Experimental investigation on load capacity and wear rate of principal metal alloys used for bearing manufacture.

Bako D. M.[1], H. B. Abdulkadir[2] and A. Babawuya[3]. Vehicle Inspection Department, Ministry of Transportation, Niger State, Minna. Scientific Equipment Development Institute,(SEDI)-Minna. Mechanical Engineering Department, School of Engineering and Engineering technology, Federal University of Technology, Minna.

Abstract.

In this study, a boundary condition test was conducted on journal bearing materials (Al-Tin alloy and Lead-Bronze alloy) used in Peugeot and Toyota automobiles were examined at room temperature conditions. The results of experiments are presented in graphics which proves that the average loading capacities, PV factor and wear factor for the two alloys are 143.94kPa, 63.17kPa, 6.76 m^3, 4.7 m^3, 16.97 and 8.75 respectively. The coefficient of wear for Lead-Bronze is 0.4, while that of AL-Tin is 0.54. The Lead-Bronze alloy shows better properties than the Al-Tin alloy. It was also observed that both wear rate and load capacity factor increase with increase in journal surface velocity for Al-Tin Alloy and decreases for Lead-Bronze alloy.

Keywords: Experimental Investigation, Aluminum-tin, Lead-bronze, Journal Bearing Design.

Email: bako.danladi@yahoo.com

Received: 2013/10/27
Accepted: 2013/12/30
DOI: http://dx.doi.org/10.4314/njtr.v8i2.9S

Introduction

With development in auto and manufacturing technology journal bearings are widely used in rotating machinery, especially when shafts are submitted to both high speeds and heavy applied loads. These properties, high speed and applied force in addition to the bearing material affects the performance and area of application of bearing. Bearing has being manufactured over the ages with different material such as brass, bronze and metal. Currently, in addition to these bearing materials Al-Ti, Lead-Bronze base materials are widely used as journal bearing materials. Load bearing capacity and wear resistance are very important properties that journal bearing should possess, (Bekir, 2009). Al –Ti alloys are used in bearing application where corrosion is a problem. Al-Si alloy have excellent coefficient of friction and mechanical properties such as castability, thermal conductivity and welderbility, (Stolarski, 2000), while lead-bronze based metal alloys are used to their antifriction properties as bearing material (Shigley *et al*, 2003).

According to Bekir (2009), journal bearing materials are expected to have several properties such as low friction coefficient, high load capacity, high heat conductivity, compatibility, high wear and corrosion resistance. These properties directly affect the fatigue and wear life (Hillier *et al*, 1966).

There are several studies and investigation on the tribological properties of bearing material (Katsarova, 2007, Bekir, 2009, Demirci *et. al.*, 2011, Zhi, 1995), there is still incomplete understanding on the bearing dynamics, (Zhi, 1995). It will be of great importance to study the load bearing capacity of bearing materials used in common automobile in Nigeria i.e., Toyota and Peugout. When faced with these phenomena, an investigation into their loading capacities will make it possible to design bearings with satisfactory lives and good reliabilities. Accomplishing this kind of task is the essence of this paper, i.e. to use wear factor to investigate the loading capacity of metal alloys used for bearing manufacture or development.

Materials and Method

The materials used for the experiment are:

- Journal Bearing Friction Apparatus – the apparatus in figure 2.1, was designed and fabricated at the mechanical workshop of Federal University of technology, Minna.
- Two Bearings made from i. Al-Ti alloy and ii. Lead-bronze alloy. The dimensions of the bearing specimens are ϕ50mm x 40mm x 5mm and ϕ45mm x 40mm x 5mm respectively.
- SAE 50 (viscosity level 0.02) oil.

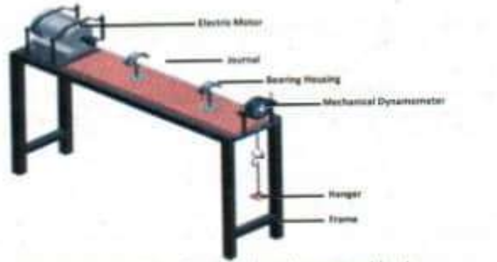

Figure I: Journal Bearing Friction Apparatus Used.

Test Procedure

In this study, Al-Ti alloy and lead-bronze alloy were used as journal bearing, SAE 50 (viscosity level 0.02) oil. The dimensions of the bearing specimens are as follows:

The experimental set up is shown in the Figure I. The electric motor was switched on and run for few minutes, while the tachometer was set at zero. The bearing inserts or sleeve (a pair of half liner) were installed on the journal and the housing closed and the cap nut tightened down.

The test speed was recorded using the hand tachometer. The bearing was loaded by adding weight on the loading hanger. Oil was supplied at a controlled rate of three drops per interval of time (Tables I - II) at the commencement of boundary lubrication. Five tests were conducted for an average of 1 hour on each bearing. At the end of each test, the dynamic data recorded includes:

- The journal speed recorded by the tachometer (RPM).
- The load tending to stop the journal rotation (N) when boundary lubrication occurred.
- The time interval between oil supply (T).

During the boundary lubrication test, an audible cracking noise developed in the journal housing and the electric motor switched off. The journal housing dismounted and the bearing removed for observation of distress. The test results recorded and shown in the Tables I and II.

Results

The results (experiment readings) of the experiments of the two bearing materials are presented in table I and II. The bearing pressure, journal surface velocity, volumetric wear rate, load velocity factor and coefficient of wear were calculated and tabulated in table III and IV. Table III shows the average values for the pressure bearing, volumetric wear rate, load velocity factor and wear coefficient for Lead-Bronze and Al-Tin alloys are 144kPa, 6.8 m^3, 17, 0.39 and 63kPa, 4.7m^3, 8.8, 0.54 respectively. Also, these readings are graphically presented in figures I-X. This will provide a clear picture of the data taken during the experiment.

Table I: Boundary lubrication test schedule for Aluminium-tin bearing inserts

Selected tachometer Reading	**Weight on Bearing (N)**	**Time Interval (min)**
30	50	6
40	75	10
50	125	12
60	150	17
70	200	20

Table II: Boundary lubrication test schedule for lead bronze bearing insert

Selected tachometer Reading	Weight on Bearing (N)	Time Interval (min)
30	60	15
40	100	13
50	150	10
60	200	8
70	250	4

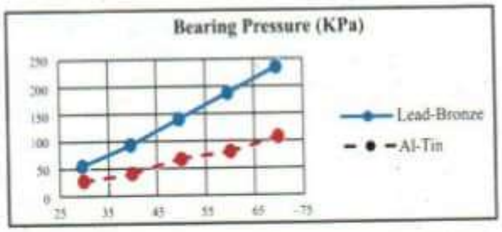

Figure II: Measured bearing load on tachometer speed over time for Al-Tin and Lead Bronze alloy.

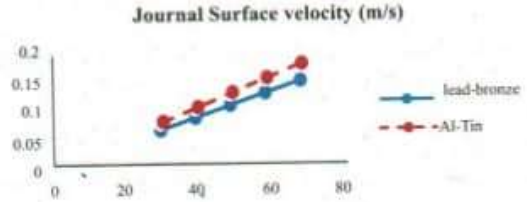

Figure III: Measured journal surface velocity on tachometer speed over time for Al-Tin and Lead Bronze alloy.

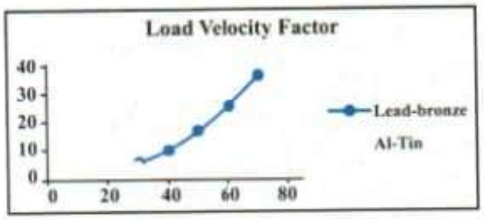

Figure IV: Measured volumetric wear rate on tachometer speed over time for Al-Tin and Lead Bronze alloy.

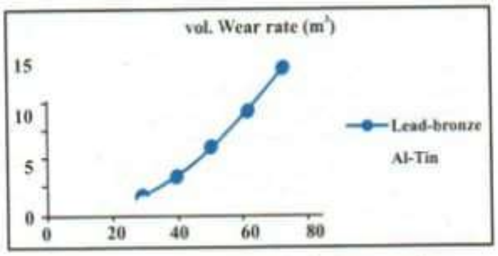

Figure V: Measured Load Capacity factor on tachometer speed over time for Al-Tin and Lead Bronze alloy.

Table III: Calculated Results of the Boundary Lubrication Test for Al-Tin Alloy.

	Time Interval (hr)	Bearing Pressure (KPa)	Journal Surface velocity (m/s)	vol. Wear rate (m³)	Load Velocity Factor	Coefficient of Wear
	0.10	26.3196	0.0739	1.0440	1.9434	0.5372
	0.17	39.4791	0.0985	2.0879	3.8867	0.5372
	0.20	65.7985	0.1231	4.3499	8.0973	0.5372
	0.28	78.9582	0.1477	6.2639	11.6601	0.5372
	0.33	105.2776	0.1723	9.7439	18.1379	0.5372
Average	0.22	63.1665	0.1231	4.6979	8.7451	0.5372

Table IV: Calculated Results of the Boundary Lubrication Test for Lead-Bronze Alloy.

	Time Interval (hr)	Bearing Pressure (KPa)	Journal Surface velocity (m/s)	vol. Wear rate (m³)	Load Velocity Factor	Coefficient of Wear
	0.07	236.7424	0.1466	13.821	34.7128	0.3982
	0.15	189.3939	0.1257	9.4773	23.803	0.3982
	0.17	142.0455	0.1047	5.9233	14.877	0.3982
	0.22	94.69697	0.0838	3.1591	7.9343	0.3982
	0.25	56.81818	0.0628	1.4216	3.5705	0.3982
Average	0.17	143.9394	0.1047	6.7605	16.9795	0.3982

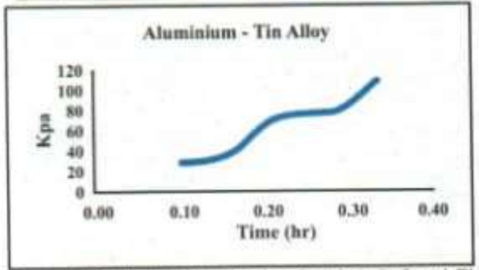

Figure VI: Calculated bearing Load against tie for Al-Tin alloy.

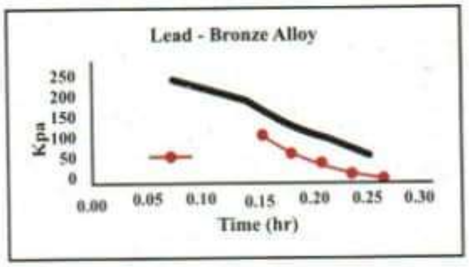

Figure VII: Calculated bearing Load against time for Lead-Bronze alloy.

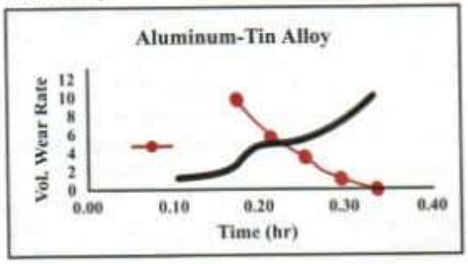

Figure VIII: Calculated volumetric wear rate against time for Al-Tin alloy

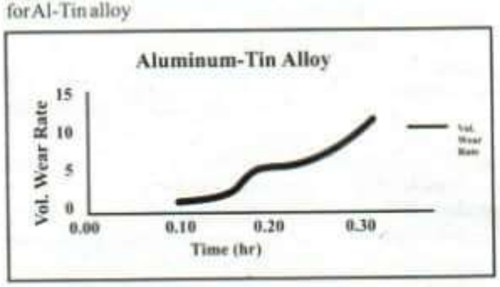

Figure VIX: Calculated volumetric wear rate against time for Leau-Bronze alloy

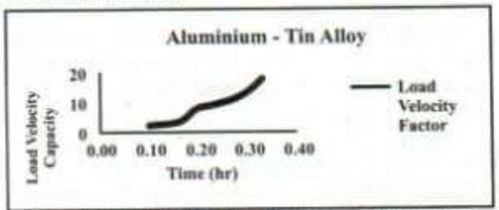

Figure X: Calculated load capacity factor against time.

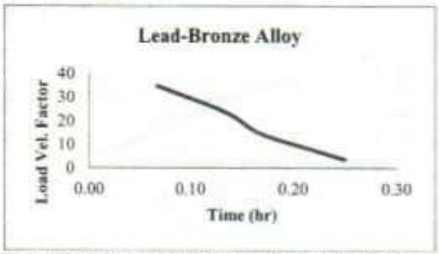

Figure X: Calculated load capacity factor against time.

Discussion

Tables I and II, shows boundary lubrication results test for both lead-bronze and Al-tin bearings. The records of varying weight and time were taken as the speed of shaft increased. The projected area of the bearings is 1056 mm^2 and 1900 mm^2 for Lead-Bronze and Al-Tin respectively. Figures II and III, shows that, as the tachometer speed increases, the bearing pressure and journal surface velocity also increases linearly. But, figure I, reveals that, lead-bronze alloy has more bearing pressure than the Al-tin ally. Figures IV and V, shows that, the volumetric wear rate and load velocity factor increases nearly exponentially as the tachometer speed increases.

Table III - IV shows the calculation of the bearing pressure, load velocity factor and wear factor in each case. The Results demonstrate that lead-bronze alloy bearing permits about 60-70% higher loading capacity than the Al-tin alloy bearings. The bearing capacity is a measure of strength. The load-velocity factor (P^1V) of lead bronze is 60-70% higher than that of Al-Tin. The P^1V valve is a measure of the ability of the bearing material to accommodate the frictional energy generated in the bearing. At the limiting P^1V value, the bearing will not achieve a stable temperature limit and rapid failure will occur. The P^1V value is also a measure of the bearing ability of absorb energy without overheating. Although, the volumetric wear rate for lead-bronze is higher due to higher applied load than the Al-tin.

Conclusion.

The following conclusions can be drawn from the present study:

- The lead bronze bearing recorded a higher loading capacity.
- The lead bronze less journal surface velocity.
- The lead bronze higher rate of wear.
- The lead bronze higher load velocity factor.
- The lead bronze less Wear Factor.
- Increase of journal surface velocity causes increase in wear rate and load capacity factor.

This was also cited in Bekir, (2009), Demirci. (2011).

References

Bako D. M. (2009), Design and Fabrication of Journal bearing Friction Apparatus for Testing The Loading Capacity of Metal Alloy Used For Bearing Manufacturing, Unpublished B. Eng. Thesis. Federal University of Technology, Minna, Niger State, Nigeria.

Bekir S. Ü. (2009). Investigation of tribological and mechanical properties of metal Bearings, Bull. Mater. Sci., © Indian Academy of Sciences. 32 (4): 451–457.

Demirci M. T., Duzcuhoglu H. and S. Ekinci (2011). Effect of Temperature in the Wear Behaviour of Glass Fiber Reinforced PA 6.6 Journal Bearings, 6th International advanced Technologies Synposium (IATS II), Elazig, Turkey, 16-18 May..

Hillier, V. A. W. and F. W. Pttuck (1966). Fundamentals of Motor Vehicle Technology. Second Edition.London Melborne Sydney Auckland, Wellington Johannesburg Cape Town and Agencies throughout the World. pgs 243 – 255.

Khanna, (1994), Material Science and Metallurgy" Revised Edition , Taj. Press, A. 35/4, May Pure Indl. Area, Phase 1, New Delhi Chapter 9, Pages 1 – 5.

Katsarova P., Nikolov S. and M. Tashev (2007). Design, Production, and Application of a Stand For Testing Friction of The Bearings, Journal of Engineering Annals, Tome V. Fascicole 2, (ISSN 1584 – 2665).

Shigley, J. E.. and R. M. Charles (2003). Mechanical Engineering Design. The McGraw – Hill Companies, Inc, New York, Pg 735 – 817

Stolarski, T. A. (1990). Tribology in Machine Design" Butter Worth – Heimann Linear House, Jordan Hill, Oxford Ox28dp 225 WIllhood Avenue, Woburn, Pgs 202, 169, 230, 3 and 50.

Zhi Ling Qui (1995). A Theoretical and Experimental study on dynamic Characteristics of Journal Bearing, Unpublished Ph. D Thesis, Univerisity of Wollongong. www.google.com-wikipedia.