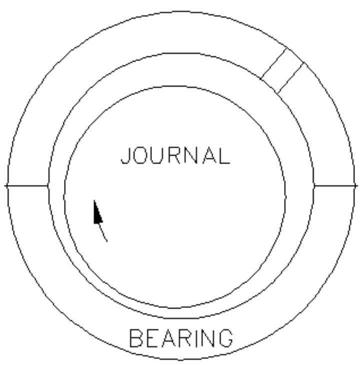
Journal Bearings

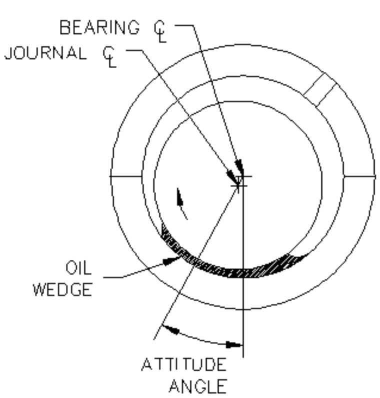
Industrial machinery with high horsepower and high loads, such as steam turbines, centrifugal compressors, pumps and motors, utilize journal bearings as rotor supports.

One of the basic purposes of a bearing is to provide a frictionless environment to support and guide a rotating shaft. Properly installed and maintained, journal bearings have essentially infinite life.

BEARING DESIGN



A journal bearing, simply stated, is a cylinder, which surrounds the shaft and is filled with some form of fluid lubricant. In this bearing a fluid is the medium that supports the shaft preventing metal-to-metal contact. The most common fluid used is oil, with special applications using water or a gas. This application note will concentrate on oil lubricated journal bearings.



Hydrodynamic principles, which are active as the shaft rotates, create an oil wedge that supports the shaft and relocates it within the bearing clearances. In a horizontally split bearing the oil wedge will lift and support the shaft, relocating the centerline slightly up and to one side into a normal attitude position in a lower quadrant of the bearing. The normal attitude angle will depend upon the shaft rotation direction with a clockwise rotation having an attitude angle in the lower left quadrant. External influences, such as hydraulic volute pressures in pumps or generator electrical load can produce additional relocating forces on the shaft attitude angle and centerline position.

An additional characteristic of journal bearings is damping. This type of bearing provides much more damping than a rolling element bearing because of the lubricant present. More viscous and thicker lubricant films provide higher damping properties. As the available damping increases, the bearing stability also increases. A stable bearing design holds the rotor at a fixed attitude angle during transient periods such as machine startups/shutdowns or load changes. The damping properties of the lubricant also provide an excellent medium for limiting vibration transmission. Thus, a vibration measurement taken at the bearing outer shell will not represent the actual vibration experienced by the rotor within its bearing clearances.

Journal bearings have many differing designs to compensate for differing load requirements, machine speeds, cost, or dynamic properties. One unique disadvantage, which consumes much research and experimentation, is an instability, which manifests itself as oil whirl and oil whip. Left uncorrected, this phenomenon is catastrophic and can destroy the bearing and rotor very quickly. Oil whip is so disastrous because the rotor cannot form a stable oil wedge consequently allowing metal-to-metal contact between the rotor and the bearing surface. Once surface contact exists the rotor begins to process, in a reverse direction from rotor rotation direction, using the entire bearing clearance. This condition leads to high friction levels, which will overheat the bearing babbit metal that leads to rapid destruction of the bearing, rotor journal, and the machine seals.

Some common designs employed are lemon bore, pressure dam, and tilt pad bearings. These designs were developed to interrupt and redirect the oil flow path within the bearing to provide higher bearing stabilities.

GEOMETRIES

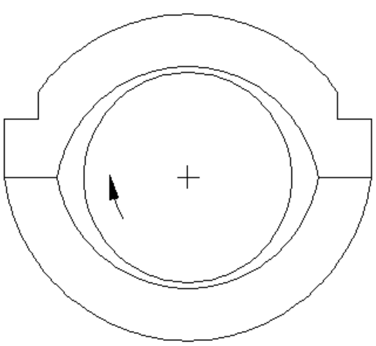
Journal bearings installed in industrial machinery today generally fall into two categories: full bearings and partial arc bearings. Full bearings completely surround the shaft journal with many differing geometries such as elliptical, lobed, or pressure dam configurations and usually are two pieces, mated at a split line. Partial arc bearings have several individual load bearing surfaces or pads and are made up of numerous adjustable components.

The bearing inner surface is covered with a softer material, commonly called babbit. Babbit, which is a tin or lead based alloy, has a thickness that can vary from 1 to 100 mils depending upon the bearing diameter. A babbit lining provides a surface which will not mar or gouge the shaft if contact is made and to allow particles in the lubricant to be imbedded in the liner without damaging the shaft.

Plain Bearing

The plain bearing is the simplest and most common design with a high load carrying capacity and the lowest cost. This bearing is a simple cylinder with a clearance of about 1-2 mils per inch of journal diameter. Due to its cylindrical configuration it is the most susceptible to oil whirl. It is a fairly common practice during installation to provide a slight amount of "crush" to force the bearing into a slightly elliptical configuration.

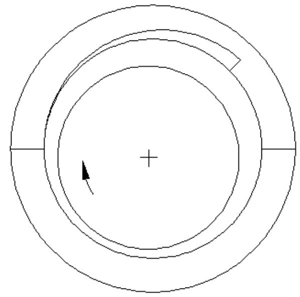
Lemon Bore



The lemon or elliptical bore bearing is a variation on the plain bearing where the bearing clearance is reduced on one direction. During manufacture this bearing has shims installed at the split line and then bored cylindrical. When the shims are removed the lemon bore pattern is results. For horizontally split bearings, this design creates an increased vertical pre-load onto the shaft.

This bearing has a lower load carrying capacity that plain bearings, but are still susceptible to oil whirl at high speeds. Manufacturing and installation costs are considered low.

Pressure Dam

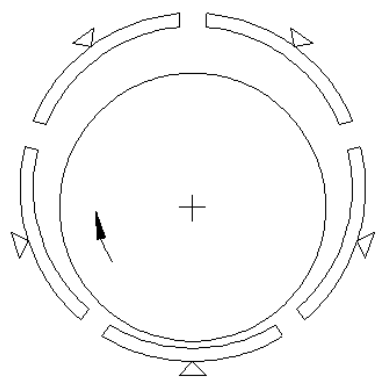


A pressure dam bearing is basically a plain bearing, which has been modified to incorporate a central relief groove or scallop along the top half of the bearing shell ending abruptly at a step. As the lubricant is carried around the bearing it encounters the step that causes an increased pressure at the top of the journal inducing a stabilizing force onto the journal, which forces the shaft into the bottom, half of the bearing.

This bearing has a high load capacity and is a common correction for machine designs susceptible to oil whirl. Pressure dam bearings are a unidirectional configuration.

Another unidirectional bearing configuration is the offset bearing. It is similar to a plain bearing, but the upper half has been shifted horizontally. Offset bearings have increasing load capacities as the offset is increased.

Tilting Pad



Tilting pad bearings is a partial arc design. This configuration has individual bearing pads, which are allowed to pivot or tilt to conform to the dynamic loads from the lubricant and shaft. This type of bearing is a unidirectional design and is available in several variations incorporating differing numbers of pads with the generated load applied on a pad or between the pads.

VIBRATION MONITORING

A shaft supported by journal bearings will move relative to the bearing housing as various forces are imposed onto the shaft. A vibration transducer is required which can monitor the relative motion between the shaft and the bearing. Higher vibration frequencies are not of prime concern since they would not be transmitted through the oil film reliably.

The only sensor available that can measure relative measurements of the shaft is the non-contacting pickup, sometimes called a displacement, eddy current, or proximity pickup. This type of sensor measures the relative vibration of the shaft and, also, the relative position of the shaft with respect to the bearing clearances. High frequencies such as blade passage and cavitations would be attenuated by the lubricant. Case mounted sensors would not provide an accurate indication of the vibration due to the inherent damping offered by the lubricant between the shaft and the bearing. For more information about installation and theory of operation of NCPUs, see the STI Application Notes: Eddy Current Transducer Installation, Part 1- Radial Vibration.

1010 East Main Street, League City, TX 77573 Phone: 281.334.0766 Fax: 281.334.4255
www.stiweb.com / www.stiwebstore.com