Review Paper on Grease Lubrication Considering Effect of Solid Contaminant in Lubrication on Vibration Response of Roller Bearing

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ABSTRACT

Grease lubrication is typically useful to rolling contact bearings. The stableness of grease prevents it from leaking out of any quite of bearing, makes it very easy to use, and should provide it high-quality quality sealing properties. The same stability prevents an optimal lubrication on bearing performance. The majority of the grease is brief of out of the cage of bearing through the primary phase of bearing operation and not dynamically participates within the lubrication process, leaving only a partial quantity available, which is stored within the bearing geometry and on the bearing, shoulders covers or seals. This stored volume strongly determines the remaining lubrication process within the ball bearing. The distribution of this volume is about by the lubricating grease flow, which is extremely complex to know due to the strong nonlinear rheology. Grease process has self healing properties where fresh grease is supplied just in case of film breakdown and self induced heat development. To affect this problem, a non invasive technique like vibration measurement is used for monitoring the performance of machines. This review paper describes the effect of lubricant contamination by solid on the dynamic behaviour of rolling bearing, to figure out the trends within the vibrations of the bearing. Review of paper is made with roller bearings lubricated with contaminated lubricant and healthy grease lubricant. Solid contaminate in three concentration levels and three grain sizes are wont to contaminate the lubricated grease. Vibrations generated during the working of bearing because of contaminants in lubricant are monitor within the terms of the source mean square and crest amplitude values by means of FFT analyzer. The results of contaminant on bearing vibration are considered for both good and defective bearings. The results show remarkable vibration in RMS velocity values on varying the contaminants concentration and grain size.

Keywords: Grease Application; Greases; Lubricant Degradation; Rolling Element Bearings; General; Contaminant; Limestone; Grease; Particle Size; FFT Analyser.

1 Introduction

The main role of grease during a rolling bearing is to provide the rolling element ring contact with a lubricant to make sure a separation of the 2 such the bearing features an extended life and low friction. The foremost reward of using grease in its place of oil lubrication are the expediency of use (it won't easily leak of the bearing due to its consistency), the inherent sealing develop, the safety next to corrosion, and low friction (provided that the bearing is correctly filled).The main disadvantage of using grease is its limited life and mechanical work on the grease deteriorates its configuration and into cases of warmth, oxidation takes place (T > 125◦C) (Ito, et al. (1). Harsh lubricant starvation occurs, causing bearing failures. This suggested that the service lifetime of the bearing could also be determined by the lifetime of the grease. There just in case the bearings may require being relubricated occasion ally; i.e., full of fresh grease. The bearing manufacturers have particular the relubricating intervals in their catalogues. These re lubrication intervals are calculated from the lifetime of the grease. Unluckily, there's no total value for this. Even it bearings are running under alright restricted conditions, like during a laboratory condition, there's the quality significant

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spread in life. The re lubrication time is defined because the L01 of grease life; i.e., the time at which 1% of a population of bearings is projected to possess unsuccessful (Huiskamp (2)). Bearing is that the component which is usually utilized in rotating, system much of machines industries. . In bearing, contamination of grease by foreign particles is that the majority cause of untimely bearing breakdown within the metal extracting industry. This research paper informs concerning the results of lubricant contamination through solid particles on the behaviour of needle bearing. Present review explores the effect of a contaminant on the rated lifetime of bearing. Solid particulate in three concentration levels and three grain sizes are used as a contaminant within the lubricant. The contaminant concentrations also because the grain sizes are different for each experiment Vibrations signatures are within the type of Root Mean Square (RMS) values by using FFT analyser are analysed. M.M.Maru (3) administered the research work on the study of solid contamination in ball bearings through vibration analysis. He investigates the effect of lubricant contamination by solid particles on the dynamic changes of bearings, for locating the vibration effect of the contaminant within the oil. He performed new tests on radial ball bearings lubricated through an oil bath and concluded that contaminant within the lubricant is liable for generating vibrations in bearing. V.Hariharan (4) performed the condition monitoring improve on ball bearings allowing solid contaminants limited by the lubricant. He finds the effect of solid contamination in lubricant on the colourful capacity of bearing. He used Silica powder as contaminant having three concentration stage and three subdivision sizes. He deals with experiment on the ball bearings lubricated with grease. The results showed that, remarkable variation was observed with change in contaminant concentration and particle size. S. Raadnui (5) tested the electrical pitting from wear debris formed by a grease lubricated bearing. He performed a selection of experimental tests for wear types and mechanisms. He explains the consequences of electrical currents also as mechanical parameters associated with grease lubricated rolling element bearings. He experienced lubricated bearings by means of the AC field and completed that electrical pitting wear particles demonstrate typical characteristics. Lars Kahlman (6) permitted out the research effort on the cause of particulate contamination during grease lubricated hybrid rolling bearings. The results showed that wear in hybrid rolling bearing reduced because of the addition of small Titania particles as well as lubrication also enhanced, resulting within low running temperature under high load. S.P.Kamalesan (7) administered the research work resting on the vibration studies lying on ball bearing considering solid contaminants within lubricants. He investigated the contaminated and non-contaminated bearing. He observed to facilitate the vibration level increased through contaminant concentration level, treatment to stabilise during a limit. With particle size increased, the vibrations first increased then decreased. N. Tandon (8) studied the grease utilized within the ball bearings of electrical motors. According to him, the lubricating grease frequently gets contaminated moreover from exterior particles or particles generated inside these bearings. Oxide and silica particles are used as contaminants contained by the grease. The results showed to facilitate level of vibration, acoustic emission, stator current and shock pulse extensively greater than before as contaminant size increased. Acoustic emission is that the excellent condition monitoring technique for the finding of foreign impurities in the grease of motor bearings. Gagan Singotia (9) performs the experiments to examination of varied solid contaminants in roller ball bearings. Different techniques are employed by him to analyse vibrations during a ball bearing. He observed that vibration level amplified through concentration level, tending to stabilize during a maximum value. Particle settling conclusion was the possible factor used for vibration intensity decreases.

5 Grease Properties

5.1 Grease Structure

Grease is definite as "a solid in the direction of semi-fluid product alternatively dispersion of a thickening representative through a liquid lubricant. Other ingredients imparting special properties also can be included" (NGLI (10)). The rock bottom oil is kept inside the thickener structure by a mixture of Van der Waals and capillary forces (Bauer, et al. (11)). Interactions between thickener molecules are dipole-dipole including hydrogen bonding (Hurley (12)) or ionic and Van der Waals forces (Forster, et al. (13)). The effectiveness of these forces depends on how these fibres contact mutually other. The thickener fibres vary long from about 1 to 100 μm and have a length to diameter ratio of 10 to 100 where this ratio has been correlated with the continuity of the grease for a given concentration of thickener. It's not obvious the thanks to visualize the structure of grease. Generally, wet samples can't be utilized in a scanning microscope. Figure 1 show the structure of some grease where the oil has been carefully washed away employing a non-polar solvent. As grease contains 80–90% oil, one can argue so as to the thickener structure might collapse if the oil is washed out which such an image could also be ambiguous. Another spectacular techniques are used also sort a freeze-fracture method (Margnin and piau(15)) ; Shuff and Clarke (16), where a production is made of a frozen grease sample which can be observed within the SEM. Also, atomic force microscopy (AFM) has been used (Hurley and Cann (17)). Shin, et al. (18) visualized the grease flow during a shear field with an optical microscope in phase contrast mode. They observed very long fibres ranging from 50 to 100 μm, which are for much longer than those observed with the SEM.

5.2 Additives

The function of additives in grease has not been explored in much aspect. At elevated temperatures, the antioxidant additives will have the greatest effect. These additives are constantly consumed during bearing operation and, reliable with a lubrication van den Kommer (19), totally consumed after 50% of grease life. Excessive pressure/anti wear (EP/AW) additives are normally useful for low speed and/or high load. The effect on grease life that these additives have isn't well understood. secure with Gow (20) some 90% of all lubricant additives demolish the thickener structure of grease since they're often supported surface-active materials and this results in what's commonly called the mayonnaise effect (softening and discoloring). He also mentions that of the remaining 10%, some 90% don't work. He describes this to the very fact that the thickener material is approximately very polar (metallic soaps) which the (also polar) EP additives will stick on to the soap structure instead of to the metal surface (Gow (21)). This is frequently in contradiction to the results established by McClintock who tested variety of greases on lubricant life and positioned a rise in life. An actually competent development is that the utilize of bismuth as an EP/AW additive because it is nontoxic and shows extraordinary performance (Rohr (22)). Kaperick (23) shows in an estimate of the "Timken OK Load Test," during which the same EP additives provides a different response to EP action for a variety of formulated greases and describes this to probable impact of mobility towards the surface during chemical interaction or attraction forces. If Gow is true then it's likely that the impact of EP additives on grease performance could also be measurable through the mechanical and thermal aging of grease. This direct impact could also be totally on consistency and bleeding rate. The primary problem is that the possible occurrence of replenishment between two consecutive rolling elements.

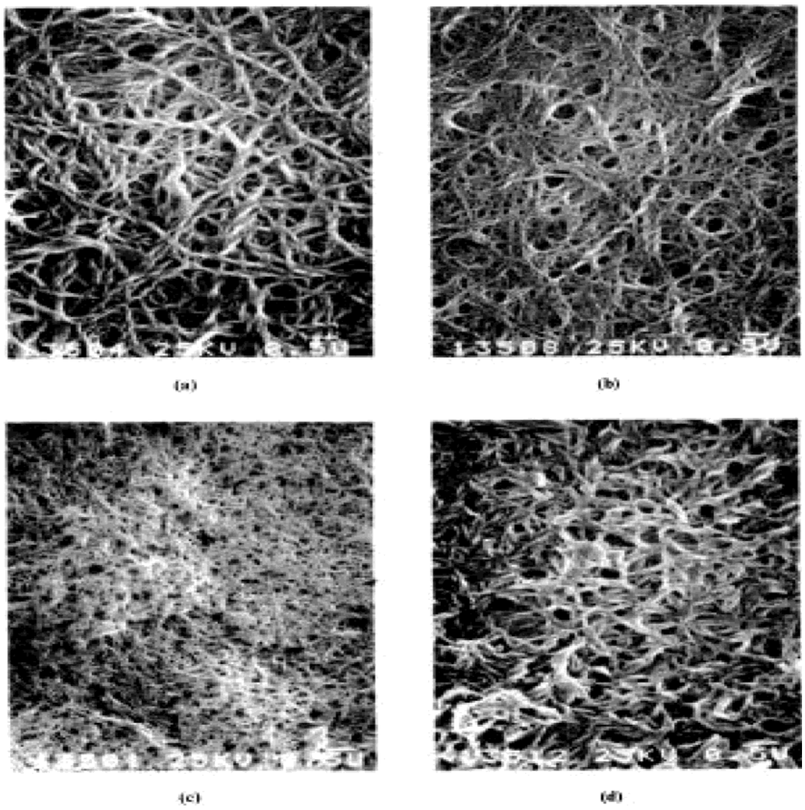

Figure 1: *SEM photographs of various grease soap structures (courtesy Piet M. Lugt[24])*

(a) lithium-12-hydroxyl stearate in mineral oil, common structure

(b) lithium-12-hydroxyl in mineral oil, healthy structure;

(c) lithium-12-hydroxyl stearate in ester oil, extremely fine structure;

(d) Modified lithium-12-hydroxy stearate in mineral oil.

6 Graphs of acceleration VS frequency considering effect of solid contaminant in Lubrication on vibration response of roller bearing:

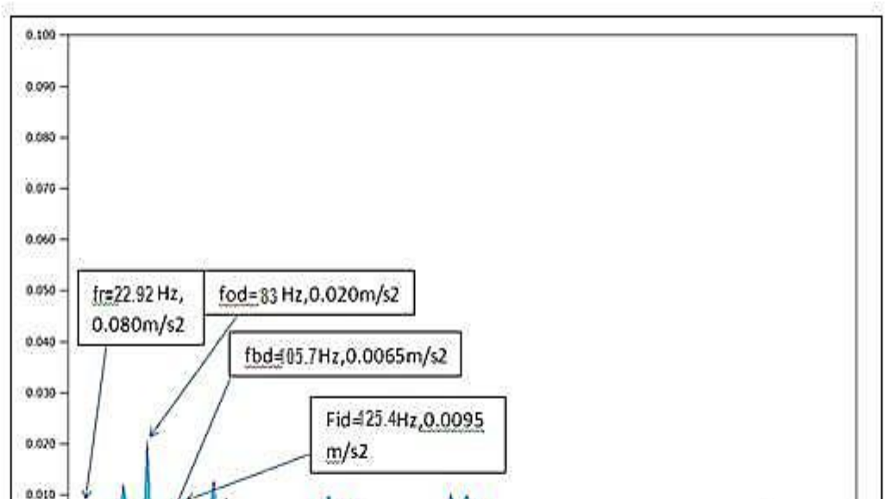

Figure 2: *Acceleration-Frequency graph for Healthy (courtesy S.S.Nawale and P.D.Kulkarni (25))*

Data is examined in terms of peak values and RMS values at corresponding defect frequencies. Above are the graphs of vibration signatures obtained experimentally by means of FFT analyser when solid contaminant is mixed. Fig.2 shows the graph obtained for healthy bearing with no contaminated grease. Here all frequencies are at buck level since there's no presence of the contaminant in lubricant which may create vibrations.

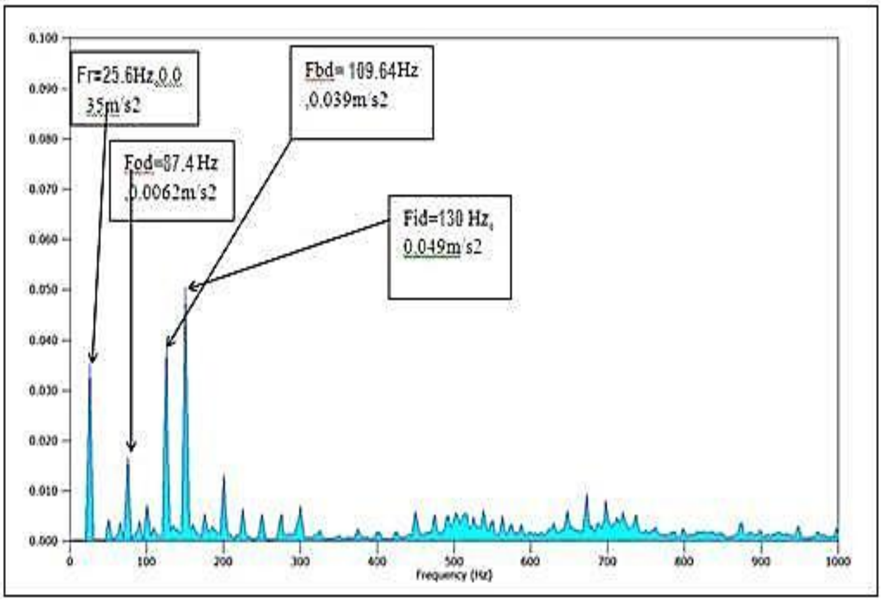

Figure 3: *Acceleration-Frequency graph for Bearing Sample C1W1 running at 1400 rpm (courtesy S.S.Nawale and P.D.Kulkarni (25))*

Figure 3 indicates small raise of acceleration value thanks to occurrence of the solid contaminant particles. This shows that a 130 micron size particle of limestone generates small vibrations within the bearing. Figure 4 indicates that there's increase in acceleration value compared to sample C1W2 thanks to increase of quantity of contaminant in bearing.

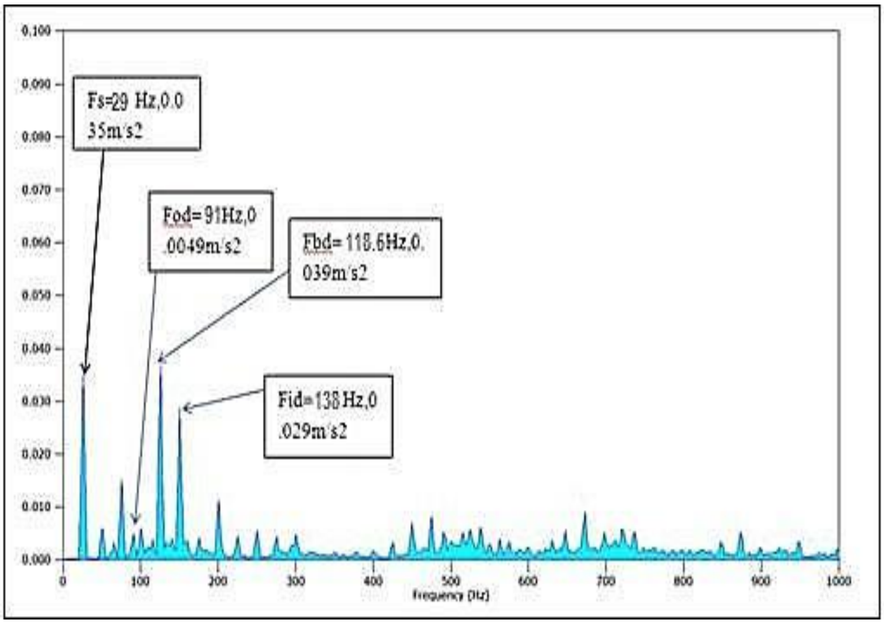

Figure 4: *Acceleration-Frequency graph for Bearing Sample C1W2running at 1400 rpm (courtesy S.S.Nawale and P.D.Kulkarni (25))*

Figure 5 indicates that with increase in quantity of contaminant there's decrease in amplitude of vibrations. Small particles at high concentration level might not are available contact with outer race hence acceleration values at outer race defect frequency decreases and acceleration values for inner race defect frequency increases.

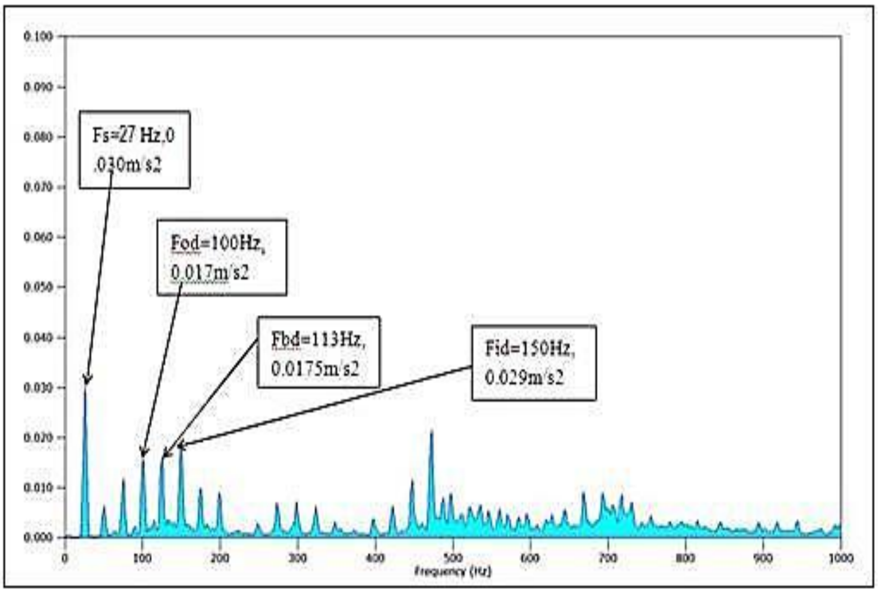

Figure 5: *Acceleration-Frequency graph for Bearing Sample C1W3 running at 1400 rpm (courtesy S.S.Nawale and P.D.Kulkarni (25))*

Figure 6 indicates that size of the particles taken for experimentation are 150μm, 250μm, 355μm with concentration levels varied as 30%, 40%, 50% of weight of grease respectively. The graph shows that with a rise of concentration level, acceleration of some defect frequency increased and a few decreased.

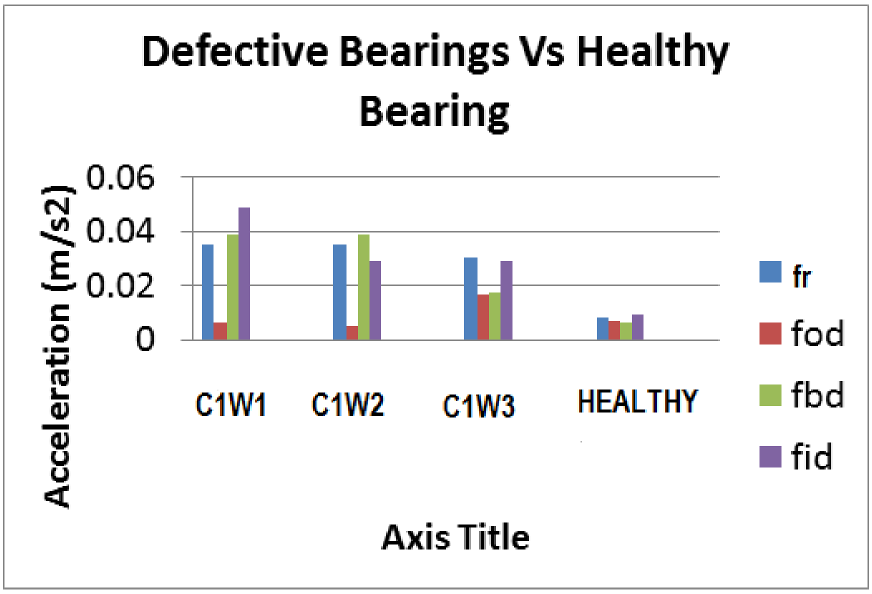

Figure 6: *Defective bearing- healthy bearing (courtesy S.S.Nawale and P.D.Kulkarni (25))*

7 Conclusion

This review paper describes about, vibration response of ball bearing is completed to watch the effect of a solid contaminant in lubricant on bearing. All frequencies are at lowest level for healthy bearing since there's no contamination in grease. Solid particulate is employed as contaminant. The results indicate that thanks to addition of the contaminant in grease, there's increase in vibration signature of ball bearing for constant speed and cargo. As grain size is increased, the corresponding acceleration values continue increasing up to specific limit then it starts decreasing. This is often thanks to contaminant occupy corners present within the bearing by virtue of its weight; therefore it doesn't are available contact with rolling elements. For the constant speed and cargo, as concentration level of contaminant increases there's a rise in vibrations of bearing which may cause failure. Extreme peak in acceleration v/s frequency graph indicates that there is raise in vibration of bearing due to adding together of contaminant in lubricant.

References

1] Ito, H., Koizumi, H., and M. Naka. (1995),"*Grease Life Equations for Sealed Ball Bearings*," Proceedings of the International Tribology Confer- ence, Yokohama, Japan, pp 931-936.

2] Huiskamp, B. (2004), "Grease Life in Lubricated-for-Life Deep Groove Ball Bearings," Evolution, 2, pp 26-28.

3] M.M. Maru and R.S.Castillo, *"Study of Solid Contamination in Ball Bearings through Vibration and Wear Analyses",* Tribology International," Vol.40, pp.433–440, 2007.

4] V Hariharan, *"Condition Monitoring Studies on Ball Bearings Considering Solid Contaminants in the Lubricant"*, Proc. Imeche Vol. 224 pp.1727-1747, 2009.

5] S. Raadnui and S. Kleesuwan," *Electrical Pitting Wear Debris Analysis Of Grease-Lubricated Rolling Element Bearings"*, Wear,Vol 271, pp.1707– 1718,2011.

6] LarsKahlman and Ian M. Hutchings*,"Effect of Particulate Contamination in Grease-Lubricated Hybrid Rolling Bearings "*, Tribology Transactions,Vol.42, pp. 842-850,2008.

7] P.Kamalesan, *Vibration Studies On Ball Bearing Considering Solid Contaminant In Lubricants*, South Asian Journal of Engineering and Technology Vol.2 ,pp.121,2016.

8] N. Tandon,"*Condition Monitoring of Electric Motor Ball Bearings for the Detection of Grease Contaminants*", Tribology International, Vol 40, pp.29–36, 2007.

9] GaganSingotia*, "Experimental Study Of Various Solid Contamination In Ball Bearings",* IJERT ,Vol.5,Issue 3, ,ISSN 2249-61,2013.

10] National Lubricating Grease Institute (NLGI). (1987), *Lubricating Grease Guide*, 2nd ed., Kansas City.

11] Bauer, W.H., Finkelstein, A.P., and Wiberley, S.E. (1960), "*Flow Proper- ties of Lithium Stearate-Oil Model Greases as a Function of Soap Concen- tration and Temperature*," ASLE Transactions, 3, pp 215-224.

12] Hurley, S. (2000), "*Fundamental Studies of Grease Lubrication in Elas- tohydrodynamic Contacts*," PhD Thesis, University of London, Imperial College of Science, Technology and Medicine, UK.

13] Forster, E.O., Kolfenbach, J.J., and Leland, H.L. (1956), "*Fibers, Forces and Flow*," NLGI Spokesman, 20(3), pp 16-22.

14] Scarlett, N.A. (1967), "*Use of Grease in Rolling Bearings*," Proc. IMechE. Part 3A, 182, pp 167-171.

15] Magnin, A. and Piau, J.M. (1989), "*Application of Freeze-Fracture Tech- nique for Analysing the Structure of Lubricating Greases*," Journal of Ma- terials Research, 4(4), pp 990-995.

16] Shuff, P.J. and Clarke, L.J. (1991), "*The Structure of Grease via Electron Microscopy and Image Analysis*," Lubrication Science, 4(1), pp 35-50.

17] Hurley S. and Cann, P.M. (2001), "*Examination of Grease Structure by SEM and AFM Techniques*," NLGI Spokesman, 65(5), pp 17-26.

18] Shin, M., Shiraishi, T., and Sakai, H. (2006), "*Visualization of Grease Flow in Shear Field*," Proceedings of ASIATRIB 2006, Kanazawa, Japan, pp 263-264.

19] van den Kommer, A. and Ameye, J. (2001), "*Prediction of Remaining Grease Life-A New Approach and Method by Linear Sweep* Voltamme- try," Proceedings Esslingen Conference, pp 891-896.

20] Gow, G. (2007), "*Ecclesiastes 3:1, Time for a New Approach?*" NLGI pre- print, presented at the NLGI 74th Annual Meeting, Scottsdale, Arizona.

21] Gow, G. (1995), "*Alassca, A Complex Complex*," NLGI Spokesman, 59(1), pp 10-18.

22] Rohr, O. (2007), "Preformed Soap as Thickener and Additive for Grease Production," NLGI Spokesman, 71(1), pp 15-20.

23] Kaperick, J. (2007), "*Timken OK Load-Media Bias?, A Comparison of Timken Response to Similar Additive Systems in Both Grease and Oil Formulations*," NLGI Spokesman, 71(5), pp 13-17.

24] Piet M. Lugt (2009), "*A Review on Grease Lubrication in Rolling Bearings, Tribology Transactions*," 52:4, 470-480

25] S.S.Nawale and P.D.Kulkarni (2017), "Analysis of solid contaminant in lubrication on vibration response of ball bearing," vol. 6 issue 6, June 2017.