- Common tool materials
  - Requirements of tool materials
    - High Hot hardness
    - High strength and toughness (impact resistance)
    - Thermal shock resistance
    - High wear resistance
    - Chemical stability
    - High thermal conductivity
    - Low cost
  - Cast-cobalt Alloys
    - Less suitable than high-speed steels for interrupted cutting operations
    - good wear resistance
    - high hardness
    - not tough as high-speed steels and are sensitive to impact forces
    - can maintain their hardness at elevated temperatures
  - High-speed Steels
    - can be hardened to various depths
    - have good wear resistance
    - inexpensive
    - There are two basic types
      - molybdenum (M-series)
      - tungsten (T-series)
    - available in wrought, cast and powder-metallurgy (sintered) forms
    - can be coated for improved performance
  - Carbides
    - Low thermal expansion
    - High thermal conductivity
    - Cost-effective tool for a wide range of applications
    - High elastic modulus
    - High hardness over a wide range of temperatures
    - Versatile
    - Tungsten Carbide:
      - consists of tungsten-carbide particles bonded together in a cobalt matrix
      - As the cobalt content increases, the strength, hardness, and wear resistance of WC decrease
      - Its toughness increases? because of the higher toughness of cobalt
    - Titanium Carbide:
      - Consists of a nickel–molybdenum matrix
      - Has higher wear resistance than tungsten carbide; but is not as tough
      - Suitable for machining hard materials and for cutting at speeds higher than tungsten carbide
  - Coated Tools
    - Lower friction
    - Higher adhesion
    - Higher resistance to wear and cracking
    - Acting as a diffusion barrier
    - Higher hot hardness and impact resistance
    - Common coating materials are:
      - Titanium nitride
      - Titanium carbide
      - Titanium carbonitride
      - Aluminum oxide
    - Coatings are applied on cutting tools and inserts by two techniques:
      - Chemical-vapor deposition (CVD)
      - Physical-vapor deposition (PVD)
    - Coatings have the following characteristics:
      - High hardness
      - Chemical stability and inertness
      - Low thermal conductivity
      - Compatibility and good bonding
      - Little or no porosity
  - Diamond
    - The hardest known material
    - have low friction, high wear resistance and the ability to maintain a sharp cutting edge
    - used when a good surface finish and dimensional accuracy are required
    - Synthetic or industrial diamonds are used, as natural diamond has flaws and performance can be unpredictable
    - As diamond is brittle, tool shape and sharpness are important
  - Silicon-nitride-based Ceramics
    - Tools have high toughness, hot hardness
    - consist of silicon nitride with various additions of aluminum oxide, yttrium oxide and titanium carbide
    - good thermal-shock resistance
    - Due to chemical affinity to iron at elevated temperature, SiN-based tools are not suitable for machining steels
  - Cubic Boron Nitride
    - The hardest material available after diamond
    - CBN provides shock resistance
    - high wear resistance and cutting-edge strength
    - At elevated temperatures, it is chemically inert to iron and nickel
    - Its resistance to oxidation is high and suitable for cutting hardened ferrous and high-temperature alloys
  - Alumina-based Ceramics
    - Additions of titanium carbide and zirconium oxide improve toughness and thermal shock resistance
    - very high abrasion resistance and hot hardness
    - Ceramic
      - consist of fine-grained and high-purity aluminum oxide
    - Cermets
      - Consist of ceramic particles in a metallic matrix
      - They are chemical stability and resistance to built-up edge formation
      - brittle, expensive and limited usage