Review on Non ferrous Materials for sliding contact Bearing

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Abstract - *In the past few years, the need for low-cost, high-performance materials is increasing. Design engineers and researchers are replacing the metals and alloys with advanced materials. Bearings are integral parts of machines, engines, etc to serve the purpose. They play a significant role in the performance, efficiency, minimizing the cost of operation, enhancing the durability and reliability of the system. Materials used for these sliding elements have undergone tremendous change since the invention of Tin Babbitt. In this paper, review of non ferrous bearing materials for sliding contact, right from the old-age Babbitt to advanced materials in use till date is presented. A large number of metallic materials are used as sliding bearing materials because no single material is capable of satisfying all various requirements. This is, also, the reason why new materials are continually being developed. Among these, the application of Zn-based alloys has been on the increase during the last decade. New types of Zn-based alloys have been developed to satisfy the requirements of bearing materials.*

***Key Words*: Bearing Materials; Bearing Metal; Babbitt Metal; White Metal; Composite Bearings, casting**

1. INTRODUCTION

Bearings are the internal parts of machine, engines, rotating equipments etc. they play a significant role in the performance, efficiency, minimizing the cost of operation, enhancing the durability and reliability of the system. Bearing materials play a vital role in the design of bearings with respect to strength, rigidity and reliability. Basically there are two types of bearings; rolling contact and sliding contact bearings.

In this paper a complete review of materials used for sliding contact bearing is presented. Materials used for these sliding elements have undergone tremendous change since the invention of Tin-Babbit here non ferrous bearing materials for sliding contact bearings is considered for the review.

H.K. Hirschmaw and J.L. Basil [1] discussed about mechanical properties of white metal bearing alloys at different temperature, A .Rac, R. Ijnkore [2] studied the tribological properties of Zn-A27 bearing alloy under boundary lubrication. P. Sairam, ch vishveswara Rao [3] presented a paper on recent development in cast- non ferrous bearing materials. Ahmet Turk, et al [4] deal with the effect of Ti –B and Sr on the mechanical behavior of ZA-12 Alloy. K.G Basavakumar, et al [5] studied the influence of grain refinement of cast aluminium alloys. Bakir Sadik [6] investigated some results on mechanical properties of metal bearings. M Babic et al [7] had presented the importance of tribological, mechanical properties of Zn –Al alloys. Temel Savaskan, Osman Bican [8] had discussed on Developing aluminium–zinc-based a new alloy for tribological Applications, T. Rameshkumar, I. Rajendran [9] had presented on A study on Tribological Behavior of Aluminium-Based Bearing Material in oil Lubricated Conditions. T. M. Chandrashekharaiah and S.A. Kori, [10] had discussed "Effect of Grain Refinement and Modification on the Dry Sliding Wear Behaviour of Eutectic Al-Si Alloys, T. Rameshkumar, I. Rajendran, A. D. Latha,[11]studied on "Investigation on the Mechanical and Tribological Properties of Aluminium-Tin Based Plain Bearing Material. Soheyl Soleymani, Amir Abdollah-zadeh*, Sima Ahmad Alidokht, [12] had investigated on Improvement in Tribological Properties of Surface Layer of an Al Alloy by Friction Stir Processing. R. S. Rana, Rajesh Purohit, and S Das,[13] had Reviews on the Influences of Alloying elements on the Microstructure and Mechanical Properties of Aluminum Alloys and Aluminum Alloy Composites, M. Ateeb Razvi, Dr. Ashesh Tiwari,[14]had investigated on Investigations and Analysis of Tribological Properties for Engineering Materials. L.Nirmala, C.Yuvaraj, K. Prahlada Rao, Seenappa, [15] had discussed Microstructural and Mechanical Behaviour of Zincaluminium Cast Alloys, K. Narayana, Md.Ruksar Sultana, et al[16] was studied on Influence of Heat Treatment on Mechanical and Tribological Properties of Tin brass. Himanshu Kalaa, K.K.S Merb, Sandeep Kumar was presented [17] A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminum Matrix Composites,

L. Montesano*, A. Pola, M. Gelfi, G.M. La Vecchia, [18] were studied on Wear behavior of Zn-15Al-1Cu-Mg alloy after aging. V. Ramakoteswara Rao, N. Ramanaiah and M. M. M. Sarcar were studied 19], Tribological properties of Aluminium Metal Matrix Composites (AA7075 Reinforced with Titanium Carbide (TiC) Particles, Mr. S. R. Hule, Prof. D. S. Galhe, had [20] Study on the Hydroudynamic Bearing Materials & Properties.

2. Sliding Contact Bearings:

Bearings are machine elements which are used to support a rotating member viz., a shaft. They transmit the load from a rotating member to a stationary member known as frame or housing. They permit relative motion of two members in one or two directions with minimum friction, and also prevent the motion in the direction of the applied load. The bearings are classified broadly into two categories based on the type of contact they have between the rotating and the stationary member

- Sliding contact
- Rolling contact

The sliding contact bearings having surfaced contact and are coming under lower kinematic pair.

2.1 Sliding Contact Bearings - Advantages and Disadvantages:

These bearings have certain advantages over the rolling contact bearings. These include

- The design of the bearing and housing is simple.
- To occupy less radial space and are more compact.
- Cost less.
- The design of shaft is simple.
- To operate more silently.
- They have good shock load capacity.
- They are ideally suited for medium and high speed operation.

The disadvantages are:

- The frictional power loss is more.
- Required good attention to lubrication.
- Normally designed to carry radial load or axial load only.

2.2 Sliding Contact Bearings – Classification:

Sliding contact bearings are classified in three ways.

- Based on type of load carried
- Based on type of lubrication
- Based on lubrication mechanism.

2.2.1 Bearing classification based on type of load carried

a. Radial bearings

b. Thrust bearings or axial bearings

c. Radial – thrust bearings.

2.2.2 Bearing classification based on type of lubrication

The type of lubrication means the extent to which the contacting surfaces are separated in a shaft bearing combination. This classification includes:

a. Thick film lubrication.

b. Thin film lubrication.

c. Boundary lubrication.

2.2.3 Bearing classification based on lubrication mechanism

a. Hydrodynamic lubricated bearings

b. Hydrostatic lubricated bearings

c. Elastohydrodynamic lubricated bearings

d. Boundary lubricated bearings

e. Solid film lubricated bearings.

2.3 Requirement of sliding contact Bearing Material: [21]

The following are the requirements of sliding contact bearing materials

2.3.1 Load capacity: The allowable compressive strength the material can withstand without any appreciable change in shape is the primary deciding factor in deciding a bearing material. Plain bearings are expected to have the following characteristics for the ease of functioning and satisfying the design criteria. Strength to take care of load-speed combinations

2.3.2.Fatigue strength: where bearing materials are subjected to stress cycle as in internal combustion engines. The retention of strength characteristics of softer bearing materials at temperature of operation which may rise within the design limit. The material must easily conform to shape of the journal and should be soft enough to allow the particulate contaminants to get embedded

2.3.3. Conformability: Conformability (low elastic modulus) and deformability (plastic flow) to relieve local high pressures caused by misalignment and shaft deflection. It helps to accommodate misalignment and increase the pressure bearing area (reduce the localized forces). Relatively softer bearing alloys are better in this respect.

2.3.4.Embeddability: Embeddability or indentation softness, to permit small foreign particles to become safely embedded in the material, thus protecting the journal against wear. It is the ability of a material to embed dirt and foreign particles to prevent scoring and wear (decrease 3rd. Body abrasion). Materials with high hardness values have poor embeddability characteristics.

2.3.5. Shear Strength: Low shear strength for easy smoothing of surface asperities.

2.3.6. Bondability: Many high capacity bearings are made by bonding one or more thin layers of a bearing material to a high strength steel shell. Thus, the strength of the bond i.e. bondability is an important consideration in selecting bearing material.

2.3.7. Strength: Adequate compressive strength and fatigue strength for supporting the load and for enduring the cyclic loading as with engine bearings under all operating conditions.

2.3.8. Coefficient of friction: Low coefficient of friction the material combinations of sliding surfaces, along with the lubricant should provide a low friction coefficient for reducing damage and lower running costs

2.3.9. Thermal conductivity: The bearing material should be of high thermal conductivity so as to permit the rapid removal of the heat generated by friction.

2.3.10. Thermal expansion: Bearing material should be of low coefficient of thermal expansion, so that when the bearing operates over a wide range of temperature, there is no undue change in the clearance.

2.3.11. Compatibility: The shaft and bearing materials in rubbing condition should not produce localized welds leading to scoring or seizure. A good bearing-shaft metal combination is necessary. It should be compatible with journal material to resist scoring, welding and seizing.

2.3.12. Corrosion resistance: The oxidized products of oils corrode many bearing alloys. Some protection can be provided by forming a thin layer of anti-corrosion materials on the bearing alloy surface should have good corrosion resistance against the lubricant and combustion products.

2.3.13. Wettability: An affinity for lubricants so that they adhere and spread to form a protective film over the bearing surface.

2.3.14. Relative hardness: The bearing material should usually be softer than that of the journal to prevent shaft wear but hard enough to resist adhesive and abrasive wear of its own surface. Bearings are easier to replace than shafts (that require dismantling of the whole engine). If one bearing is worn out only that bearing needs replacement instead of the whole shaft.

2.3.15. Elasticity: should be elastic enough to allow the bearing to return to original shape upon relief of stresses that may cause temporary distortion, such as misalignment and over.

2.4 Materials Used For Sliding Contact Bearings:

2.4.1. Babbit metal: [20], [1]

Babbitts are the most commonly used bearing materials. Babbitts have excellent conformability and embeddability, but have relatively low compressive and fatigue strength, particularly above 77°C. Babbitts can seldom be used above about 121°C. Other materials such as tin bronze, leaded bronze, copper lead alloy, aluminium bronze, aluminium alloys and cast iron are also used in many applications. Widely used bearing material compositions are given below:

a. Tin base babbits: Tin 90%; Copper 4.5%; Antimony 5%; Lead 0.5%.

b. Lead base babbits: Lead 84%; Tin 6%; Antimony 9.5%; Copper 0.5%.

c. Copper alloys such as Cu- 10% to 15% Pb.

The tin base and lead base babbits are widely used as a bearing material, because they satisfy most requirements for general applications. The babbits are recommended where the maximum bearing pressure (on projected area) is not over 7 to 14 N/mm^2. When applied in Marine bearings automobiles, the Babbit is generally used as a thin layer, 0.05 mm to 0.15 mm thick, bonded to an insert or steel shell.

In industry today, tin-based Babbitt alloys are physically far superior to lead-based Babbitt alloys. Tin-based Babbitt can withstand surface speeds of 1000 to 2400 ft/min and loads of 100-2000 lbs/sq. in., easily surpassing the lead-based Babbitt limits of 100-1000 ft/min and 100-500 lbs/sq. in. Tin-based Babbitt alloys are also structurally stronger as they exhibit greater tensile strength and elongation than lead-based Babbitt. Even with the significant advantage tin-based Babbitt holds over lead-based Babbitt, there is no lack of demand for lead-based Babbitt today. Not every application requires the full capabilities of tin-based Babbitt and, in those cases, lead-based Babbitt may suffice. Needing only 10% tin to obtain maximum strength at room temperature, lead based Babbitt is a much more economical choice when work is being done at a slower speed and/or with a less heavy load.

2.4.2 Copper:

Copper is one of the earliest metals discovered by man. The boilers on early steamboats were made from copper. The copper tubing used in water plumbing in Pyramids was found in serviceable condition after more than 5,000 years. Cu is a ductile metal. Pure Cu is soft and malleable, difficult to machine. Very high electrical conductivity second only to silver. Copper is refined to high purity for many electrical applications. Excellent thermal conductivity – Copper cookware most highly regarded–fast and uniform heating. Electrical and construction industries are the largest users of Cu.

2.4.3 Copper Alloys:

Brasses and Bronzes are most commonly used alloys of Cu. Brass is an alloy with Zn. Bronzes contains tin, aluminum, silicon or beryllium. Other copper alloy families include copper-nickels and nickel silvers. More than 400 copper-base alloys are recognized

2.4.4 Brasses:

Brass is the most common alloy of Cu – It's an alloy with Zn. Brass has higher ductility than copper or zinc. Easy to cast- relatively low melting point and high fluidity. Properties can be tailored by varying Zn content. Some of the common brasses are yellow, naval and cartridge. Brass is frequently used to make musical instruments (good ductility and acoustic properties). The proportions of the copper and zinc are varied to yield many different kinds of brass. Basic modern brass is 67% copper and 33% zinc. Lead commonly is added to brass at a concentration of around 2%.

2.4.5 Bronze:

Copper alloys containing tin, lead, aluminum, silicon and nickel are classified as bronzes. Cu-Sn Bronze is one of the earliest alloys to be discovered as Cu ores invariably contain Sn. Stronger than brasses with good corrosion and tensile properties; can be cast, hot worked and cold worked. Wide range of applications: ancient Chinese cast artifacts, skateboard ball bearings, surgical and dental instruments. 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.

The gun metal (Copper 88%; Tin 10%; Zinc 2%) is used for high grade bearings subjected to high pressures (not more than 10 N/mm^2 of projected area) and high speeds.

The phosphor bronze (Copper 80%; Tin 10%; Lead 9%; Phosphorus 1%) is used for bearings subjected to very high pressures (not more than 14 N/mm2 of projected area) and speeds.

2.4.6 Beryllium copper:

Cu-Be alloys are heat treatable. Max solubility of Be in Cu is 2.7% at temp. Imparts precipitation hardening ability. Cast alloys - higher Be. Wrought alloys – lower Be and some Co. Cu-Be is ductile, weldable and machinable. Also resistant to non-oxidizing acids (HCl or H2CO3), abrasive wear and galling. Thermal conductivity is between steels and aluminum. Applications -Used in springs, load cells and other parts subjected to repeated loading. Low-current contacts for batteries and electrical connectors. Cast alloys are used in injection molds. Other applications include jet aircraft landing gear bearings and bushings and percussion instruments.

2.4.7 Silver:

The silver and silver lead bearings are mostly used in aircraft engines where the fatigue strength is the most important consideration.

The rapid increase in the commercial use of Zinc- Aluminum alloys as bearing material is the result of extensive investigations and studies undertaken in the last twenty years .Two materials usually recommended for sliding bearings are ZnAl12 and ZnAl27, which contain 12 and 21 Vo Aluminum respectively. These materials were included into the EN 1174198 and ASTM B 669-89 standards.

Zinc-based alloys containing Al and Cu have superior mechanical properties, good wear resistance, good embeddability, good running-in characteristics, low density and good castability The increasing interest in Zn Al alloys during the last decade, especially with 2l Vo Al, as a wear resistant material, has made it necessary or establish their tribological characteristics.

Selection of material for bearing applications depends on the type of bearing, type of lubrication and environmental conditions. [2]

This paper is aimed to for sliding contact bearing materials are starting with Babbitt and other non ferrous materials. Tensile behavior, hardness, fatigue and tribological properties of these bearing materials were discussed thoroughly and compared.

3. Recent Developments of sliding contact Bearing Materials

Nowadays almost variety of materials is available often specialized for a particular application. In most cases, the selection is unique and manufacturer's assistance needs to be taken. Bearing materials can be metallic or non-metallic. Metallic bearings are made of white metal (tin and lead based), bronzes (copper based), aluminum based, porous metals, and coated metal.

Cast nonferrous bearing materials inspite of the versatility of the casting process, probably the great majority of cast bearings are made in simple shapes [7]. Close tolerances and more complicated shapes are readily obtained but at an increase in cost. The category of cast bearings includes many types of bearings ranging from cast Babbitt bearing lining to iron castings which have bearing surfaces. However, the term usually refers to bearings cast in bronze, although in recent year's aluminum base and zinc base alloys have received much attention. Bronze is popular material because of its high strength, good bearing properties and high heat conduction. The following are the materials of different non ferrous materials used as material for bearings

1. Babbits: Tin and lead based babbits
2. Copper base alloys: Bronzes and copper lead alloys

3. Aluminum based alloys: Al-Sn alloys

4. Zinc based alloys: ZnAl alloys

5. Cadmium alloys and

6. Silver alloys

3.1. Cast Aluminium Bearing Alloys Aluminium bearing alloys are relatively new [7]. These alloys usually have excellent resistance to corrosion in acid oils, good load carrying capacity and good fatigue resistance. These alloys are the result of an intensive research and development program carried out by Hunsicker and others. Alumnium-tin alloys are the main alloys in this category. Pure Al-Sn alloys do not possess the strength needed in highly stressed bearings. The addition of Si forms has constituent which increases strength noticeably. Antiscuffing qualities are improved also, although ductility is reduced. Al-Sn-Si-Cu alloy is the most successful Al bearing alloy. Manufacturing costs are low because of good machining characteristics and high speed with which the material can be cut and finished. In this family, Al-10%Sn, Al- 20%Sn, Al-30%Sn and Al-40%Sn are the most important alloys. 20%Sn alloys have high fatigue strength along with embeddability and conformability. Corrosion resistance is also good for this alloy. 30%Sn alloy, for service in especially dusty conditions, has been known for its greater embeddability and conformability than 20%Sn alloy. For 40%Sn, the compatibility and conformability is more than 30%Sn. ZA-27 alloy (27.6% Al, 2.5% Cu, 0.012% Mg and balance Zn) alloy was processed by the liquid Metallurgy route [15]. The ZA-27 alloy was processed by the liquid metallurgy route. The purity of aluminum was 99.90%, zinc 99.99 % and copper 99.5%. Alloy was melted in a graphite crucible in an electric resistance furnace. The melt was overheated to 680oC and cast into a steel mold to obtain samples as 100 mm long bars with rectangular cross-section with dimensions of 30 X 20mm.

3.2Tin Bronzes: C90300, C90500, C90700 Tin's principal function in these bronzes is to strengthen the alloys (Zn also adds strength, but more than about 4% Zn reduces the antifrictional properties of the bearing alloy) [3]. The tin bronzes are strong and hard and have very high ductility.

3.3 Leaded Tin Bronzes: C92200, C92300, C92700 some tin bronzes contain small amounts of lead, and its main function is to improve machinability. A few of the leaded bronzes also contain zinc, which strengthens the alloys at a lower cost than tin. Otherwise these have similar properties as the tin bronzes.

3.4 High Leaded Tin Bronzes: C93200, C93400, C93500, C93700, C93800 The family of high-leaded tin bronzes includes the workhorses of the bearing bronze alloys. These high leaded tin bronzes are used for general utility applications under medium loads and speeds

3.5 Aluminum Bronzes: C95300, C95300HT, C95400, C95400HT, C95500, C95500HT, C95510 The aluminum bronzes are the strongest and most complex of the copper based bearing alloys. The aluminum content provides most of their high strength and makes them the only bearing bronzes capable of being heat treated. Their high strength, up to 120 ksi permits them to be used at unit loads up to 50% higher than leaded tin bronzes. They consequently require shafts hardened to

3.6 Manganese Bronzes (High Strength Brasses): C86300, C86400 These are modifications of the Muntz metal type alloys containing small additions of Mn, Fe and Al plus lead for lubricity, anti-seizing and embeddability. These bearings can operate at high speeds under heavy loads, but require high shaft hardnesses and nonabrasive operating conditions.

3.7Copper Beryllium Alloys: C82400, C82600, and C82800 Copper beryllium alloys can be heat treated to attain higher strengths than any other copper alloy. Copper beryllium alloys have good bearing properties.

4. Mechanical Behavior of Bearing Materials.

Mechanical properties of metals and alloys depend on their alloying elements, % of impurities present, microstructure, and their processing technique.

4.1L.Nirmala1 at el [15]

Materials and Moulds used Zinc based alloys were prepared by liquid metallurgy route. The raw materials used to prepare these alloys are 99.99 % Zinc and 99.99 % aluminium and are melted up to 6300C, then poured into a preheated die of cylindrical pattern of diameter 22 mm and 165 mm long. Measurement of tensile, impact and hardness properties tensile test was conducted as per ASTM A370 standards at ambient temperature with a strain rate of 1.3x10-3/s using universal testing machine. The impact test was performed in accordance with ASTM E23 standards. Hardness of metallographically prepared samples was measured using a Micro Vickers hardness tester as per ASTM E10 standards.

Microstructural studies of the alloys were carried out using Scanning electron microscope (SEM) and Energy dispersive X-ray spectroscopic.

The following table- 1 that shows the wt% of nickel and other alloys are present in ZA27 alloy. And table-2 that show the

Mechanical properties correspondence to wt % of nickel

Table -1 Chemical composition of the experimental ZA 27 Alloy (wt %) [15]

Nickel content	Al	Ni	Cu	Mg	Fe	Ti	Pb	Mn	Zn
0	24.71	0.001	0.03	0.105	0.09	0.00069	0.0031	0.007	Rem
1	24.53	1.09	0.03	0.102	0.09	0.0007	0.003	0.007	Rem
2	23.98	1.95	0.034	0.108	0.09	0.0007	0.003	0.007	Rem
3	24.10	3.10	0.035	0.120	0.092	0.0007	0.003	0.007	Rem

Table-2 Mechanical properties of ZA27 from the experiments [15]

Nickel content	UTS (MPA)	Yield strengths (mpa)	Ductility %	Hardness (MVHN)	Impact Energy (J)
0	236.00	203.00	10.80	115	4
1	288.65	224.57	8.77	121	6
2	295.18	238.30	6.03	127	7
3	328.84	248.95	3.65	135	8

4.2 Dr. P. Sriram et al [3]

Zinc based bearing materials: (ZA bearing materials) Zinc-Aluminium (ZA) alloys have emerged in recent years as a cost effective alternative to bronze alloys. In addition ZA cast alloys possess a number of other shop floor advantages(such as lower melting and casting temperatures, lower energy requirement for melting, absence of fumes, excellent casting characteristics and superior machinability) over conventional copper base alloys. Table -3 that shows chemical composition of ZA-12 and ZA-27 with respective mechanical properties.

Table- 3 ZA-12 and ZA-27 Alloy Composition and properties [3]

					YS	TS	El	BHN	COPM YS	FATIGUE	THERM
Alloy	Zn	Al	Cu	Mg	ksi	ksi	%	500kg	ksi	STRE ksi	CONDU
ZA12	88	11	1	0.02	31	45	2	95	34	8	67.1
ZA27	81	27	2.25	0.015	54	64	5	120	48	15	72.5

4.3 Bekir Sadik Ünlü et.al., [6] Mechanical properties of copper based bronze, brass and aluminum based duralumin bearing materials generally occurred than those of zinc based zamac and tin–lead based white metal bearing materials. Hardness of these bearing specimens was found to be around 100 HB.

Wear properties, the wear rate values of bearings depending on materials are shown in figure 1. Friction coefficient was determined as a function of normal and friction force [8] .The highest friction coefficients and bearing temperatures occurred in CuSn10 and CuZn30 bearings, whereas the lowest friction coefficients and bearing wear losses occurred in other ZnAl, AlCuMg2 and SnPbCuSb bearings. Fig -1 shows that values of the wear rate depend on different chemical composition.

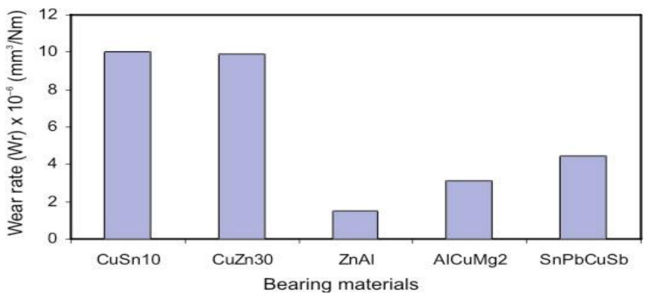

Fig -1 The wear rate values of bearings depending on materials [6]

4.5 M. Babić, S. et.al. [7]

Sliding wear tests ZA-27 alloy (27.6% Al, 2.5% Cu, 0.012% Mg and balance Zn) alloy was processed by the liquid Metallurgy route. The ZA-27 alloy was processed by the liquid metallurgy route. The purity of aluminum was 99.90%, zinc 99.99 % and copper 99.5%. Alloy was melted in a graphite crucible in an electric resistance furnace. The melt was overheated to 680oC and cast into a steel mold t obtain samples as 100 mm long bars with rectangular cross-section with dimensions of 30 X 20mm.The specimens were tested using a computer aided block-on-disc sliding wear testing machine with the contact pair geometry in accordance with ASTM G 77 - 83. A schematic configuration of the test machine is shown in Fig. 2

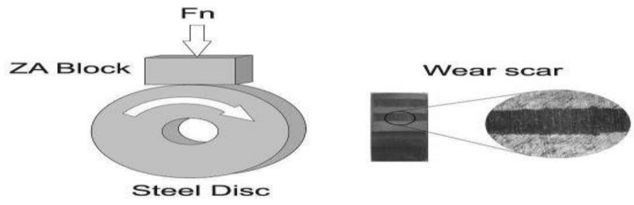

Fig. 2. The test block was loaded against the rotating steel disc. [7]

The test blocks (6.35 x 15.75 x 10.16 mm) were prepared from the as-cast and heat-treated zinc aluminum alloys. Their contact surfaces were polished to a roughness level of Ra = 0.2 μm. The counter face (disc with 35 mm diameter and 6.35 mm thickness) was fabricated using the Casehardened 30CrNiMo8 steel with hardness of 55HRC. The roughness of the ground contact surfaces was Ra = 0.3 μm. The lubricated and dry tests were performed under applied loads of 10 – 100 N and sliding speeds of 0.26 – 1.0 m/s. The lubricant used for the lubricated tests was ISO grade VG 46 hydraulic oil, a multipurpose lubricant, recommended for industrial use in plain and antifriction bearings, electric motor bearings, machine tools, chains, and gear boxes, as well as in high-pressure hydraulic systems. During the lubricated tests, the discs were continuously immersed up to 3 mm of dept in 30 ml of lubricant the wear behavior of block was monitored in terms of the wear scar width. Using the wear scar width and geometry of the contact pair, the MT8500 Series) were used to examine the worn surfaces of the tested wear blocks.

4.4 Ramakoteswara Rao et.al. [20]

Hardness Behavior [7] Figure 2 shows, the hardness behavior of matrix metal and composites. Previously an attempt has been made for investigation on properties of TiC reinforced AA7075 metal matrix composites [19]. It can be observed that hardness shows increasing trend with increasing percentage of TiC particulates. However, declining of hardness was observed for C5 composite due to agglomeration and casting defect. This hardness increase was observed from 181 VHN for matrix metal to 202 VHN at 8 wt% TiC reinforced composite (C4) at T6 condition. This could be due to the presence of TiC particulates which are hard in nature. Different hardness values are recorded by increasing %of reinforcement as shown in fig-3.

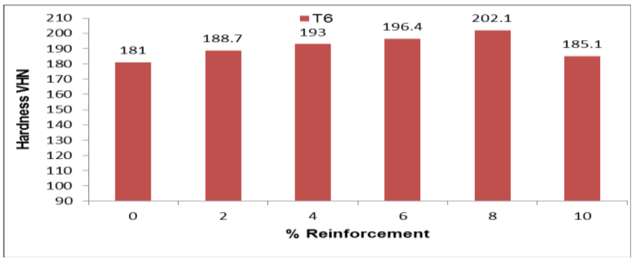

Fig – 3 The hardness behavior of matrix metal and composites

4.5 M. Ateeb Razvi, Dr. Ashesh Tiwari et.al. [9]

Carried out Wear Rate Measurement

The plunger moment as an indication of wear rate is sensed by LVDT. As wear occurs its plunger lifts up and this movement is displayed as wear on controller. The least count of LVDT is 1 micrometer, the initial position of plunger measurement is kept at midpoint of to have both +ve & -ve wear readings.The maximum wear rate measurement possible is +/-2mm. In ad-dition to the wear as indicted by LVDT, the wear on specimen may also be computed by measuring the initial & final length of specimen using Digital vernier caliper or micrometer.

Fig -4 show, it has been noticed that when we increase the load the wear was found to be increased. In case of Aluminium, wear in-creases at starting and then retarded. In Brass, the wear was increasing linearly.

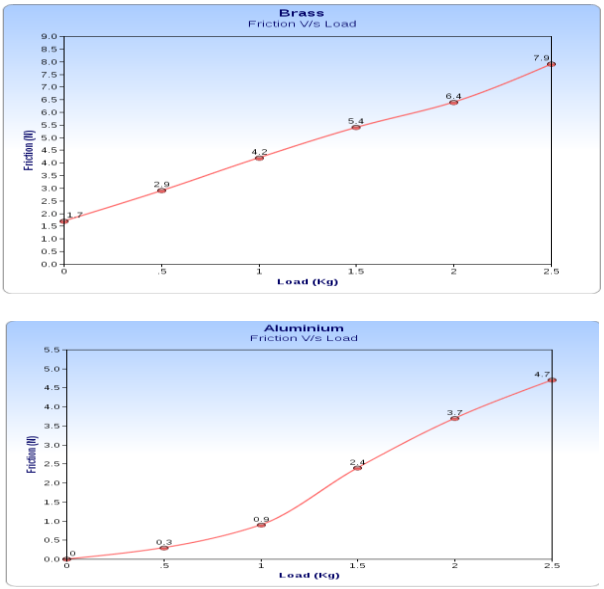

Fig – 4 It has been noticed that when we increase the load the wear was found to be increased

5. CONCLUSIONS

The above review for the sliding contact bearing materials leads to the following conclusions:

1. Bearing material selection is a significant step in the design of the equipment. It affects the overall efficiency of the equipment. Designers need to choose appropriate materials for their bearing requirement. Even though, many new bearing materials have come up in recent past

2. Stir casting method can be successfully used to manufacture metal matrix composite with desired properties.

A few authors have reported about modified stir casting methods for improving the distribution of the reinforcement in the matrix. However, there is a lack of work regarding availability of efficient techniques for nano level reinforcements.

3. Now a day's number of non ferrous bearing materials is available for using for sliding contact bearing application. The choice cans be made by comparing all the required properties for the particular application, design aspects of the bearing. There is no single best bearing material, every material promising individual property to meet particular service requirements.

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