Catalog Component Selection

24-370 - Spring 2011

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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
  - Fasteners, bearings, shafts, wire rope, most things…
- Stock Drive Products: www.sdp-si.com
  - Gears, belts and pulleys
- Many others, such as:

  MSC Industrial Supply: www1.mscdirect.com, W. M. Berg: www.wmberg.com, Quality transmission: www.qtcgears.com, Harmonic Drive: www.harmonicdrive.net, Gordon Composites: www.gordoncomposites.com, Carbon Fiber Tube Shop: www.carbonfibertubeshop.com, Airpot: 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

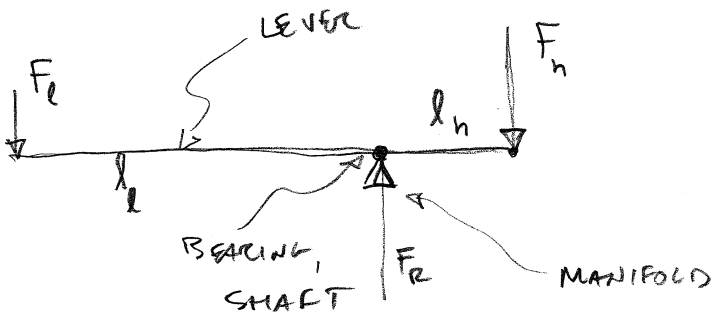
- What properties are important?
  - Strength: maximum radial load, axial load
  - Size: inner and outer diameter, width
  - Speed: maximum angular velocity (sometimes)
- Design and selection process:
  - Simple model analysis to obtain loading (and speed)
  - Guess at good bearing type (plain, ball, etc.)
  - Go to catalog to find candidate parts

Selecting Spur Gears

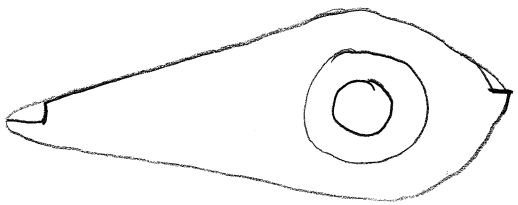
- What parameters are important?
  - Diameter(s): gear ratio
  - Strength: material, tooth geometry, width
- Process: iterative guess and check
  - Simple model analysis using gear model…

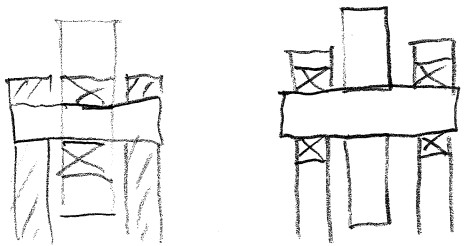
$\Sigma M = 0$ ↷ $\Sigma F = 0$

$F_h = \frac{l_l}{l_h} \cdot F_l$ $F_R = F_L + F_h = F_l\left(1 + \frac{l_l}{l_h}\right)$



$F_l = 50$ lb, $l_l = 5$ in $l_h = 1$ in.





MCMASTER CARR #
5905K131

F.O.S.? 2

SPEED = 5 RAD/S

$F_R = 300$ lbf ⇒ FOS 600 lbf (2 BEARINGS → 300)

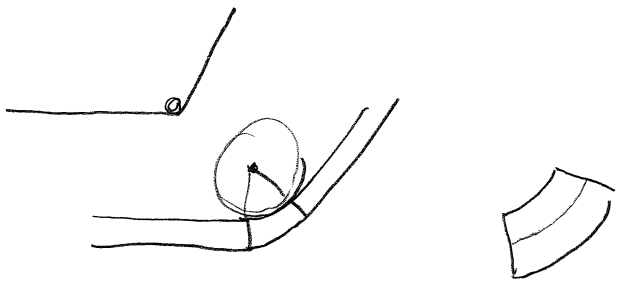
FRICTION: ?

SPEED: SLOW

SIZE: ?

TOLERANCE: ?

$$\frac{300 \text{ lb}}{\frac{3}{16} \cdot \frac{1}{4}} = 6,400 \frac{\text{lb}}{\text{in}^2}$$



F.O.S = 2, PEAK FORCE (RADIAL LOAD) = 300 lbf

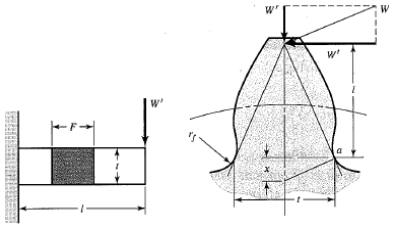
CASE 1: SIZE CRITICAL, SPEED LOW, FRICTION OK ⇒ BUSHING E.G. 6695K1

CASE 2: SIZE CRITICAL, SPEED MEDIUM, FRICTION CRITICAL ⇒ NEEDLE ROLLER E.G. 5905K21

CASE 3: SPEED HIGH, FRICTION CRITICAL, TOLERANCES CRITICAL ⇒ BALL BEARING E.G. 57155K302

Simple gear model

- Gear tooth as beam in bending
- $\sigma_m = W^t P F^{-1} Y^{-1}$
  - 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)



Number of Teeth	Y	Number of Teeth	Y
12	0.245	28	0.353
13	0.261	30	0.359
14	0.277	34	0.371
15	0.290	38	0.384
16	0.296	43	0.397
17	0.303	50	0.409
18	0.309	60	0.422
19	0.314	75	0.435
20	0.322	100	0.447
21	0.328	150	0.460
22	0.331	300	0.472
24	0.337	400	0.480
26	0.346	Rack	0.485

Selecting Spur Gears

- What parameters are important?
  - Diameter(s): gear ratio
  - Strength: material, tooth geometry, width
- Simple model: gear tooth as beam in bending
  - $\sigma_m = W^t P F^{-1} Y^{-1}$, 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 → nominal diameter
    - Or, guess and check when intuition is good
  - Find desired part in catalog