PLAIN BEARINGS.

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Abstract

The use of plain & rolling bearings in sugar mills is very common. Both types are an essential part of rotating machinery. So whenever there is a failure it causes production loss which cannot be tolerated. Maintenance engineers of sugar mills make all out efforts to prevent their failure. In this paper we will discuss in detail the types of plain bearings, method of lubrication and causes of their failure.

Introduction

Though seemingly simple, less expensive yet sleeve bearings are highly engineered components. In sugar industry they range in size from an inch to 24 inches in diameter. With few exceptions, plain bearings lubrication is hydrodynamic i.e during operation, the shaft floats on a thin film of the lubricant. Because of this, friction and wear are minimized. It is important that this minimum film thickness is not the same as the bearing clearance, the minimum film thickness is typically only about one ten thousand of an inch. Remember plain bearings can have very long life provided proper maintenance practice is followed.

Classification of bearings

Though the bearings may be classified in many ways, yet the following are important from the subject point of view:

1. Depending upon the direction of load to be supported. The bearings under this group are classified as:
   1. Radial bearings 2. Thrust bearings.

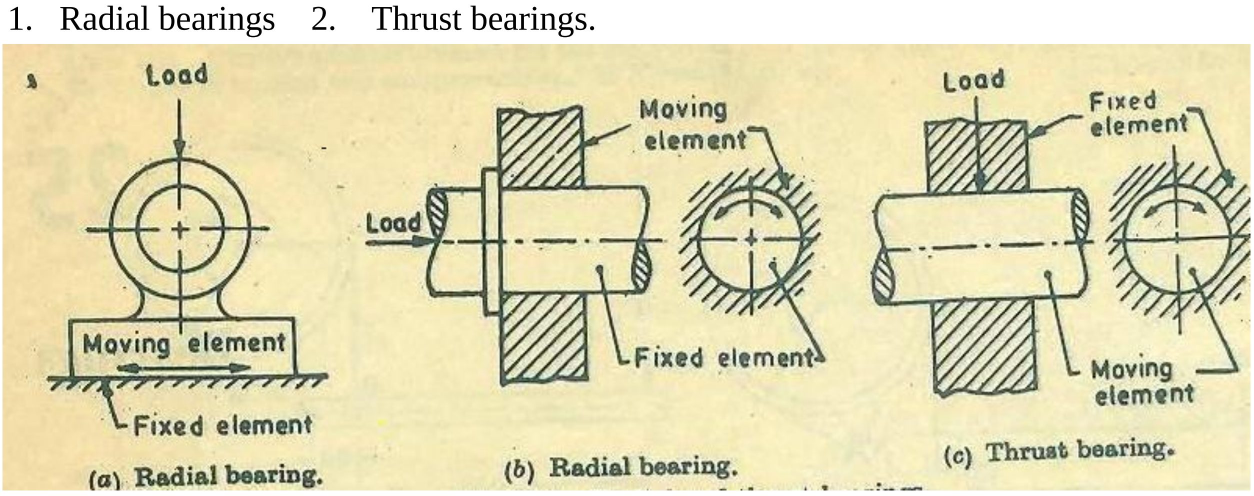

Figure 1 Radial and thrust bearings.

1. **Redial Bearings.**
   In redial bearings, the load acts perpendicular to the direction of motion of the moving element as shown in Fig. 1.(a and b).

2 **Thrust Bearings.**

In thrust bearings the load acts along the axes of rotation as shown in Fig.1(c) .

Note: These bearings may move in either of the directions as shown in Fig.1.

Depending upon the nature of contact. The bearings under this group are classified as:

1. Sliding contacts bearings and 2. Rolling contacts bearings.

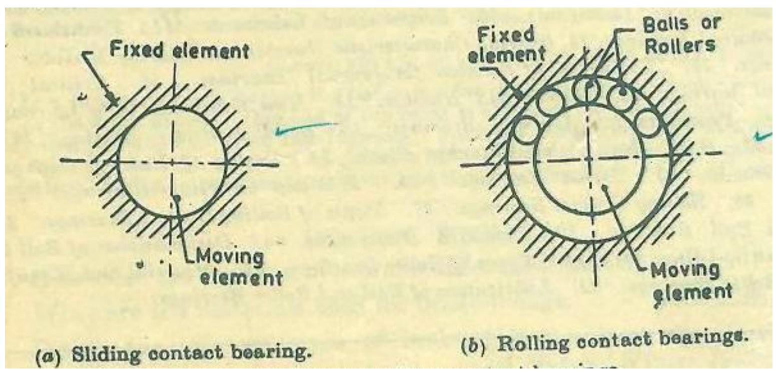

Figure. 2 Sliding and Rolling contact bearings.

In sliding contact bearings as shown in Fig 2 (a), the sliding takes place along the surfaces of contact between the moving element and the fixed element. The sliding contact bearings are also known as plain bearings.

In rolling contact bearing as shown in Fig. 2 (b), the steel balls or rollers, are interposed between the moving and fixed elements. The balls offer rolling friction at two points for each ball or roller.

Sliding Contact Bearing

The Sliding contact bearing in which the sliding aqction guided in straight line and carrying radial loads, as shown in Fig.1(a), may be called slipper or guide bearings. Such types of bearings are usually found in cross head of steam engines.

Lubrication

The life blood of any machine is lubricant as it saves the vital parts from self destruction. The principal factors that influence the choice of a lubricant for any particular purpose are …

1. Speed
2. Temperature
3. The intensity of pressure between the mating surfaces.

The effect of suitable lubrication is to interpose a thin film of lubricant which prevents the actual contact of the mating surfaces. Such a film is incredibly thin, yet it must keep the moving surfaces apart while they carry enormous loads. If the lubricant is too thin and the normal pressure too great, the oil film breaks down and the mating surfaces touch.

The resulting friction generates great heat. This causes surfaces to lock together or seize.

In a milling train the turbine is lighter side and mill is to heavily loaded side. That is why for lubricators of turbine bearings T-68 and on mill side oil-3800 lubricant is used.

Material Used For Plain Bearings

The materials commonly used for plain bearings are discussed below.

1. **Babbit Metal.**

The tin and lead base babbit are used as a bearing material for steam turbines and compressors.

The composition of the babbits metal is as follows.

Tin base babbits	Tin	90%	Copper	45%
	Antimony	5%	lead	0.5%
Lead base babbits	Lead	84%	Tin	6%
	Antimony	95%	copper	0.5%

2. **Bronzes.**
   The bronzes (alloys of copper, tin and zinc) are generally used in the form of machined bushes pressed into the shell. The bush may be in one or two pieces. The bronzes commonly used for bearing material are gun metal and phosphor bronzes.

Its composition is	Copper	88%,	Tin	10%	Zinc	2%

The gun metal is used for high grade bearings subjected to high pressure and high speed.

The phosphor bronze Composition is

Copper	80%	Tin	10%	Lead	9%
Phosphorous	1%				

3. **Cast Iron**

The cast iron bearings are usually used with steel journals. Such type of are fairly successful where lubrication is adequate and the pressure is limited to 3.5 N/mm^2 and speed to 40 meters per minute.

Copper	88%	Tin	10%	Zinc	2%

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Properties of Metallee Bearing Materials

Requirement

Surface Action: Sometimes refers to as slipperiness or compatibility, surface action is the ability of a material to resist seizure when contacted by the shaft. Contacts takes place every time the equipment is started or stopped and can also occur during momentary overloads.

Fatigue Strength: This is the ability of a bearing material to withstand the loads to which it is subjected without cracking. Generally the bearings should last at least until the first overhaul.

Conformability: The material must also be soft enough to creep or flow slightly to compensate for the minor geometric irregularities which are present in every assembly. These include misalignment, out-of-proud and taper.

Embedability: The ability of a material to absorb foreign particles circulating in the oil stream is referred to as embedability. Some particles will go unfiltered, so the materials must be soft enough to ingest them.

Temperature Strength: As operating temperature increase, bearings materials tend to lose strength. This property indicates how will a material carries a load at elevated temperature, without breaking up or flowing out of shape.

Thermal Conductivity: Shear of the oil film by the shaft generators significant heat, most of which is carry away by the oil. Nevertheless, it is important for the bearing to transfer heat rapidly from its surface through its back to avoid overheating and resultant reduction in life.

Corrosion Resistance: Oils oxidize with use and the products of this degradation can be corrosive. Blow by products and fuel or coolant contamination of the oil also promote a corrosive environment. Bearing materials should e resistant to these effects.

TABLE OF PROPERTIES OF MATALLIC BEARING MATERIALS (Table 1)

BEARING MATERIAL	FATIGUE STRENGTH	COMFOR-MABILITY	EMBED-DABILITY	CORROSION RESISTANCE	THERMAL CONDUCTIVITY
Tin base Babbit	Poor	Good	Excellent	Excellent	Poor
Lead base Babbit	Poor to fair	Good	Good	Fair to good	Poor
Lead Bronze	Fair	Poor	Poor	Good	Fair
Copper Lead	Fair	Poor	Poor to fair	Poor to fair	Fair to good
Alumi-Nium	Good	Poor to fair	Poor	Excellent	Fair

Silver	Excellent	Almost none	Poor	Excellent	Excellent
Silver lead deposited	Excellent	Excellent	Poor	Excellent	Excellent

Design Procedure for journal bearings

The following procedure may be adopted in designing journal bearings, when the bearing load, the diameter and the speed of the shaft are known.

1. Determine the bearing length by choosing a ratio of l/d from table 1.
2. Check the bearing pressure, p = w/l.d from table 1. for probable satisfactory value.
3. Assume a lubricant from table 1. and its operating temperature (t_0). This temperature should be between 26.5° C and 60° C with 82° C as a maximum for high temperature installation such as steam turbines.
4. Determine the operating value with corresponding value of ZN/p for the assumed bearing temperature and check this value with corresponding values in table 1, to determine the possibility of maintaining fluid film operation.
5. Assume a clearance ratio c/d from table 1
6. Determine the coefficient of friction (μ) by using the relation as discussed in art 25.3.
7. Determine the heat generated by using the relation as discussed in art.
8. Determine the heat dissipated by using the relation as discussed in art.
9. Determine the thermal equilibrium to that the heat dissipated becomes at least equal to the heat generated. In case the heat generated is more than the heat dissipated then either the bearing is redesigned or it artificially cooled by water.

Table.2

Machinery	Bearing	Maximum bearing pressure		Operating values					
				Absolute viscosity (Z)		ZN/p		c/d	l/d
		N/mm²	kgf/cm²	kg/m-s	Centipoise	Z in kg/m-s p in N/mm²	Z in centipoise p in kgf/cm²		
Steam turbines	Main	0·7–2	7–20	0·002–0·016	2–16	14	1400	0·001	1–2
Generators, motors, centrifugal pumps	Rotor	0·7–1·4	7–14	0·025	25	28	2800	0·0013	1–2
Transmission shafts	Light, fixed Self aligning Heavy	0·175 1·05 1·05	1·75 10·5 10·5	0·025–0·060	25–60	7 2·1 2·1	700 210 210	0.001	2–3 2·5–4 2–3
Machine tools	Main	2·1	21	0·04	40	0·14	14	0·001	1–4
Punching and shearing machines	Main Crank pin	28 56	280 560	0·10	100	—	—	0·001	1–2
Rolling Mills	Main	21	210	0·05	50	1·4	140	0·0015	1–1·5

Mills Rollers

The dimensions of the roller journals are determined by the limit of pressure permissible for the bearings (cf. p. 125). Their length / is generally made equally to 5/4 of their diameter d, and their diameter to half that of the rollers.

$$d = \frac{D}{2} \qquad l = \frac{5}{4} d \qquad (18.1)$$

Some recent mills make d slightly greater than D/2.

The hydraulic pressure should be proportional to LD, and, since d is half of D, it would be logical to make l proportional to L. hence we should have:

$$d = \frac{D}{2} \quad l = 0.3\,L \qquad (18.1)$$

Designers, moreover, are compelled to approach the letter proportions with large roller, since rule (18.1) would otherwise lead to excessive bearings pressures in large mills, the roller of which have a ratio L/D appreciably higher than that small mills, according to the series regarded as standard.

The fillets of the journal should have a radius sufficient to avoid the risk of starting factures, as breakages are more frequent at these points[1]. A radius of 1/20 of the journal diameter is recommended: 2 cm for a 40-cm diameter journal, for example. Fracture of roller shafts more often occurs at the inner side of the mills housing on the driving side.

Analysis of used bearings

Dirt: Dirt is responsible for more bearings failure than any other mechanisms. When dirt particles are large or numerous, they embed in the bearing lining, deforming the structure beneath and displacing the surrounding metal upward. The resulting high spot may be large enough to contact the journals.

Cause of dirt contamination are improper cleaning of the engine and parts prior to assembly; road dirt and sand entering through the air intake manifold; or wear of other parts.

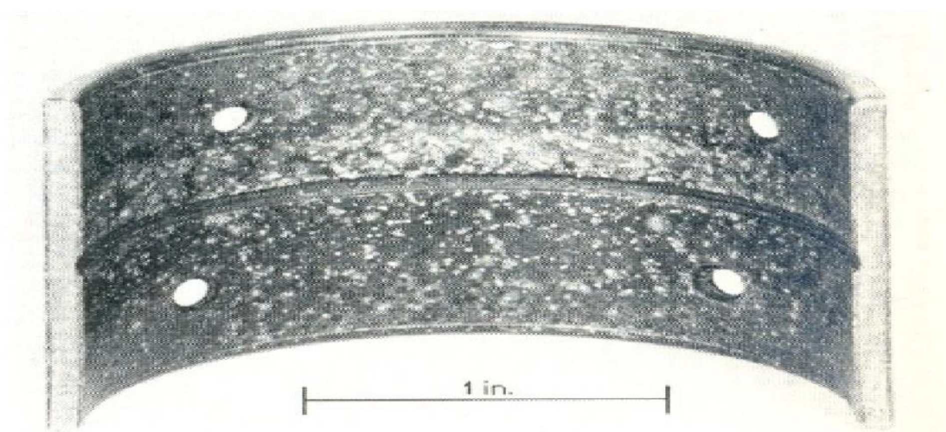

Fig. 1-8 Bearing with severe dirt embedment.

Causes of dirt contamination are improper cleaning of the engine and parts prior to assembly; road dirt and sand entering through the air-intake manifold; or wear (including failure) of other engine parts, causing small fragments to enter the oil supply. Poor maintenance practices are generally the root cause of the problem.

Corrective actions: (1) Grind and polish the journal surfaces if necessary, (2) install new bearings, paying particular attention to cleaning procedure, and (3) change filter and oil at the interval recommended by the engine manufacturer.

Fatigue: Generally speaking, bearings fatigue results when either the load or times in service exceed the alloy’s capability. There are several possible causes: load concentration due to dirt, poor shaft or bore geometry, misassemble of the bearing, material weakness caused by high temperature operation or corrosion, or simply exceeding the bearing’s normally expected life span.

Fatigue cracks initiate at the bearing surface and propagate perpendicular to it. Before reaching the steel, the cracks turn, run parallel to the steel, and join. The material can then flake out.

The most common type of fatigue is that on the overlay on trimetal bearings. But since the primary overlay functions are to absorb small dirt particles and provide a slippery surface for starting and stopping conditions, slight overlay fatigue is not regarding as bearing failure. The load-carrying strength of a bearing is in its intermediate layer. A true fatigue failure involves the intermediate material layer rather than the sacrificial overlay.

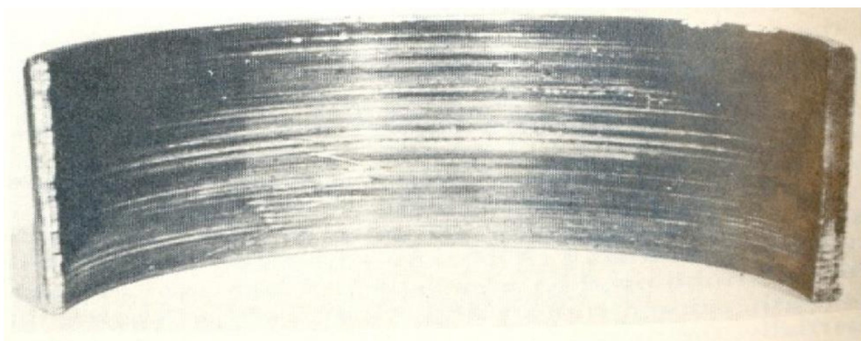

Fig. 1-9 Bearing damaged by scoring.

A few bearing escape some degree of fatigue during normal operation. Premature failure occur in stages, begging with normal “hen track” patterns. As fatigue progresses into the second stage, it takes on the classical “worm hole” appearance, shown in Fig. 1-10 for a lead-base babbit bearing.

Figures 1-11 and 1-12 show fatigue caused by misshapen shafts, while Fig. 1-13 illustrates what happens when the bearing cap shifts. Regrinding the crankshafts will correct the former. Cap shift can be avoided by : (1) ALTERNATING torquing from side to side to assure proper cap seating, (2) using new bolt to assure against excessive play in bolt holes, (3) making sure the cap is not reserved when installed, and (4) using the correct size socket to tighten the bolts to avoid interference with the cap.

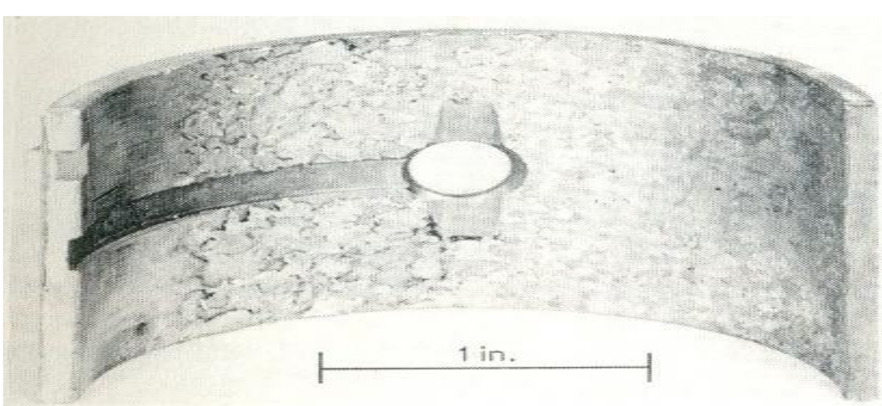

Fig. 1-10 Fatigue of bearing lining.

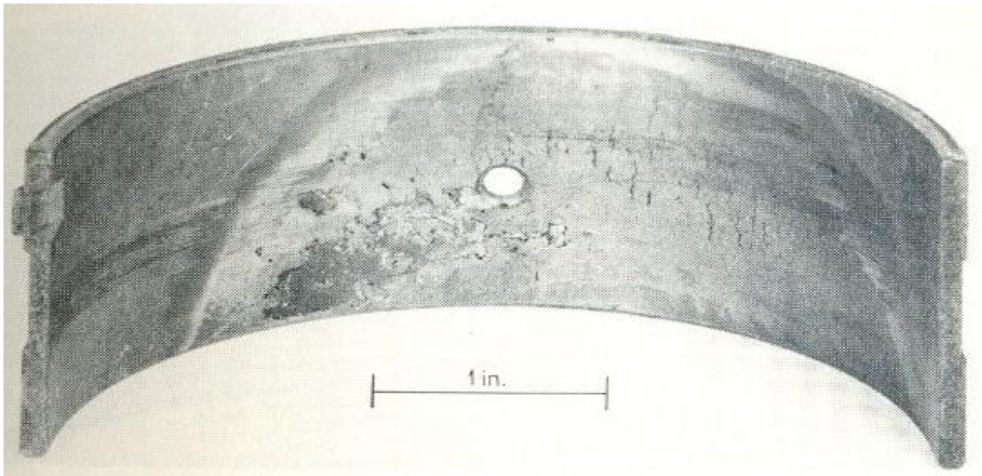

Fig. 1-11 Fatigue caused by a tapered shaft.

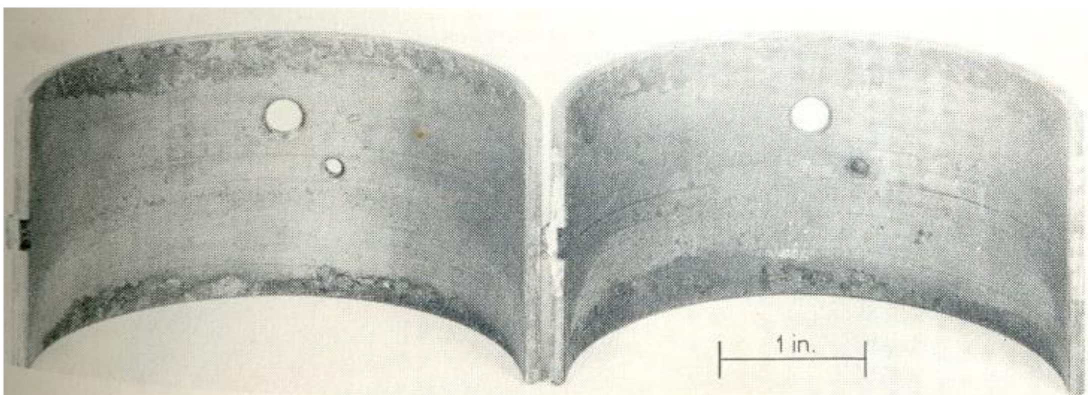

Fig. 1-12 Fatigue caused by an hourglass-shaped shaft.

6-10 **Maintenance of Mechanical Equipment**

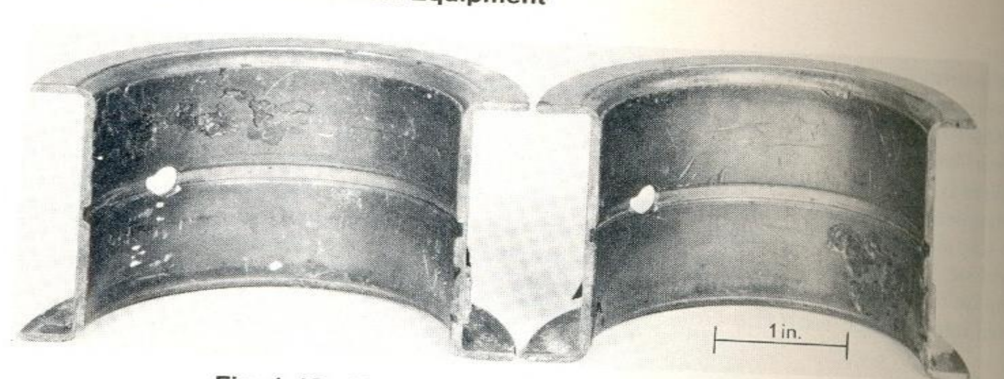

Fig. 1-13 Fatigue caused by a shifted bearing cap.

Excessive wear: Some of the same factors which produce fatigue can also cause excessive wear. Generally, what determine the phenomenon that prevails is the load level and the severity of the irregularity which causes the problem. Geometric defects not only concentrate load, but also cause oil films to be thinner than normal. This result in more frequent metal-to-metal contact and wears the lining much faster than normal. Figure 1-14 showed excessive wear caused by a barrel shaped journal, while Figure 1-15 showed the skewed wear from a twisting connecting rod. Regrinding the shaft will correct the former, while replacing the rod is the best course of action in the letter case. Related upper cylinder parts should also be checked and replaced when a bin or twisted rod has been discovered.

Foreign material on bearing back: Dirt on the bearing back causes high spots on the I.D. it also prevents good heat transfer in these areas, which leads to localized overheating.

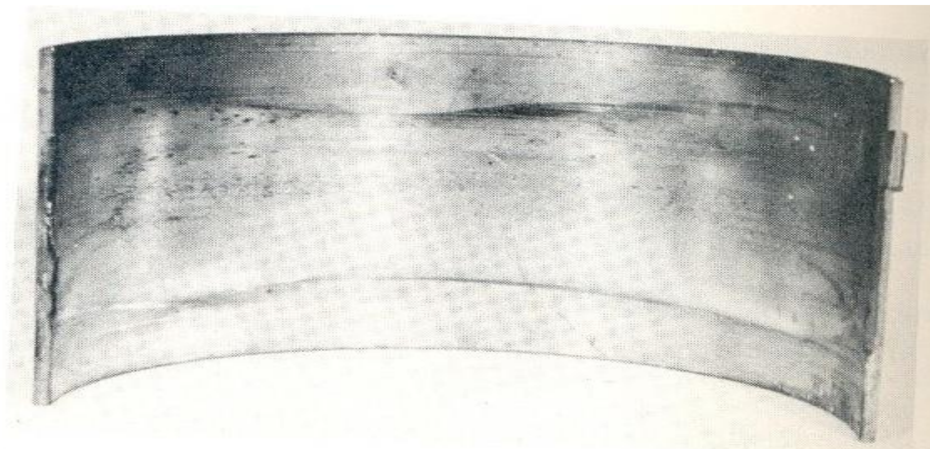

Fig. 1-14 Bearing worn in the center by a barrel-shaped shaft.

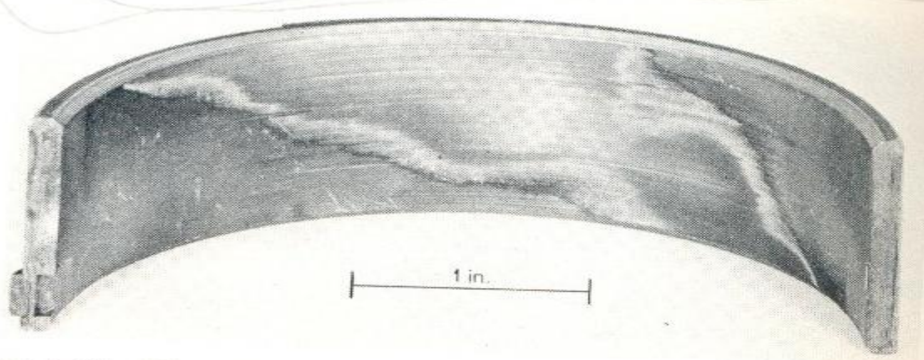

Fig. 1-15 Skewed-wear pattern caused by a bent connecting rod.