperature 80°C.

Fig. 66. TTT diagram for Alice (S) O1. Austenitizing (hardening) temperature 85°C.

Fig. 67. Tempering diagram for Alice (S) O1. The beginning of each curve shows the normal hardness after quenching from each respective hardening (austenitizing) temperature.
Tool steels

- **D** – high carbon high chromium die steels
  - Used for long run dies
  - Tough and good wear resistance
- **S** – shock resisting tool steels
  - Low carbon and high toughness
- **H** – hot work die steels
  - Low carbon and high alloy content

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Tool steels

- **T and M** – tungsten and molybdenum based high speed steels
  - Good red hardness and abrasion resistance
- **L** – low alloy tool steels
  - Limited application
  - Coining and impression dies
- **F** – finishing steel
Cast iron

- High compressive strength and easy casting
- Large forming and drawing dies

Non-ferrous Tool Materials

- Aluminum
  - High strength to weight ratio
  - Corrosion resistant
  - Supports and locators to base plates and tool bodies
- Magnesium
- Bismuth alloys
  - Low melting temperature
Heat treatment for Non-ferrous materials

- Cold work
- Precipitation hardening

Hot working operations

- **Operations**
  - Warm forging, dies and punches
  - Roll forging, rolling segments
  - Upset forging, clamping tools
  - Progressive forging, dies
  - Axial closed die rolling, top and bottom dies
  - Cross forming, segments
  - Hot bending, tools
  - Hot calibration, tools
  - Zinc die casting, dies
  - Al-tube extrusion.

Hot working operations

- **Properties required**
  - Wear resistance
  - Toughness
  - High hot wear resistance
  - Very good high temperature properties
  - High resistance to thermal fatigue
  - Very good temper resistance
  - Very good thermal conductivity.
Cold working operations

- Operation
  - Cold Forging
  - Cold Rolling
  - Cold Extrusion
  - Sheet metal operations

Properties required
- high hardness
- high volume of carbides
- high hardness of the carbides
- large carbide size
- Wear resistance
- Toughness
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