Overview

- Machining center
  - Turning
  - Boring
  - Drilling
  - Planing
  - Nearly any machining process
  - CNC - automated
- Reconfigurable machines
  - Modular components allow for easy reconfiguration
- Trends in design and materials for machine tools
  - Independent variables (you get to choose)
    - Stiffness
    - Vibration
    - Chatter
    - Damping characteristics
  - Dependent variables (determined by independent variables)
    - Surface quality
    - Dimensional accuracy
    - Tool life
    - Productivity
    - Machining Economics
Examples of Parts Machined Using Machining Centers

- Note that no one machining operation could produce any of these parts

Machining Center

- Computer-controlled machine
- Workpiece is stationary (fixtured)
- Machining operation is brought to the workpiece
Machining Center Components and Definitions

- **Pallet**
  - Workpiece fixtured on it

- **Automatic tool changer (ATC)**
  - Takes tool from storage to spindle

- **Touch probes**
  - Check dimensions of tool and part

- **Traveling column**
  - Changes position of spindle

- **Bed**
  - Pallet and column move on this rigid fixture

- **Envelope**
  - Dimensions that the cutting tools can reach

---

Pallet Flow in a Manufacturing Process

- The workpiece is attached to a pallet prior to entering a machining center
  - Less time between machining workpieces
  - Saves money
**ATC**

- Tool storage – up to 200 cutting tools can be stored
  - Magazine
  - Drum
  - Chain
- Automatic tool changing
  - Saves time (takes only 5 – 10 sec typically)
  - Saves money

---

**Touch Probes**

- Touch probes determine
  - Workpiece dimensions
  - Tool dimensions
    - Tool wear
Vertical Machining Centers

- Deep cavities
  - Molds
  - Dies
- Handles thrust forces
  - Good dimensional accuracy
  - Less expensive than HMCs

Horizontal Machining Centers (HMC)

- Typically for Tall workpieces
- Universal machining centers combine both
  - VMC
  - HMC
Chip Management

- Chip conveyors necessary
  - High production rate of parts
  - High production rate of chips
- Spindle speeds
  - Typically 4,000 – 8,000 rpm
  - As high as 75,000 rpm
  - Chips galore

Characteristics of Machining Centers

- Operate efficiently, economically, repetitively
  - Tolerances typically 0.0001"
- Versatile and capable of quick changeovers
- Times reduced
  - Loading and unloading workpieces
  - Changing tools
  - Gaging the part
  - Troubleshooting
- Detection of worn and broken tools
  - Position compensation for worn tools
- In-process and post-process gaging
- Completely automated – reduces labor costs
Machine-Tools Structural Materials
(Relatively Cheap)

• Structures are typically made of
  – Gray cast iron
    • Good damping
    • Low cost
    • Heavy
  – Welded steel
    • High stiffness-to-weight ratio
    • Low damping capacity

Machine-Tools Structural Materials
(Relatively Expensive)

• Granite-epoxy
  – Good castability
  – High stiffness-to-weight ratio
  – Thermal stability
  – Resistance to environmental degradation
  – Good damping capacity
• Polymer concrete
  – Good damping capacity
  – Low stiffness
  – Poor thermal conductivity
• Ceramic
  – Strong
  – Stiff
  – Corrosion resistant
  – Gives good surface finish
  – Good thermal stability
  – Low density – good for high speed machinery
• Composites (polymer-matrix, or metal-matrix, or ceramic matrix)
  – Allows for high-accuracy
  – High speed machining
  – Expensive
Design Considerations

- Consider the following factors
  - Design, materials, construction
  - Spindle materials and construction
  - Thermal distortion and machine components
  - Error compensation and motion control in the slideways

Alternative Development

- Hexapod machine – new design considerably different from traditional machining centers
- Increased machining flexibility and larger envelope
- Telescoping tubes (struts or legs) control six sets of coordinates
  - 3 linear
  - 3 rotational
- Characteristics of the hexapod
  - High stiffness
  - Not as massive as a machining center
  - 1/3 fewer parts
  - Large machining envelope
  - High flexibility