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Investigations on Sliding Contact Characteristic of Frp Composite Bearing using Artificial Neural Networks

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***Abstract* – In rotary machines vibration is an inherent phenomenon which has the tendency to affect required performance. Amongst the different parameters that affect vibration, selection of appropriate bearing is the most critical component. In this work the effect of different types of bearing on vibration in rotary machines is studied and the magnitude of vibration produced by use of different set of bearings under the same condition of loads and rotational speeds were investigated. Bearings considered in this work were ball bearing, tapered roller bearing, thrust bearing and shaft material considered is of mild steel. From experimental result, it was noted that tapered roller bearing gives the highest amplitude of vibration among all the three bearings whereas the ball bearing gives least amplitude under similar operating conditions.**

***Keywords*– Vibration of Composite Shaft & Vibration Analysis of the Rotating Shaft.**

I. INTRODUCTION

Bearings are machine elements that allow components to move with respect to each other. Bearings are used to support large skyscrapers to allow them to move during earthquakes, and bearings enable the finest of watches to tick away happily. Without bearings, everything would grind to a halt, including people, whose joints are comprised of sliding contact bearings!

There are two types of bearings, contact and noncontact. Contact-type bearings have mechanical contact between elements, and they include sliding, rolling, and flexural bearings. Mechanical contact means that stiffness normal to the direction of motion can be very high, but wear or fatigue can limit their life.

Non-contact bearings include externally pressurized and hydrodynamic fluid-film (liquid, air, mixed phase) and magnetic bearings. The lack of mechanical contact means that static friction can be eliminated, although viscous drag occurs when fluids are present; however, life can be virtually infinite if the external power units required to operate them do not fail [1,2,3].

1. Sliding Wear

Sliding wear may be defined as ‘wear due to localized bonding between contacting solid surface leading to material transfer between the two surfaces or loss from either surface’. Specific wear rate is the measure of the wear loss per unit distance and per unit load. The coefficient of friction is the ratio of frictional load to the normal load applied. For the applications like gears, bearings and cams, low specific wear rate and low coefficient of friction is essential parameters. But for components like clutches and brakes low specific wear rate and high coefficient of friction is required. However, in both the cases thermal conductivity of the material is essential property. Most commonly used matrix materials are polymeric. The reason for this are two fold. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and does not require high temperature. Also equipment’s required for manufacturing polymer matrix composites are simpler [4,5].

2. Roller Bearing

Fiber-reinforced plastic (FRP) (also fiber-reinforced polymer) is a composite material made of a polymer matrix reinforced with fibers. The fibers are usually glass, carbon, agamid, or basalt. Rarely, other fibers such as paper or wood or asbestos have been used. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use.

FRPs are commonly used in the aerospace, automotive, marine, construction industries and ballistic armor[6].

A polymer is generally manufactured by step growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers the result is referred to as a plastic. Composite plastics refer to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties.

Fiber-reinforced plastics are a category of composite plastics that specifically use fiber materials to mechanically enhance the strength and elasticity of plastics.

Fig.1. roller bearing.

The original plastic material without fiber reinforcement is known as the matrix[7,8,9]. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibers. The extent that strength and elasticity are enhanced in a fiber-reinforced plastic depends on the mechanical properties of the fiber and matrix, their volume relative to one another, and the fiber length and orientation within the matrix [10,11].

3. Unbalance identification

The different unbalance conditions are considered such as[12-15]

1. no additional unbalance
2. 4 gm unbalance
3. 6 gm unbalance and
4. 8 gm unbalance each at 5.3 cm radius on the disc.

The unbalance mass is considered at an arbitrary position on the disc, however, the additional masses are added at the same location each time in the experiment. In each case 20 sets of data are taken. The pre processing is performed on the whole signal to extract the required statistical features like mean (μ), root mean square (rms) and variance (2σ), standard deviation, skewness and kurtosis using MATLAB. Training and testing of the neural network is done with the experimental data and confusion matrix is obtained in four different cases: one is with statistical features in horizontal direction, second is with statistical features in vertical direction, third is with frequency domain amplitude in horizontal direction, and fourth is with frequency domain amplitude in vertical direction. Unbalance severity of the rotor bearing system is classified based on the above mentioned four methods and using ANNs.

II. REVIEWOF ARTICLES

PramilaBaiet. al. [1] reported "that Si additions (4-24%Si) improved wear resistance of aluminium, no relationship between wear rate as a function of Si content was found. Wear rate increased linearly with applied pressure but was independent of sliding velocity. The value of the friction coefficient was found to be insensitive to applied pressure, Si content and sliding velocity. The fact that no transition in wear mechanism was observed with increased pressure, as reported by other authors could be due to the narrow range explored (0.105-1.733 MPa)".

Liang Y. N. et. al.[2] Reported that the MMCs containing SiC particles exhibit improved wear resistance. Particle size is one of the mostimportant factors in determining wear of particulate-reinforced metalcomposites. However, it appears to be difficult to draw a fundamentalconclusion from the reports about this problem. Some reports havesuggested that wear resistance of the composites increased with increasingparticle size, while others indicated that an increase in particle size had anegligible influence on the wear rate.

H.C. How and T.N. Baker[3]In their investigation of wearbehavior of Al6061-saffil fiber, concluded that "saffil are significant inimproving wear resistance of the composite".The steady-state wear ofaluminium alloy AA6061 and AA6061-based Saffilfibre-reinforcedcomposites, manufactured by a PM route, was investigated with a pin-ondisc configuration under dry sliding conditions. Using a constant slidingvelocity, the wear rates of the monolithic alloy and the compositesincreased proportionally with the applied load. The benefit of Saffilreinforcement at volume fractions of 5, 10 and 20% was not substantial at loads ranging from 4.9 to 48.3 N. As the applied load decreased to 1.1 N,the composite showed a promising improvement in wear resistance as thevolume fraction of Saffil reinforcement increased.

R. Dasgupta, R. Thakur, and B. Govindrajan (2002) [4] concluded intheir study that "the high stress wear behavior is dependent on thecombination of a number of experimental factors. The behavior can beexplained based on the material removal mechanism operating under acombination of experimental factors. A regression analysis of theexperimental data shows that the dependence is nonlinear. The equationarrived at by regression analysis helps in predicting the wear rate. A comparison between the experimental and predicted observed valuesindicates a variation of ±15%. Such an analysis should aid in predictingthe high stress abrasive wear behavior of steels exposed to variouscombinations of load, particle size, and sliding distances".

M.S. Zaamout (2004)[5] the objective of this research is to investigatethe abrasive wear behaviour of polymer base auto motive paint, which islocally used for steel painting. Research has been conducted under dry,water lubricated, and water-soap lubricated conditions. The effects ofapplied load, sliding distance, abrader surface roughness, and paint dryingtime on the abrasive wear volume and abrasive wear rate wereinvestigated under controlled environment of 23 C temperatures and 40%humidity. L.J. Yang (2005) [6] in their study found that the Wear coefficientvalues obtained from different investigators can vary significantly up to adeviation of 1000% due to lack of a standard test method. Higher wearcoefficient values can be obtained when the wear tests are carried out within the transient wear regime, or with an excessive sliding distance inthe steady-state wear regime.

BasavarajappaS. and Chandramohan G (2006) [7]reported that “thesliding distance has the highest effect on the dry sliding wear behavior ofMMCs than that of the load and sliding speed”.

Y. Reda et.al (2008) [90] studies on Al6061-SiC and Al7075 - Al2O3Metal Matrix Composites and R. Clark et. al.[9] in their studies onAl7075 reported that “pre-aging at various retrogression temperaturesimproves the hardness, tensile properties and electrical resistivity”.

Q Wang, Z H Chen, Z X Ding and Z L Liu 2008 [8] “Conductedstudy on Performance of abrasive wear and erosive wear of WC-12Cocoatings sprayed by HVOF. They used WC-Co cermets as wear resistantmaterials. Their work examines the performance of such conventional andnano-structured materials in the form of coatings deposited by highvelocity oxy-fuel (HVOF) thermal spraying. The results indicated that:microstructures of nano-structured and multimodal WC-12Co coatingsprepared by HVOF are dense with little porosity, and their microhardnessvalues are obviously higher than conventional WC-12Co coatings, thoughNano WC did during spraying

B. Sidda Reddy, G. Padmanabhan and K. Vijay Kumar Reddy(2008)[9]
in their study deals with the development of a surface roughnessprediction model for machining aluminum alloys using multiple regressionand artificial neural networks. The experiments have been conducted usingfull factorial design in the design of experiments (DOE) on CNC turningmachine with carbide cutting tool. A second order multiple regressionmodel in terms of machining parameters has been developed for theprediction of surface roughness. The adequacy of the developed model isverified by using co-efficient of determination, analysis of variance(ANOVA), residual analysis and also the neural network model has beendeveloped using multilayer perception back propagation algorithm usingtrain data and tested , using test data. To judge the efficiency and abilityof the model to predict surface roughness values percentage deviation andaverage percentage deviation has been used.

D. Kakas, B. Skori C, S. Mitrovi C, M. Babi C, P. Terek, A. Mileti C , M. Viloti C (2009) [10]The influence of applied load and sliding speed on the tribological performance, i.e. friction and wear of TiN IBAD coating in sliding with corundum ball has been evaluated using reciprocating sliding wear test. Post characterization of wear zones was conducted using AFM, SEM and EDX. The results show that coefficient of friction decrease with decreasing applied load and with increasing the sliding speeds.

Hua-Nan Liu, KeisakuOgi [11] In this study the tribological properties of Al2O3 continuous fibre reinforced Al-4.43 wt %Cu alloy composites with a fibres’ volume fraction of about 0.55 were measured for five types of fibre orientations under a dry sliding contact with a bearing steel. Fibres were in a plain perpendicular to wear surface and parallel to sliding direction, and had the angles 0o , 45o , 90o, or 135owith respect to the direction of motion of the counter face; or were anti-parallel the sliding direction. The results show obvious dependence of wear characteristics on fibres orientation: for the 45o , 90o , and 135o orientations, the larger the fibres’ angle, the lower the volume loss; while the 0o orientation resulted in a higher steady-state wear rate than those of the 45o , 90o , and 135o , orientations, except that the anti-parallel orientation caused the highest volume loss at all sliding distances.

A.A. Torrance (2005) [12] In his study the abrasive wear rates of materials may be very simply related to their mechanical properties, provided wear takes place under very simple conditions. However, wear rates in many practical situations can be controlled by effects which either relate to mechanical properties in more subtle ways, or which are controlled by quite different parameters.

III. PROBLEM IDENTIFICATION

The review study on wear showed the strengths and findings of various mathematical models. The investigation of the same should be utilized to allow new work to progress and therefore improve our knowledge. It is in the view of this author that a multi orientation set-up is need of the hour , so that wear should be checked at different angular position , this will not only add the new dimension to study the wear but will also gives the better understanding of wear behavior of different metal at different orientation.

This approach might be very different and new when compared to approaches discussed earlier in different models.A comprehensive literature review was done according to problem selected, due to the uniqueness of the same, it was decided that research paper concerning abrasive wear will be taken in to consideration.

1. Significance of this experimental

The significance of this experimental study is to improve the selection of water-lubricated bearings materials and as a result, improve their performances. The outcomes of this research project are:

- Analysis of the existing types of materials, and experimental models and techniques for modelling and simulating the operational conditions of water-lubricated bearings
- Identification of the existing problems associated with the contemporary technology of water-lubricated bearings materials
- Development of an experimental methodology and technique for the application of a Pin-on-Disk test rig and determination of the main contributing factors
- Identification and analysis of various lubrication and operational conditions for water-lubricated bearing materials and systems and development of further recommendations for future work.

2. The expected outcomes from this research project are:

- Identification of the existing problems in the contemporary technology of water- lubricated bearing materials and systems
- Further development and extension of the experimental methodology of investigation of friction, vibration, and wear of water-lubricated bearings materials using a Pin-on-Disk test rig
- Identification and further development of methods to analyse friction, vibration, wear, the vibration-wear relationship, and the effect of water contamination on the tribological behavior of water-lubricated bearing materials
- Development of practical recommendations to improve the materials design, performance, selection, and overall modelling and performance of water-lubricated frictional systems.

3. Effect of damping on vibration and wear

During the design stage of rotating machines, wear and vibration in bearings are significant problems for designers. Several investigators have been interested in the damping phenomenon. In previous studies on wear initiation and development, theoretical analyses predicted that contact damping is the most effective factor for preventing wear (Suda and Komine, 1996). It is known that increased damping reduces contact vibration, resulting from surface roughness, although the mechanism may be different (Suda and Komine, 1996).

4. A few methods exist for contact damping to improve bearing performance

These methods include (Sutherland, 2002):

- Structural damping (which refers to energy dissipation within the structure by add- on damping devices such as an isolator, by structural joints and supports, or by structural member's internal damping);
- Self-balancing damping (when the vibrations of rotors can be reduced or eliminated by adding self-balancing mechanical components);
- Liquid damping (when the vibrations of rotors can be reduced or eliminated by adding self-balancing liquid);
- Speed control damping (when the vibrations of rotors can be reduced or eliminated by a change of rotation speed);
- Magnetic damping (when the vibrations of rotors can be reduced or eliminated by a magnetic field).

Structural damping is not always sufficient to limit vibration and wear to within the desired level. In these cases, magnetic damping may provide a solution.

5. Objectives

1. The steady-state friction regime where the frictional force increases linearly with the normal load.
2. The non-linear friction regime where the friction force increases non-linearly with the normal load and the coefficient of friction is no longer constant but increases with the normal load.
3. The transient regime, characterized by intermittent variation of the friction force. When the friction force reaches a sufficiently high value, a temporary burst of self- excited vibrations occur and the friction force falls to a lower value.
4. The self-excited vibration regime where the friction force drops to a low value and is accompanied by high-amplitude periodic self-excited oscillations.

IV. METHODOLOGY

ANN is that the term used for systems that attempt to work the approach the human brain works. Suggests that system tries to perform a precise task the approach humans do. commonly computers do any work the approach it's educated within the sort of code, however it doesn't have the aptitude of finishing works that it absolutely was ne'er schooled of. however if we tend to contemplate an individual's brain, it's self-learning capability that makes it perform several processes that it's been neither performed nor schooled. So, ANN essentially tries to inherit this capability of the human brain to self-train itself for tasks that area unit ne'er been performed by it that too terribly with efficiency.

Human brain’s structure consists of neurons that area unit interconnected with one another and there by forming giant network that is well connected thereby helps in playing a awfully complicated task like voice and image recognition very simply. a similar task once performed mistreatment traditional pc will not offer AN correct result.

V.CONCLUSION

The present review paper discusses some challenges related to the use and testing of bulk and thin film polymer based tribo-components such as sliders, bushings ball bearing cages, electrically conductive bearing, gears, and coatings. Attention is not only given to basic influencing parameters such as contact pressure, sliding velocity, environmental conditions (including high and very low temperatures, and counterpart material. Also new manufacturing aspects, e.g. 3D printing, and advanced techniques for better self-lubrication and self-healing of tribo-materials by incorporation of microcapsules are considered.

Obviously, along with the extensive application of polymer composites for tribological purposes, the better understanding of polymer tribology is becoming increasingly important. Vice versa, increased understanding of polymer tribology will promote the tribolgical application of these materials [2]. This paper has traced the progress of achievements in academic understanding and industrial use of polymer composites for numerous tribological applications over the past three decades. However, further efforts are needed to utilize in the future the full potential of reinforced polymeric materials in the wide field of tribology. The tribological properties of Brass and Brass composites filled with mos2 were systematically studied under different operating condition at ambient temperature. From the result the following conclusions are drawn.

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