

Power Loss Due to a Thrust Bearing

Abstract

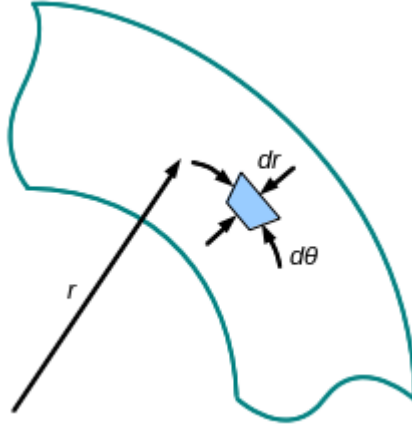
This is a short analysis of the power requirement of a non-hydrodynamic thrust bearing.

Problem Description: A plain thrust bearing without active lubrication at a constant angular velocity is required to overcome frictional forces. Given a coefficient of friction μ , a normal force N , and an angular velocity ω the power requirement can be calculated.

First, it is reasonable to assume a uniform pressure distribution on the surface of the bearing. Hence, if N is the normal force and A is the total area, the pressure load is defined as follows

$$p = \frac{N}{A}$$

Considering an infinitesimal portion of the bearing surface, the area of that region can be described as a function of its radial location as follows. It follows that the force on the bearing surface can be described as a function of the radial position, r .



$$A(r) = \int_0^{2\pi} r \, d\theta = 2\pi r \, dr$$
$$N(r) = p A(r) = 2\pi r p \, dr$$

The friction force may then be quantified as a function of the radius.

$$F_f(r) = \mu N(r) = 2\pi \mu r p \, dr$$

Since torque is equal to the force multiplied by the radius, r , it can be described as a function of the radius, which may be integrated between the inner and outer radii to determine the total torque.

$$T(r) = r F_f(r) = 2\pi \mu p r^2 \, dr$$
$$T_{\text{tot}} = \int_{r_1}^{r_2} 2\pi \mu p r^2 \, dr = \frac{2}{3}\pi \mu p (r_2^3 - r_1^3)$$

Remembering that power is equal to torque, T , multiplied by angular velocity, ω , the power required to maintain the thrust bearing at speed is as follows:

$$P = \omega T_{\text{tot}} = \frac{2}{3}\pi \mu \omega p (r_2^3 - r_1^3)$$

Or, in terms of diameters rather than radii,

$$P = \omega T_{\text{tot}} = \frac{1}{12}\pi \mu \omega p (d_2^3 - d_1^3)$$