Lecture 18

Chapter 24
Milling, Sawing, and Filing; Gear Manufacturing
(cont.)

Planing

- For production of:
  - Flat surfaces
  - Grooves
  - Notches
- Performed on long (on average 10 m) workpieces
- Workpiece moves / Tool is stationary
- Uses a reciprocating motion
  - Typically only on stroke cuts
    - Not efficient or economical
- Due to length of cut – chip breakers are necessary
Shaping

• Same as planing except tool moves
• Specific process – horizontal shaper
  – Tool travels back and forth along a straight path
• Typically the forward ram movement cuts (push cut)
• Others cut on the return stroke of the ram (draw cut)

Broaching

• For production of:
  – Internal surface features
    • Holes
      – Circular
      – Rectangular
      – Irregular
    • Keyways
    • Teeth of internal gears
    • Multiple spline holes
  – External surface features
    • Flat surfaces
    • Grooved surfaces
Broaching

- Similar to shaping except it is a multi-tooth cutter
- Broach depth of cut = sum of depth-of-cut of each tool
- Gives relatively good
  - Surface finish
  - Dimensional accuracy
- Tooling is expensive – for high-quantity production runs

- Rake (hook) angle depends on material cut
- Clearance is typically between $1^\circ$ and $4^\circ$
- Pitch of teeth depends on:
  - Length of cut
  - Tooth strength
  - Size and shape of chips
- Pitch = $k(l)^{0.5}$
  - $k = 1.76$ when $l$ is in mm
Chip Breakers and Processing

- Chip breakers for broaches
  - Slots placed along a tooth
  - Staggered
- Process for internal broaching
  - Drill hole
  - Boring
  - Broaching

Other Broaching Operations

- Pull type internal broach
- Broaching of crankshafts
Other Broaching Operations

- Several different pull-type broaches

Broaching Process Parameters and Guidelines

- Process parameters
  - Broach materials
    - M2 and M7 HSS
    - Carbide inserts
    - Coatings
      - Improve tool life
      - Surface finish
  - Cutting fluids are recommended especially for internal broaching

- Design Guidelines
  - Parts
    - Design for ease of clamping
    - Parts should have sufficient structural strength and stiffness
  - Avoid blind holes, sharp corners, dovetail splines
  - Chamfers are preferred over round corners
Sawing

- **Definition**
  - Cutting with a tool consisting of a blade with a series of small teeth
- **Kerf** – width-of-cut
- **Saw blades** are generally high carbon and HSS
- **Sawing thin stock**
  - Thinner stock needs finer teeth and more teeth per unit length
  - At least 2 teeth need to be engaged to prevent snagging

**Different Types of Saws**

- **Hacksaws**
  - Straight blades
  - Reciprocating motion
    - Cutting only takes places on one stroke (push or pull)
- **Circular saws**
  - Used for “cutting off” processes
  - Circular blade with teeth along:
    - Outer diameter
      - Large, irregular cross sections
    - Inner diameter
      - Cutting of single crystal Si wafers
- **Band saws**
  - Long, flexible blades
  - Allow for continuous cutting – more economical
Filing

- Involves the removal, on a small-scale, of material from:
  - Surfaces
  - Corners
  - Edges
  - Holes
- Common use for removal of burrs
- Usually made from high carbon or HSS
- Typical shapes (non-rotary)
  - Rectangular
  - Circular
  - Triangular

Gear Manufacturing

- Gears: a mechanism by which to transmit rotational motion for:
  - Conversion to linear motion
  - Conversion to rotational motion at the same/different velocities and torques
- Gear-tooth quality affects:
  - Energy transmission
  - Vibration and noise
  - Frictional and wear characteristics
There are 2 main methods of forming gears
- Form cutting
- Generating

Form cutting
- Cutter mounted on an arbor travels parallel to axis of gear
- After each pass the gear is rotated a constant amount

Broaching is a form cutting method
- Used particularly for internal gear teeth
- Cost-effective only for high-quantity production
Gear Generating

- Pinion shaped cutter
  - Cutter rotates slowly while axially reciprocating
- Rack shaper
  - Reciprocates parallel to axis of gear blank that is incrementally rotating

Gear Hobs

- Hob – gear-cutting screw
  - Hob and gear blank rotate at the same time and at different rates
  - Creates
    - Spur gears
    - Helical gears
  - Hobbing is used extensively in industry
Gear Finishing

- Gear-tooth quality affects:
  - Energy transmission
  - Vibration and noise
  - Frictional and wear characteristics
- Shaving – removes small amounts of material from tooth profile
- Burnishing – surface plastic deformation process
  - Resulting cold worked piece
    - Compressive residual stresses in tooth surface
    - Improved fatigue life
- Grinding, honing and lapping
  - Final three processes (performed in the above order) to give a gear superior:
    - Accuracy
    - Lifetime
    - Quiet operation
    - Low production rates
    - Costly

Gear Manufacturing Costs

- Higher number gives:
  - Higher dimensional accuracy
  - Higher price