Machine Design Test 3

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[1]:
```python
# Notebook Preamble
import sympy as sp
import matplotlib.pyplot as plt

plt.style.use('maroon_ipynb.mplstyle')
```

Contents

1 Problem 11-2

1.1 Given

A certain application requires a ball bearing with the inner ring rotating, with a design life of 25 kh at a speed of 350 rpm. The radial load is 2.5 kN and an application factor of 1.2 is appropriate. The reliability goal is 0.9.

1.2 Find

Find the multiple of rating life required, x_D, and the catalog rating C_{10} with which to enter a bearing table. Choose a 02-series deep-groove ball bearing from Table 11–2, and estimate the reliability in use.

1.3 Solution

The relationship for x_D is,

$$x_D = \frac{L_D}{L_R}$$

[2]:
```
LD = 60*25_000*sp.S(350)
LR = 10**6
xD = LD/LR
xD
```

[2]: 525

The catalog rating comes from Eq. 11-9,

$$C_{10} = a_f F_D \left(\frac{x_D}{x_0 + (\theta - x_0)[\ln(1/R_D)]^{1/b}} \right)^{1/a}$$

[3]:
```
# Weibull parameters
x0, theta = sp.S('0.02'), sp.S('4.459')
b = sp.S('1.483')

a = sp.S(3)
af = sp.S('1.2')
FD = sp.S('2.5')
RD = sp.S('0.9')
C10 = af*FD*(xD/(x0 + (theta - x0)*(sp.log(1/RD))**(1/b)))**(1/a)
C10  # kN
```

[3]: 24.2553302533208

Choose the 02-35 mm with a $C_{10} = 25.5$ (from Table 11-2). The reliability may be estimated using Eq. 11-21.

$$R = \exp\left(-\left\{\frac{x_D\left(\frac{a_f F_D}{C_{10}}\right)^a - x_0}{\theta - x_0}\right\}^b\right)$$

[4]:

```
C10 = sp.S('25.5')
R = sp.exp(-((xD*(af*FD/C10)**a - x0)/(theta - x0))**b)
R
```

[4]:

0.919509230992636

2 Problem 11-8

2.1 Given

A straight (cylindrical) roller bearing is subjected to a radial load of 20 kN. The life is to be 8000 h at a speed of 950 rpm and exhibit a reliability of 0.95.

2.2 Find

What basic load rating should be used in selecting the bearing from a catalog of manufacturer 2 in Table 11–6?

2.3 Solution

The catalog rating may be found using the same procedure from the previous problem.

[5]:
```
LD = 60*8_000*sp.S(950)
LR = 10**6
xD = LD/LR
xD
```

[5]:

456

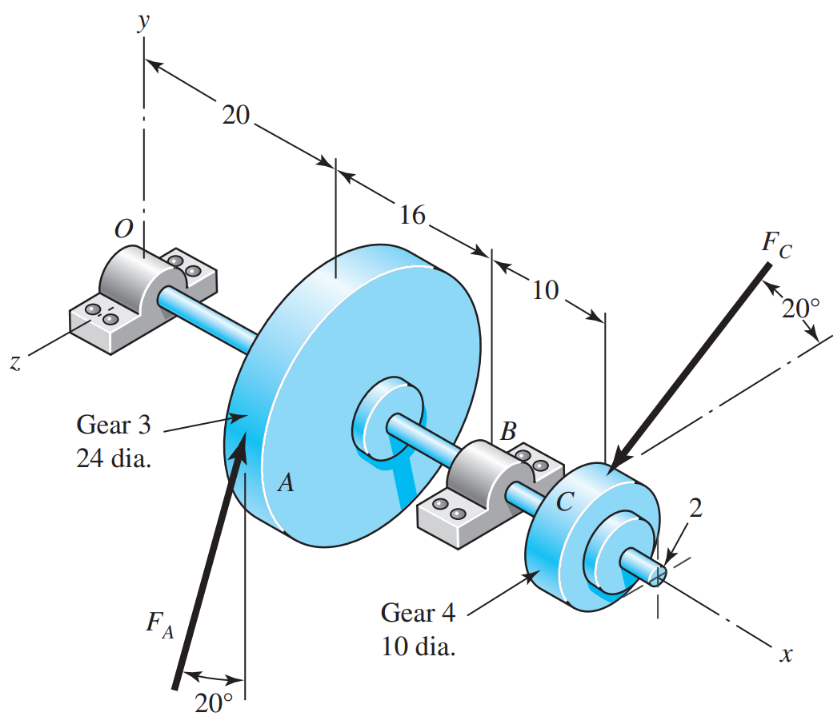
[6]:
```
x0, theta = sp.S('0.02'), sp.S('4.459')
b = sp.S('1.483')

a = sp.Rational(10, 3)
af = 1
FD = sp.S(20)
RD = sp.S('0.95')
C10 = af*FD*(xD/(x0 + (theta - x0)*(sp.log(1/RD))**(1/b)))**(1/a)
C10  # kN
```

[6]:

144.944057059528

3 Problem 11-34

3.1 Given



The figure shown above is a geared countershaft with an overhanging pinion at C. The statics solution gives the force of bearings against the shaft at O as $R_O = -387\hat{j} + 467\hat{k}$ lbf, and at B as $R_B = 316\hat{j} - 1615\hat{k}$ lbf. The shaft runs at a speed of 420 rpm.

3.2 Find

Select an angular contact ball bearing from Table 11-2 for mounting at O and an 02-series cylindrical roller bearing from Table 11-3 for mounting at B. Specify the bearings required, using an application factor of 1.2, a desired life of 40 kh, and a combined reliability goal of 0.95, assuming distribution data from manufacturer 2 in Table 11–6.

3.3 Solution

Calculated x_D first. The combined reliability entails that $R_{D,O} \cdot R_{D,B} = R_{combined}$. If $R_{D,O} = R_{D,B} = R_D$, then $R_D = \sqrt{R_{combined}}$.

[7]:
```
LD = 60*40_000*sp.S(420)
LR = 10**6
xD = LD/LR
xD
```

[7]:

1008

3.3.1 Bearing O

[8]:
```python
x0, theta = sp.S('0.02'), sp.S('4.459')
b = sp.S('1.483')
RD = sp.sqrt(sp.S('0.95'))

kN = sp.S('4.44822')/sp.S(1000)

a = sp.S(3)
af = sp.S('1.2')
FD = sp.sqrt(sp.S(-387)**2 + sp.S(467)**2)
C10 = af*FD*(xD/(x0 + (theta - x0)*(sp.log(1/RD))**(1/b)))**(1/a)
(C10*kN).n()  # kN
```

[8]: 44.2269113767268

For Bearing O, select the 02-55 mm angular contact bearing with a rating of 46.2 kN.

3.3.2 Bearing B

[9]:
```python
a = sp.Rational(10, 3)
af = sp.S('1.2')
FD = sp.sqrt(sp.S(316)**2 + sp.S(-1615)**2)
C10 = af*FD*(xD/(x0 + (theta - x0)*(sp.log(1/RD))**(1/b)))**(1/a)
(C10*kN).n()  # kN
```

[9]: 92.3909500897365

For bearing B, select the 02-75 mm with a rating of 93.1 kN.