Lubrication of Anti-Friction Bearings

Introduction

Although the basic principle of ball and roller bearings is the rolling of one element over another, some sliding friction is generated during operation of anti-friction bearings. Successful operation of an anti-friction bearing requires a lubricating film in the areas of sliding contact. In cageless bearings, the rolling elements slide against each other. When a cage is present the rolling elements slide against this and under some operating conditions, the cage slides against ring guiding surfaces. When a ball under load rolls in a curved bearing raceway, pure rolling occurs only along two lines in the contact area; other contact points on the ball slide or spin along areas of the raceway. This is because the effective diameter of the ball is smaller at points distant from the bottom of the race-groove. See Figure 1.

a. The forces of slippage between zone #1 and the two zones #2 are equal in magnitude.

b. The slippage in zone #1 is in opposite direction from that in zone #2.

c. Technically the zones of pure rolling in #3 are very narrow but there are larger areas that approach pure rolling.

d. These conditions exist, although less obvious, even when loads are lighter and the ball paths narrower.

Without lubrication in the highly loaded contact areas, very high friction will be encountered in ball bearings. High friction generally creates high heat and thermal expansion, usually concentrated in the rolling elements and inner ring races which may cause a loss of internal clearance and radial preloading. This frequently causes surface degeneration and early fatigue. Cage breakage may also result from extreme stresses.

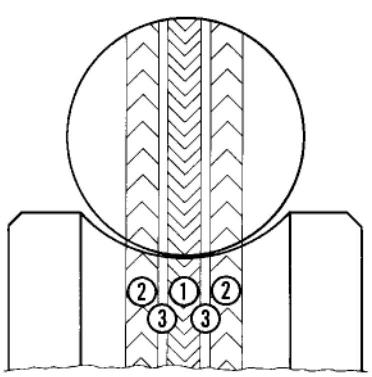

Figure 1

Bearing Construction

An anti-friction bearing is a precision device and a marvel of engineering. It is unlikely that any other mass produced item is machined to such close tolerances. While boundary dimensions are usually held to tenths of a thousandth of an inch, rolling contact surfaces and geometries are maintained to millionths of an inch. It is for this obvious reason that very little surface degradation can be tolerated.

Bearing steels are hard, durable alloys, highly free of impurities in order to withstand the high unit stresses which occur at the point of contact between a rolling element and the race. Also, they must be sufficiently elastic to quickly regain their original shape after deformation through loading.

Race and rolling element finish are also critical since even minute surface imperfections can cause high stress concentrations resulting in premature failure.

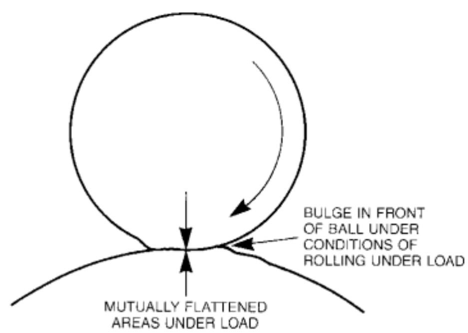

Figure 2

Principle of Operation

When a ball in a bearing is subjected to load, an elliptical area of contact results between the ball and the race. In operation, as each ball enters the loaded area, slight deformation of both the ball and the race occurs. The ball flattens out in the lower front quadrant and bulges in the lower rear quadrant. (See Figure 2) The amount of deformation is a function of the magnitude and direction of load, ball size, race geometry, and elasticity of the bearing materials. Any particular point on the race goes through a cycle of these stress reversals as each ball passes it. One source of heat developed in a bearing results from these stresses and the deformation of the bearing material associated with them.

The life of an anti-friction bearing running under good operating conditions is usually limited by fatigue failure rather than by wear. Under optimum operating conditions, the fatigue life of a bearing is determined by the number of stress reversals and by the cube of the load causing these stresses. As examples, if the load on the bearing is doubled, the theoretical fatigue life is reduced to one-eighth. Also, if speed is doubled, the theoretical fatigue is reduced to one-half.