Lecture 21

Chapter 25
Machining Centers, Advanced
Machining Concepts and
Structures, and Machining
Economics (cont.)

Vibrations and Chatter

• Vibrations and chatter occurs in cutting tools and
  machine components
  – Low stiffness
  – Low damping

• Effects of vibrations and chatter
  – Poor surface finish
  – Loss of dimensional accuracy
  – Premature wear/chipping of tools
  – Possible damage to machine tool components
  – Noise
Forced Vibrations

• Forced vibration – caused by a periodic applied force
  – Gear drives
  – Imbalance of machine-tool components
  – Misalignment
  – Motors
  – Pumps
  – Entry and exit from a workpiece

Removal of Forced Vibrations

• Solution: isolate or remove the forcing element
  – Natural frequency – \( \omega_n \)
    • Increase/Decrease k (increasing preferred)
    • Increase damping
  – Cutting parameters generally does nothing
    • Cutting speed change helps
    • Tool geometry change helps
  – Direct driving forces closer to center of gravity
    • Reduce bending moment
Self Excited Vibrations (Chatter)

• Cause: Interaction of the chip removal process and the structure of the tool
  – Type of chips produced
  – Lack of homogeneity in the workpiece material or its surface conditions
  – Variations in the frictional conditions at the tool-chip interface

• Solution
  – Increase stiffness
  – Increase damping

Factors Influencing Chatter

• Chatter is proportional to:
  – Cutting forces
  – Depth of cut
  – Width of cut
  – Hardness

• Chip type
  – Continuous chip means steady forces – no chatter
  – Discontinuous or serrated means unsteady forces – chatter possible

• Other factors
  – Dull cutters
  – Lack of cutting fluids
Internal Damping of Structural Materials

- Damping is the rate at which vibrations decay
- External Damping – from outside sources
  - Floors
    - Specially prepared
    - Reinforced foundations

Joints in Machine Tools

- Internal damping – energy loss in materials during vibration
  - Bolted joints dampen a machine-tool system
    - Reduces overall stiffness
Guidelines for Reducing Vibration and Chatter

- Minimize tool overhang
- Improve stiffness
  - Workholding devices
  - Support workpieces rigidly
- Modify tool and cutter geometry to minimize forces and make them uniform
- Change cutting processes
  - Cutting speed
  - Cutting fluids
- Increase the stiffness of the machine tool and its components
  - Higher E
  - Larger cross-sections
- Improve the damping capacity of the machine tool

Machining Economics

- Limitations of machining (but machining is still important)
  - Relatively long time for machining (relative to forming/shaping)
  - Need to reduce non-cutting time
  - Material is wasted
- Economic factors
  - Tools / Machine Tools / Fixtures
  - Labor and overhead
  - Time for setup
  - Material handling
  - Gaging (Metrology)
  - Cutting and Non-Cutting times
Optimal Economics

Rest of notes are board-work