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# Analysis of Bearing Material: A Review

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***Abstract:*** *In this paper we emphasize the general needs of bearing materials and bearing material properties. Material of bearing is one of the most important aspects of any bearing because different material has different material properties and composition which can affect the bearing life. The different causes of failure of Roller bearings along with remedies to avoid them are discussed. The research work related to failure of bearings is presented.*

***Keywords****: Roller bearing, bearing material, Fatigue Strength, corrosion resistance.*

## I- INTRODUCTION

While the contact surfaces of a bearing's raceways and rolling elements are subjected to repeated heavy stress, they still must maintain high precision and rotational accuracy. To accomplish this, the raceways and rolling elements must be made of a material that has high hardness, is resistant to rolling fatigue, is wear resistant, and has good dimensional stability. The most common cause of fatigue in bearings is the inclusion of non-metallic impurities in the steel. Nonmetallic inclusion includes hard oxides that can cause fatigue crack. Clean steel with minimal non-metallic inclusion must therefore be used.

To determine the choice of a bearing material it is useful to recognize four main types of bearing applications:

(i) Reciprocating engine bearings operating with hydrodynamic lubrication, a dynamic load being applied to the bearing surface through the oil film. The bestknown examples are the big-end and main bearings of the automotive engine. This bearing application is of particular importance, not only because of the sheer volume of internal combustion engines now produced, but because the high oil-film pressures generated over the bearing surface have provided an important impetus in bearing materials development.

(ii) Rotating plant bearings operating with hydrodynamic lubrication, the load applied to the bearing surface through the oil film being steady. Examples are turbine journal bearings, rolling-mill bearings, marine stern tubes, tilting-pad thrust bearings.

(iii) Lubricated bearing applications operating under conditions that do not create full hydrodynamic lubrication. This category covers the important classes of oil-impregnated porous bronze bearing and pre lubricated plastic or plastic-lined bearings.

(iv) Non-lubricated bearing applications, i.e. bearings operating dry or in non-lubricating media. For such applications the most commonly used bearing materials are those based on the polymer polytetrafluoroethylene.

## II. GENERAL REQUIREMENTS OF BEARING MATERIALS

a) Score resistance
b) Mutual Solid Solubility
c) Compressive strength
d) Fatigue strength
e) Deformability
f) Corrosion resistance
g) Structure

Bearing materials are selected on the basis of applications and which properties are of prime importance in that application.

a) Score Resistance: - The anti-weld or anti-seizure characteristic of a bearing material is referred as score resistance. White metals are used where score resistance is of prime importance. Improved score resistance is obtained at the expense of loss of hardness or strength. Table I shows the relative order of common bearing metals with regard to score resistant tendencies.

**TABLE -III**

| Bearing Material | Order of Score Resistance | Order of Inherent hardness or strength | Application |
|---|---|---|---|
| Aluminum Alloys | 3 | 1 | For heavily loaded moderate speed bearing |
| Copper leads | 2 | 2 | For heavily loaded high speed bearing |
| White Metal alloy | 1 | 3 | Low to moderately loaded, low to high speed bearing where dirt and deflection are present |

*Source: -from research paper by S. B. Chikalthankar[1], V. M. Nandedkar[2], P. V. Jawale[3]*

b) Mutual Solid Solubility: Early work by Ernst and Merchant showed that the mutual solid solubility between metal pairs was a very significant parameter in predicting friction and wear. Table 2 lists scoring resistance of elements against steel

*Source: -from research paperby S. B. Chikalthankar, V.*

| **Good** | **Fair** | **Poor** | **Very Poor** |
|---|---|---|---|
| Germanium | Carbon | Magnesium | Beryllium |
| Silver | Copper | Aluminium | Silicon |
| Cadmium | Selenium | Copper | Calcium |
| Indium | Cadmium | Zinc | Titanium |
| Tin | Tellurium | Barium | Chromium |
| Antimony | | Tungsten | Iron |
| Thallium | | | Cobalt |
| Lead | | | Nickel |

*M. Nandedkar, P. V. Jawale*

c) Compressive Strength: the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.

d) Fatigue Strength: - the value of stress at which failure occurs after $N_f$ cycles, and fatigue limit, $S_f$, as the limiting value of stress at which failure occurs as $N_f$ becomes very large. Highest stress that a material can withstand for a given number of cycles without breaking. It is affected by environmental factors such as corrosion. In other words, the maximum stress that can be applied for a certain number of cycles without fracture is the *fatigue strength*.

**TABLE-IV**

| **Sr. No.** | **Bearing Material** | **Order of Fatigue Strength** | **Order of eformability** |
|---|---|---|---|
| 1 | Bronzes | 1 | 7 |
| 2 | Copper Lead with tin or silver | 2 | 6 |
| 3 | Thin-Babbit overlays | 3 | 5 |
| 4 | Aluminium alloys | 4 | 4 |
| 5 | Copper-Lead | 5 | 3 |
| 6 | Cadmium alloys | 6 | 2 |
| 7 | Lead and Tin | 7 | 1 |

*Source: -from research paper by S. B. Chikalthankar, V. M. Nandedkar, P. V. Jawale*

e) Deformability-Deformability is the degree to which applying a force can make a particle or solid change shape.The ability of cells to change shape as they pas s through narrow spaces, such as erythrocytes passing through themicrovasculature.

f) Corrosion resistance: The corrosive aspects of bearing materials are important especially in engine bearings the capacity of a metal or alloy to resist the corrosive action of a medium. It is determined by the rate of corrosi on undergiven conditions.The rate of corrosion is character ized by qualitative and quantitative indexes. Among the qu alitative indexes are changes inthe surface appearance and microstructure of a metal. Quantitative indexes include the time required for the appearance ofthe first corrosion site o r the number of corrosion sites appearing over a given time period, the reduction in thickness of themetal per unit time , change in the weight of the metal per unit area and time, The volume of gas released (hydrogen) orabsorbed (oxyge n) in the course of corrosion per unit area and unit time, the current density corresponding to the rate of thegiven corro sion process, and the percentage change in any mechanical property, electric resistance, and reflectivity of themetal ov er a given period.

TABLE -V

| Non-corrodible | Intermediate | Corrodible |
|---|---|---|
| Aluminium alloys | Bronzes (High Lead) | Cadmium Alloys |
| Tin-base Babbitt | Copper-Lead | |
| Lead base Babbitt | Alkali hardened lead | |
| Cadmium Indium alloys | Silver | |
| Bronzes (low lead) | | |
| | | |

*Source: -from research paper by S. B. Chikalthankar, V. M. Nandedkar, P. V. Jawale*

**Following are the material normally used in bearing:**

**1) High/mid carbon alloy steel**

In general, steel varieties which can be hardened not just on the surface but also deep hardened by the so-called "through hardening method" are used for the raceways and rolling elements of bearings. Foremost among these is high carbon chromium bearing steel, which is widely used. For large type bearings and bearings with large cross sectional dimensions, induction hardened bearing steel incorporating manganese or molybdenum is used. Also in use is midcarbon chromium steel incorporating silicone and manganese, which gives it hardening properties comparable to high carbon chromium steel gives chemical composition of representative high carbon chrome bearing steel that meets JIS standards. SUJ2 is frequently used. SUJ3 with enhanced hardening characteristics containing a large quantity of Mn is used for large bearings. SUJ5 is SUJ3 to which Mo has been added to further enhance hardening characteristics, and is used for oversized bearings or bearings with thick walls. The chemical composition of SUJ2 is equivalent to AISI 52100 (US) and DIN 100Cr6 (Germany).

**2) Case hardened (carburizing) steel**

Carburizing hardens the steel from the surface to the proper depth, forming a relatively soft core. This provides hardness and toughness, making the material suitable for impact loads. NTN uses case hardened steel for almost all of its tapered roller bearings. In terms of case hardened steel for NTN's other bearings, chromium steel and chrome molybdenum steel are used for small to medium sized bearings, and nickel chrome molybdenum steel is used for large sized bearings. Table 13.2 gives the chemical composition of representative JIS case hardened steel.

**3) Heat resistant bearing steel**

When bearings made of ordinary high carbon chromium steel which have undergone standard heat treatment are used at temperatures above 120˚C for long durations, unacceptably large dimensional changes can occur. For this reason, a dimension stabilizing treatment (TS treatment) has been devised for very high temperature applications. This treatment however reduces hardness of the material, thereby reducing rolling fatigue life. For standard high temperature bearings used at temperatures from 150˚C – 200˚C, the addition of silicone to the steel improves heat resistance and results in a bearing with excellent rolling fatigue life with minimal dimensional change or softening at high temperatures. A variety of heat resistant steels are also incorporated in bearings to minimize softening and dimensional changes when used at high temperatures. Two of these are high speed molybdenum steel and high speed tungsten steel. For bearings requiring heat resistance in high speed applications, there is also heat resistant case hardening molybdenum steel.

**4) Corrosion resistant bearing steel**

For applications requiring high corrosion resistance, stainless steel is used. To achieve this corrosion resistance a large proportion of the alloying element chrome is added to martensite stainless steel.

**5) Induction hardened steel**

Besides the use of surface hardening steel, induction hardening is also utilized for bearing raceway surfaces, and for this purpose mid-carbon steel is used for its lower carbon content instead of through hardened steel. For induction hardening of the deep layers required for larger bearings and bearings with large surface dimensions, mid-carbon steel is fortified with chrome and molybdenum.

**6) Other bearing materials**

For ultra-high speed applications and applications requiring very high level corrosion resistance, ceramic bearing materials such as $Si_3N_4$ are also available.

## CONCLUSION

The Analysis of bearing failure material is depends upon properties and composition of material, It's also depends upon the proper selection of bearing material and it is greatly affected by the working condition of bearing.

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