Catalog Component Selection

24-370 - Spring 2011
Professor Steve Collins

Reminders and Announcements

• Project 2 component orders due in 2 weeks
  – Budget of $250 per team, details today
  – Reversal: Output shaft will have flat...
• HW5 due in class Wednesday
• Graded HWs and reports in personal folders
• Mid-Semester Feedback Form
Catalog Component Selection

• Why purchase parts from a catalog?
  – Can be cheaper, easier than custom design
• When purchase parts from a catalog?
  – Complex commodities, e.g. fasteners, bearings, gears
  – Complex stock, e.g. wire rope, tubing, shafting
• Why not purchase parts from a catalog?
  – Might not be exactly what you want
• When not purchase parts from a catalog?
  – Specialized parts, e.g. manifolds
  – High-performance commodity items

Catalog Component Selection

• Another way of thinking about it:
  – Catalog parts do most of the tricky tasks
  – Custom parts hold everything together nicely
# Common components to purchase

- Materials
- Fasteners
- Shafts
- Bearings
- Gears
- Belts and Pulleys
- Cables and Capstans
- Springs
- Electromechanical items: motors, sensors (later)

# Prominent catalog sources

- McMaster-Carr: [www.mcmaster.com](http://www.mcmaster.com)
  - Fasteners, bearings, shafts, wire rope, most things...
- Stock Drive Products: [www.sdp-si.com](http://www.sdp-si.com)
  - Gears, belts and pulleys
- Many others, such as:
  - MSC Industrial Supply: [www1.mscdirect.com](http://www1.mscdirect.com), W. M. Berg: [www.wmberg.com](http://www.wmberg.com)
  - Quality transmission: [www.qtcgears.com](http://www.qtcgears.com)
  - Harmonic Drive: [www.harmonicdrive.net](http://www.harmonicdrive.net), Gordon Composites: [www.gordoncomposites.com](http://www.gordoncomposites.com)
  - Carbon Fiber Tube Shop: [www.carbonfibertubeshop.com](http://www.carbonfibertubeshop.com), Airpot: [www.airpot.com](http://www.airpot.com)
General catalog source issues

• Lead time
  – Is the item in stock?
  – How long until it ships and arrives?

• Cost
  – Prices listed?
  – Part and shipping costs

• Minimum quantities
  – Price breaks?

• Reliability

Selecting catalog components

• Process overview
• Specific components:
  – Shafts
  – Bearings
  – Spur Gears
  – Belts and Pulleys
  – Wire Rope (and capstan design)
  – Springs
  – Fasteners
Selecting catalog components

- Generic selection process:
  - Identify important component properties
  - Perform simple analyses to determine requirements
  - Try to find desirable components
  - Iterate

Selecting Shafts

- What properties are important?
  - Strength: material, diameter
  - Interface: diameter

- Shaft-centric process:
  - Guess at material, e.g. 304 stainless steel
  - Simple model analysis to obtain min diameter
  - Step up to available/convenient value

- Bearing-centric process:
  - Do bearing analysis, pick shaft that fits

- Other-centric process: diameter(s) to fit parts
### Selecting Bearings

- **What properties are important?**
  - Strength: maximum radial load, axial load
  - Size: inner and outer diameter, width
  - Speed: maximum angular velocity (sometimes)

- **Design and selection process:**
  - Simple model analysis to obtain loading (and speed)
  - Guess at good bearing type (plain, ball, etc.)
  - Go to catalog to find candidate parts

### Selecting Spur Gears

- **What parameters are important?**
  - Diameter(s): gear ratio
  - Strength: material, tooth geometry, width

- **Process: iterative guess and check**
  - Simple model analysis using gear model...
\[ \sum M = 0 \quad \sum F = 0 \]

\[ F_n = \frac{l_n}{l_h} F_L \quad F_R = F_L + F_n = F_L \left(1 + \frac{l_n}{l_h}\right) \]

\[ F_L = 50 \text{ lb}, \quad l_L = 5 \text{ in}, \quad l_h = 1 \text{ in}. \]

McMaster Carr 
5905K131
F.O.S. = 2
Speed = 5 rad/s

\[ F_R = 300 \text{ lbf} \quad \Rightarrow 600 \text{ lbf} \quad \text{2 Bearings} \]

Friction: ?
Speed: Slow
Size: ?
Tolerance: ?

\[ \frac{300 \text{ lb}}{3 \times \frac{1}{16} \times \frac{1}{4}} = 6,400 \text{ lb/ft}^2 \]

F.O.S. = 2, Peak force (radial load) = 300 lbf

Case 1: Size critical
- Speed low
- Friction OK
\[ \Rightarrow \text{Bushing, E6.60695K1} \]

Case 2: Size critical
- Speed medium
- Friction critical
\[ \Rightarrow \text{Needle roller, E6.5905K21} \]

Case 3: Speed high
- Friction critical
- Tolerances critical
\[ \Rightarrow \text{Ball bearing, E6.57155K302} \]
Simple gear model

• Gear tooth as beam in bending
• \( \sigma_m = W^t \cdot P \cdot F^{-1} \cdot Y^{-1} \)
  – \( W^t \) is transmission load
  – \( P \) is diametral pitch
  – \( F \) is face width
  – \( Y \) is form factor (14-2)
• Diametral pitch (teeth/inch) ≠ pitch diameter (inch)

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Selecting Spur Gears

• What parameters are important?
  – Diameter(s): gear ratio
  – Strength: material, tooth geometry, width
• Simple model: gear tooth as beam in bending
  – \( \sigma_m = W^t \cdot P \cdot F^{-1} \cdot Y^{-1} \), where \( W^t \) is transmission load, \( P \) is diametral pitch, \( F \) is face width, \( Y \) is form factor (14-2)
  – Diametral pitch (teeth/inch) ≠ pitch diameter (inch)
• Process: Iterative guess and check
  – Start with low \( P \), check available sizes, verify strength
• Detailed analysis, see Shigley Ch. 14 (more later)
Selecting Timing Belts and Pulleys

• What parameters are important?
  – Diameter(s): gear ratio
  – Strength: belt style, width

• Process:
  – Simple model analysis
    • Include pre-tension
  – Iterative guess and check
    • Select small pulley diameter
    • Use manufacturer specifications to determine width

Selecting Wire Rope

• What parameters are important?
  – Strength: breaking strength (diameter, material)
    • Breaking strength ≠ operating load!
  – Flexibility: construction

• Process:
  – Simple model analysis
    • Gearing force analysis
    • Min. drum/capstan diameter ≈ 20 x cable diameter
  – Iterative guess and check
    • Start with low rope and capstan diameter, work up to meet load requirements
## Selecting Springs

- **What parameters are important?**
  - Strength: maximum load
  - Stiffness
  - Size: resting length, diameter
- **Process:**
  - Simple model analysis
    - Find required stiffness, strength
    - Get idea of tolerable size
  - Iterative guess and check
    - Usually hard to find small springs that take load

## Selecting Fasteners

- **What parameters are important?**
  - Strength: tensile cross-sectional area
  - Size: nominal diameter
  - Pitch: something standard
  - Durability: material, finish, head type
- **Process:**
  - Simple model analysis
    - Find required $A \rightarrow$ nominal diameter
    - Or, guess and check when intuition is good
  - Find desired part in catalog