Machine Design Homework 6

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Gabe Morris

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

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

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1 Problem 11-1

1.1 Given

Timken rates its bearings for 3000 hours at 500 rpm.

1.2 Find

Determine the catalog rating for a ball bearing running for 10,000 hours at 1800 rpm with a load of 2.75 kN with a reliability of 90%.

1.3 Solution

Use Eq. 11-3,

$$C_{10} = F_D \left(\frac{\mathcal{L}_D n_D 60}{\mathcal{L}_R n_R 60} \right)^{1/a}$$

[2]:
```
FD = sp.S('2.75')
nD = 1800
LD = 10_000
LR = 3_000
nR = 500
C10 = FD*(LD*nD*60/(LR*nR*60))**(1/sp.S(3))
C10  # kN
```

[2]:

6.29592833404333

2 Problem 11-3

2.1 Given

An angular-contact, inner ring rotating, 02-series ball bearing is required for an application in which the life requirement is 40 kh at 520 rpm. The design radial load is 725 lbf. The application factor is 1.4. The reliability goal is 0.90.

2.2 Find

Find the multiple of rating life x_D required and the catalog rating C_{10} with which to enter Table 11–2. Choose a bearing and estimate the existing reliability in service.

2.3 Solution

With the assumed rating life (L_R) to be 10^6,

[3]:
```
LD = 60*40_000*sp.S(520)
LR = sp.S(1e6)
xD = LD/LR
xD
```

[3]: 1248.0

Use Eq. 11-9.

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

[4]:
```
# Weibull parameters
x0, theta = sp.S('0.02'), sp.S('4.459')
b = sp.S('1.483')

a = sp.S(3)
af = sp.S('1.4')
FD = sp.S(725)
RD = sp.S('0.9')
c10 = af*FD*(xD/(x0 + (theta - x0)*(sp.log(1/RD))**(1/b)))**(1/a)
c10  # lbf
```

[4]: 10952.2598806396

[5]:
```
# Convert to kN
C10_kN = c10*4.44822/1000
C10_kN
```

[5]:

48.7180614462586

The bearing selection is the 02-60 mm bearing with $C_{10} = 55.9\ kN$. The reliability may be estimated using Eq. 11-21.

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

[6]:
```
# Getting the reliability
C10 = sp.S('55.9')
FD = FD*4.44822/1000
R = sp.exp(-((xD*(af*FD/C10)**a - x0)/(theta - x0))**b)
R
```

[6]: 0.945295510736457