Thrust Bearings

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This article introduces you to some of the terminology and design features of thrust bearings. Thrust bearings, an essential part of most extruders, have a significant effect on reliability, capacity, and performance.

As the screw pumps material from the extruder through a restriction such as a die, pressure is developed at the end of the screw which acts to force the screw back into the gearbox. The thrust bearing resists this force, or thrusting, from the rotating screw and transmits it to the gearbox housing.

Rolling contact bearings are the usual type of bearing used in extruder applications. A bearing of this type consists of a rotating ring, a set of rollers spaced inside a cage, and a stationary ring. All contact surfaces are precision machined and hardened to Rc 60. An other essential part of every bearing is a lubricating film of oil without which a bearing will destruct ma very short period of time. To have rolling contact, as the name implies, the surface speed of the roller must be equal to that of the ring surface or raceway. For a radial roller bearing (which only supports loads perpendicular to the shaft), this is relatively easy to accomplish. The rollers rotate about their own axis while they revolve around the bearing at one-half the inner ring speed. To do this, there must be sufficient tractive force at each point of contact.

The tapered roller bearing overcomes the limitations of the cylindrical roller bearing by having rollers which vary in diameter. They are designed so that the increase in roller size is matched with the increase in ring radius and, therefore, roiling contact is maintained along the line of contact. Tapered roller bearings can support combined thrust and radial loads which makes them very beneficial in applications where this normally occurs, such as helical gear speed reducers.

An important factor in thrust bearing performance is shaft misalignment which will cause an uneven distribution of load on the rollers and may drastically shorten bearing life. A solution to this problem is to use spherical roller thrust bearings. The rollers can realign themselves to changes in the shaft axis and prevent load concentration. As a design guide, a spherical roller bearing can take about eight times the misalignment of a cylindrical roller, or tapered roller bearing without a detrimental effect on life.

Fatigue life is the design basis for selecting and sizing rolling contact bearings. As the rollers continuously make contact with new raceway surfaces, a given point on either the raceway or roller surface, is loaded and unloaded. This type of loading in any machine component is recognized to reduce the amount of load that may be applied before failure occurs. Cracks propagate as load is continuously reapplied. When several cracks propagate to a point where they intersect, a chunk of raceway surface can be expected to break off and a spall is formed. This is usually considered the point of fatigue failure.

If a bearing has the proper lubricant (sufficient viscosity at the operating temperature), a film will exist at the point of contact that keeps the surfaces separate. This is known as elastohydrodynamic (EHD) lubrication in which instantaneous pressures of 200,000 to 300,000 psi are created at the point of contact. It depends on the pumping action of the rotating roller to exist.

An L10 life is the operating time in hours when the probability of fatigue failure is 10%; that is, out of 100 identical bearings, seeing the same load and speed, ten can be expected to have spalls by this operating time. In actuality, improvements in material, lubrication and de sign, have greatly reduced the probability of fatigue failure.

Dynamic capacity is the load applied for one million cycles that results in a fatigue failure probability of ten percent. The tapered roller industry uses 90 million cycles. Changes in load have a drastic effect on life. Doubling the load will reduce the fatigue life by ten.

Bearing selection and specified LI0 life can have a significant effect on power consumption. In many cases, thrust bearings consume more power than the gears and bearings transmitting screw torque. It is very important to provide for removal of this heat from a gear box. A separate motor driven pump for circulating oil through a heat exchanger and filter is usually recommended. Operating a bearing at elevated temperatures will cause a loss in film strength and cause metal-to-metal contact. This usually results in a failure before that predicted by the fatigue formula.

A serious problem encountered by roller thrust bearings is skidding, which is caused by loss of traction between rollers and raceways. Skidding can be caused by load surging or axial vibration of the screws. Contact is intermittent. A solution to this problem is to eliminate end play. However, because a bearing is mechanically very stiff (5 to 10 million pounds per inch), simply removing play from the bearing assembly by shimming or machining can result in heavy loads and considerable heat generation. A better method is to use disc springs in conjunction with reverse thrust bearings. These have a much lower and controlled spring rate. This also smoothes out axial vibration which may occur in extruder screws.

- Thomas P. Harrington

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