Bearings and wear surfaces

The purpose of a bearing is to maintain the bearing, housing and shaft centerlines as close to one another as possible for the specified length of time.

Advantages of polymeric bearing

1. Weight saving
2. Elimination of messy and costly lubricant
3. Reduction of friction, impact forces and noise
4. Significant reduction of maintenance requirements

Disadvantages

1. Bearing wear and friction are much more dependant on operating conditions than oil lubricated metal bearing
2. Efficient removal of friction generated heat is critical

Phenolics bearing was introduced in 1900's

Polymer bearings (Non metallic bearings)

1. Wet (water and process fluid lubricated)(rubber bearings)

2. Dry self lubricated (phenolics, Nylon, UHMWPE, flurocarbon resin polyimides etc – mostly widely used in bearing applications)

Nylon – extensively used for light duty automotive and appliance applications

Designer considerations

Need for increased running clearance
Adequate housing retention
Good heat dissipation

self lubricated plastic materials , resins, fabrics and coatings

Flurocarbon resins, fabrics and coatings
Phenolics
Nylon
Acetal
Polyimides
UHMWPE

Fluorocarbons

1. Low dynamic and static coefficient of friction
2. Static or beak away coefficient of friction less than dynamic friction
3. Extremely broad temperature range
4. Not affected by most substances
5. Withstand high pressures in fabric form
6. Easily worked with conventional tools
7. Does not absorb water

Disadvantages

1. Expensive
2. Transmit heat at lower rate
3. Resin form undergoes cold flow under stress

Eg. PTFE -450 to 500 F (lowest cofft of friction, available as sheets, rods, films etc
Flourinated ethylene propylene- higher cofft of friction, upper temperature 392 F

PTFE most widely used . Limited to light loads, low shaft velocities. Fillers improve these drawbacks (eg. Glass fiber); but increase friction

1. Fillers can reduce wear rate by 75%
2. Improve thermal conductivity by a factor of 5
3. Reduce cold flow
4. Improves stiffness

Glass fiber, bronze fillers, graphite etc used

Bronze increases compressive strength hardness, thermal conductivity and reduce cold flow

Fillers accelerate shaft wear. Shaft is costly

<u>Phenolics</u>
Used with textile fillers (cotton, glass fibers, cellulosics fibers)
Graphite and molybdenum disulfide are also used
PV LIMT 15000

USED IN

Automotive suspensions
Agricultural machineries
Rail road and marine applications

Nylon

1. Low wear rate
2. Low cofft of friction
3. Easily moulded and machined
4. Temp 170 F to 300 F
5. Fillers glass fibers, graphite, ptfe etc

PV design value is 1 E 3

PV improved by fillers

C fiber reduces wear rate and cofft. Of friction
Improves thermal conductivity and con be operated at higher PV ratings

Other materials

Acetals (PV rating 3.6 E 3 - 6.5 E 3) , polyimides, UHMWPE

Rubber bearings

Operate dry only for a short time
Needs at fluid lubricant

Advantages

1. Operate well in dirty or gritty water with minimum wear (both bearing and shaft)
2. Low hydrodynamic friction
3. Can operate with any fluid as lubricant
4. Very effective in handling rotating off-balance or off-center loads

5. Do not fail catastrophically

Wear mechanism

Used in marine applications the sea water act as lubricant. The sand or grit particles get trapped in between. The scoring on the metal shaft is reduced by physically depressing the sand on to the rubber surface. The rubber surface is undamaged because of elastic nature of the bearing

Design and Development

L/D = 4 (Projected bearing pressure 35 – 50 psi)
Radial load/ (Bearing length x shaft dia)

Go up to 100 psi and becomes equivalent to oil lubricated metal bearings

Water as lubricant

1. It is inexpensive compared to oil
2. Readily available
3. No pollution
4. Store twice as much frictional heat as oil under hydrodynamic conditions
5. Wear is virtually non existent

Shore A 70
T = 0.125” for 6 “
0.313” for 20”
L/D = 4

Designers Checklist

1. PV rating
2. Wear
3. Coefficient of Friction
4. Running Clearance
5. Shaft finish and hardness
6. Compatibility and corrosion
7. Electrical Properties
8. Length and wall thickness
9. Installation and fastening
10. Lubrication and seals

PV rating

It is a measure for comparing bearing performance. It is radial load per sq in of projected shaft area. Projected shaft area is bearing length x shaft dia. Radial load is the total weight carried by the bearing

Limiting value at which the bearing operating temperature and coefficient of friction stabilize for a generally satisfactory operation. It is a material property and is altered with filler loading

PV value , psi – fpm,	1,200	I0,000	10,000	15,000
	(PTFE)	Glass	(Graphite)	(Bronze)
		15%	15%	60%

Wear

It is a function of material, temperature, journal finish and hardness, and also the amount of filler:

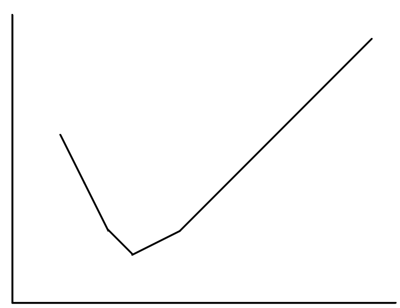
$$t = K. P. V. T$$

t= radial wear in inches
K = wear factor in in cubed – min/ lb-ft-hr
P = radial load per (journal dia x bearing length)
V = velocity in fpm
T = time, hrs.

Define the desired life and adjust other variables to give an acceptable wear value. V is fixed usually. P can be adjusted by varying bearing length.

K is filler loading dependant

K factor



[filer]   (PTFE – bronze filler)

<u>Coefficient of friction</u>
Tangential force required to move the surface relative to another divided by normal force pushing the two surfaces together.

Static coefficient of friction: Force required to move one surface relative to another from a position of rest or zero velocity

Dynamic coefficient of friction: Force required to keep the moving surface in motion.

For PTFE static and dynamic coefficient of friction are closer. Usually static value is higher than dynamic value.

The rate of frictional heat generation is related to the coefficient of friction

Power loss P = $\frac{f \times W \times rpm \times D \times 3.14}{720}$ ft-lb / sec

f = coefficient of friction
W radial load, lb
rpm = speed
D = shaft dia, inches

Running Clearance

Higher running clearance is required for polymeric bearings, since the coefficient of thermal expansion is higher and thermal conductivity is lower.

5 E -5 in/in – F for polymer and 0.8 E -5 for steel

Total running clearance = Basic shaft allowance + Allowance for installation close down + Allowance for thermal expansion

Basic shaft allowance is same for all plastic matrials ie 0.005 " for 1" shaft dia to 0.003 " for 10" shaft dia. Allowance for installation close down is 0.002 "/" OD of bearing

For 1 " dia shaft, radial wall thickness is 0.0625", tem. Rise is 150 , the TRC is 15 x E -5 x 0.0625 x 2x 150 = 0.003 "
0.005 + 0.002 + 0.003 = 0.010 "

Shaft finish and hardness

Bearings being cheaper than the shaft, bearings must wear faster than the shaft. (It can be replaced)

The shaft finish should not be smother than 2 micro inch. (one think layer o PTFE on shaft is needed for longer life, smother one does not get the thin film coating).

Too rough shaft surface leads to too rapid wear. Roughness should not be more than 30 micro inch.

8- 16 is recommended.

As the load on the bearing increases, shaft finish must be smoother. Eg. When load increase, from 1 E 3 to 10 E 3, the roughness must change from 32 to 8 micro inch.

Journal hardness is 40 to 50 Rockwell preferred for non metallic bearings.

Compatibility and Corrosion

The shell, bearing and adhesive bond should not be affected by the operating conditions. Most non metallic bearing will corrode stainless steel if stationary under load under water or in humid conditions.

Electrical

Depends on the applications. Electrical properties are to be tested. Volume and surface resistivity are usually measured.

Length and Wall thickness

For plastic bearing L/D = 1 should be used

More than 1 - frictional over heating due to bearing curvature or slight bearing wall thickness variation etc can cause vibration and wear
Less than 1 - difficult to hold in place and will not adequately guide the shaft

Wall thickness should be maintained minimum due to poor conductivity. 0.0625 “ is recommended minimum for self lubricated dry bearings.