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INFLUENCE OF ADDING CONTAMINANTS PARTICLES TO LITHIUM GREASE ON FRICTION COEFFICIENT

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ABSTRACT
This paper examines the addition of solid particles to the lubricants to explore and evaluate their influence on the friction coefficient. Silica sand with different particle sizes and iron (Fe) powder of five concentrations were dispersed in lithium grease. The effect of sliding velocity and normal load on friction and wear properties of stainless steel pin sliding against an aluminum disc was investigated. It was found that, Fe particles have shown good friction and wear reduction even at low concentration such as 2 wt. % and 4 wt. %.

KEYWORDS
Friction coefficient, lithium grease, solid contaminants.

INTRODUCTION
The variation of friction and wear rate depends on interfacial conditions such as normal load, geometry, relative surface motion, sliding speed, surface roughness of the rubbing surfaces, type of material, system rigidity, temperature, stick slip, relative humidity, lubrication and vibration. Among these factors sliding speed and normal load are the two major factors whose play significant role for the variation of friction and wear rate. There were some investigations on the tribological properties of lubricants with different micro particles added, and it was reported that the addition of micro particles to lubricant grease is effective in wear and -friction performances.
The effect of main components of white cement such as sand, kaolin and limestone contaminating lithium grease on friction coefficient and wear of steel test specimens was discussed, [1, 2]. Based on the experimental results it was found that tin proved to be effective as solid lubricant dispersed in lithium grease to decrease abrasion wear of the sliding surfaces. Several contaminants were collected from different areas in the cement factory including the air cooled slag with low ferric particles, fatty clay, sandy clay, water cooled slag with medium ferric particles, lime stone, iron ore and air cooled slag with high ferric particles. HDPE, LDPE, MoS_2, Al powder, PTFE, and PMMA were

used as lubricant additives in paraffin oil to reduce the effect of the solid contaminants, [3, 4].

The abrasive particles entering the machines cause serious wear of the sliding components, [5, 6]. Abrasive wear of composite materials is a complicated surface damage process, affected by a number of factors, such as microstructure, mechanical properties of the target material and the abrasive, loading condition, environmental influence. However, its effect on the wear mechanism is difficult to investigate experimentally, [7, 8], due to the possible synergism with other influences. Lubrication is critical for minimizing wear in mechanical systems, [9], that operate for extended time periods. Developing lubricants that can be used in engineering systems without replenishment is very important for increasing the functional lifetime of mechanical components. White Portland cement or white ordinary Portland cement (WOPC) is similar to ordinary, gray Portland cement in all respects except for its high degree of whiteness, [10].

Antifriction bearings are the most critical parts in rotating machinery. Solid contaminants are denting of the bearing raceways and roller elements. Solid contaminants may be the cause of bearing failure. Therefore, the dynamic behavior of antifriction bearing may be monitored using vibration measurements and wear debris analysis, [11, 12]. Influence of contaminants in the grease of the rolling bearing was investigated using the acoustic emission, [13 - 16]. It was found that, small size contaminant particles generated a higher acoustic emission pulse count level than large size particles. The behavior of lubricant contamination by solid Particles on the vibration signals of roller bearings was investigated.

The objectives of this work are to investigate tribological behavior of lithium grease dispersed by silica sand and Fe particles with different particles size. The contaminants concentration is varied to be 2, 4, 6, 8, and 10 wt. % of the grease. Their effect on friction and wear of moving surfaces was discussed.

EXPERIMENTAL

The Experiments were carried out using vertical universal friction and wear testing machine model MM-W1A as shown in Fig. 1. The MM-W1A machine consists of mainframe, grips, oil boxes, heater and measuring system, spring load system under close-loop control, indicator board and cabinet. The tribological properties of Different lubricant systems are tested. Lithium grease without additive is used as a basic lubricant. Generally different materials such as silica sand of (0 - 150 µm) "A", and (600 - 1400 µm) "B", and Fe micro particles at five concentration levels have been used to disperse the grease. The lubricant Li-base grease is used as a delivery grease to protect hot and cold rolled steel during transportation and storage. The amount of Li based grease was 1.0 g. The contaminants concentration is varied as 2, 4, 6, and 8 wt. % of the lithium grease.

The tests have been conducted using pin specimens with flat surfaces in the contact region with applied normal load in the range of 10 to 100 N. Rotating speed of the disk

was between 200 to 800 rpm, with 200 rpm step, at room temperature. Tests were conducted using 1.0 g of Li based grease. Prior to each test, the disk, Pin, disk holder and ball holder were cleaned for getting rid of unwanted material such as metal chips or lubricant adhering to the holders. The pin-on-disk test is generally used as a comparative test in which controlled wear is performed on the specimens. The volume loss allows calculating the wear rate of the material. Since the action performed on all specimens is identical, wear rate can be used as quantitative comparative value for wear resistance.

Fig. 1 Vertical universal friction and wear testing machine, (MM-W1A).

Fig. 2 Pin on-Disc Friction Pair.

RESULTS AND DISCUSSIONS

Effect of different contaminant particles content dispersed in grease on friction coefficient of the test specimens is shown in Fig. 3. The tests are conducted using pin specimens with flat surfaces in the contact region with the applied normal load in the range of 25 N, 200 rpm speed at room temperature. It is shown that, when the silica sand content increased, friction coefficient values increase. The increase of sand content increases the friction and wear between the contact surfaces. This phenomena may be related to the higher abrasive action of sand due to its hardness. Values of friction coefficient of sand (A) dispersed in the grease were relatively higher than that observed for sand (B). This may be attributed to the fact that the smallest particles may come in direct contact with rotating elements, break the grease film separating the contacting elements of the pin on disc friction pair. Moreover, the variation of friction coefficient values may be due to the interaction of silica particles on the contact area between the pin and the disc, as shown in Fig. 4. Furthermore, friction coefficient values decreased when the content of Fe particles increased.

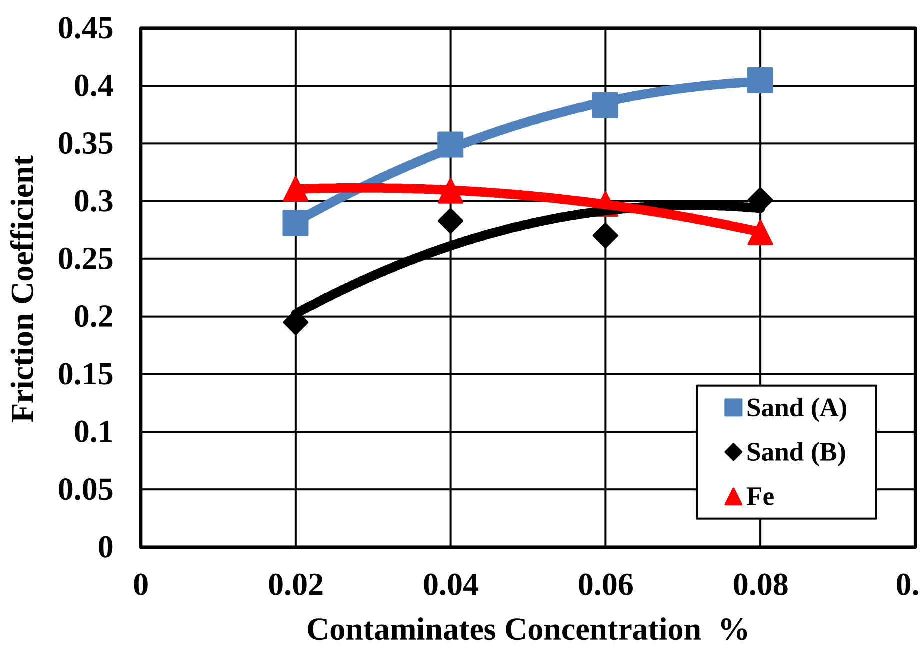

Fig. 3 Effect of additives content on the friction coefficient.

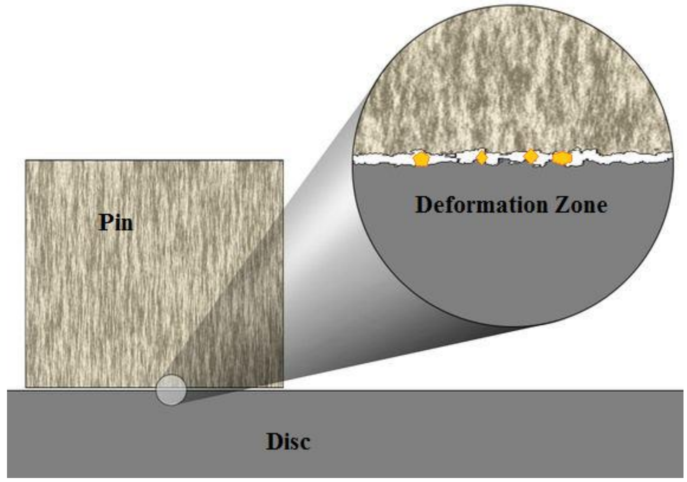

Fig. 4 A sketch of contaminants deformation in contact area.

The coefficient of friction as a function of sliding velocity generally has a negative slope. Changes in the sliding velocity result in a change in the shear rate which can influence the mechanical properties of the mating materials. The strength of many metals and nonmetals is greater at higher shear strain rates. Figure 5 illustrates the friction coefficient of the sand (A) for different concentration versus the rotating speed. The friction coefficient of sand (A) with 8 wt. % displays highest values. Also, the value of the friction coefficient increases with the increase of the rotating speed. The friction coefficient of sand (B) for different concentration versus the rotating speed is shown in Fig. 6. It is noticed that, friction coefficient have a random values. The variation of the friction coefficient may be due to random distribution of sand particles of relative bigger particles size. Figure 5 illustrates friction coefficient of Fe particles for different concentration versus the rotating speed. It is found that, the friction coefficient values decreased when the rotating speed increased at different concentration of the Fe particles.

The effect of rotating speed on the friction coefficient displayed by lithium grease dispersed by solid particles is presented as comparison in Fig. 8. It is seen that values of friction coefficient for dry, Li based grease only, Fe particles-grease and different size of sand decrease with the increase of sliding speed. The decrease of friction coefficient with the increase of sliding speed may be due to the change in the shear rate which can influence the mechanical properties of the mating materials. The strength of these materials is greater at higher shear strain rates. But in the dry test with increasing speeds the friction coefficient also increased.

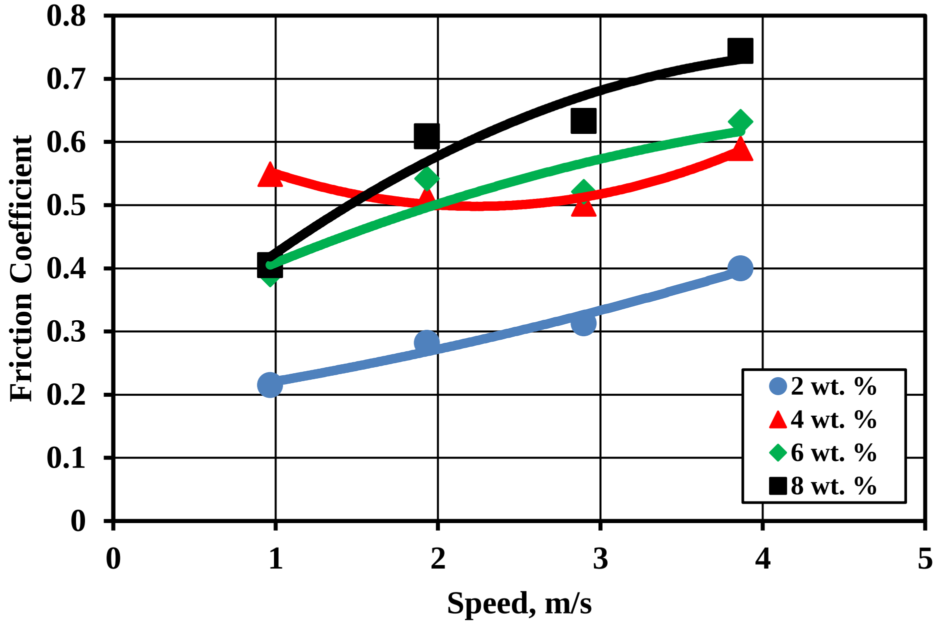

Fig. 5 Friction coefficient curves with speed measured of Sand (A).

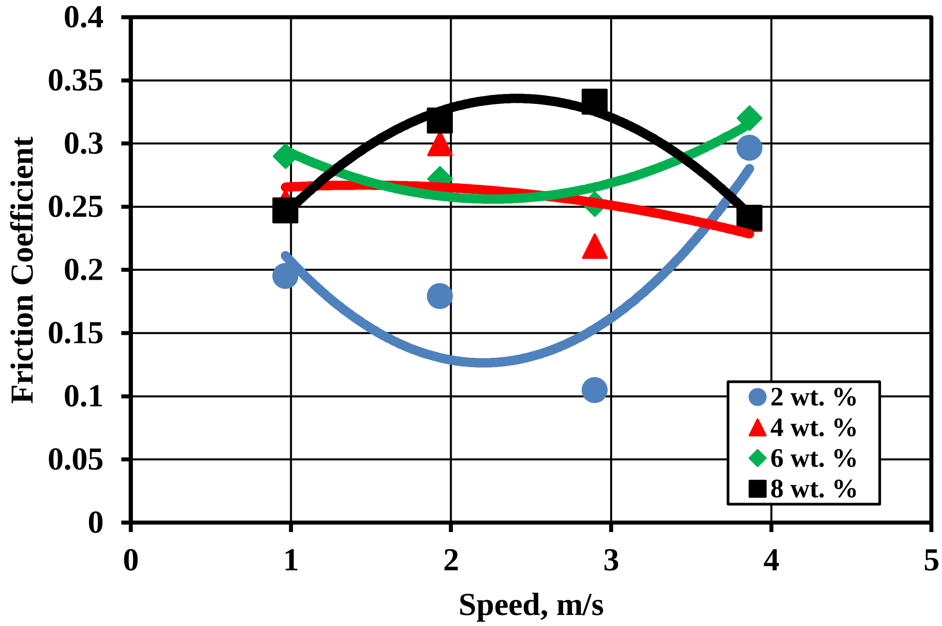

Fig. 6 Friction coefficient curves with speed measured of Sand (B).

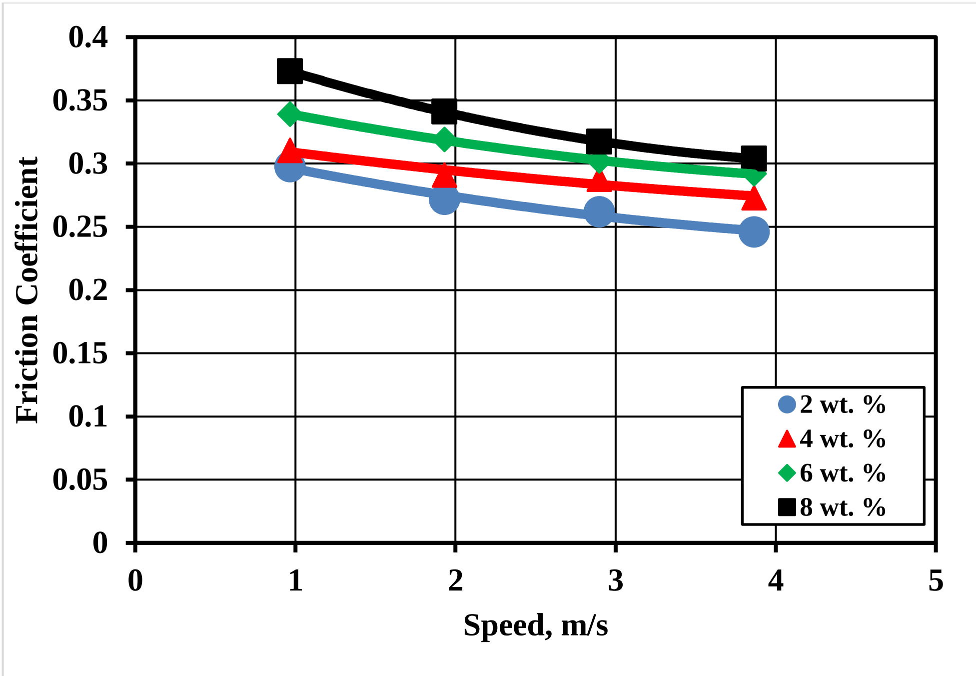

Fig. 7 Friction coefficient curves with speed measured of Fe powder.

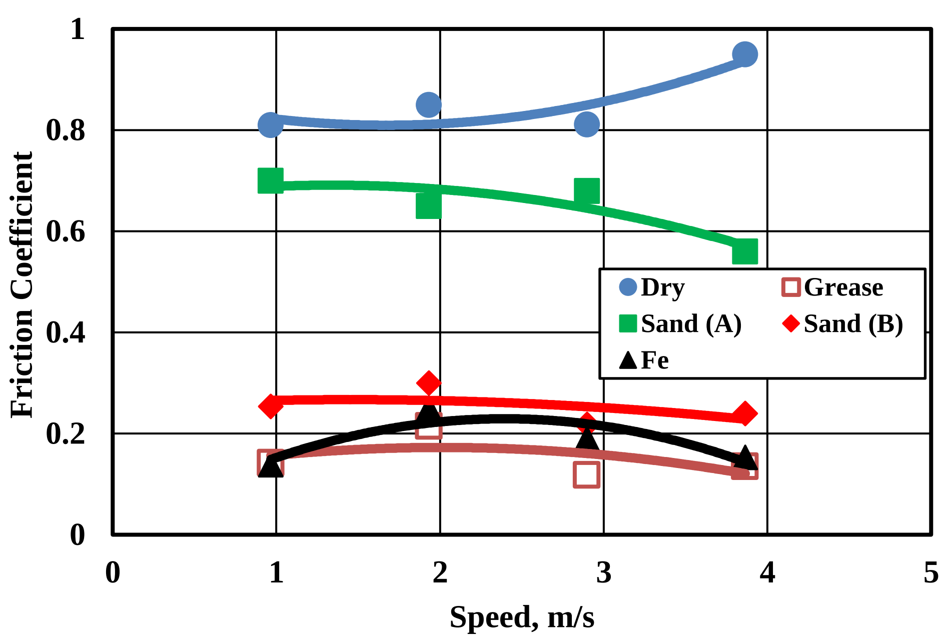

Fig. 8Friction coefficient curves with speed measured with pin on disk test.

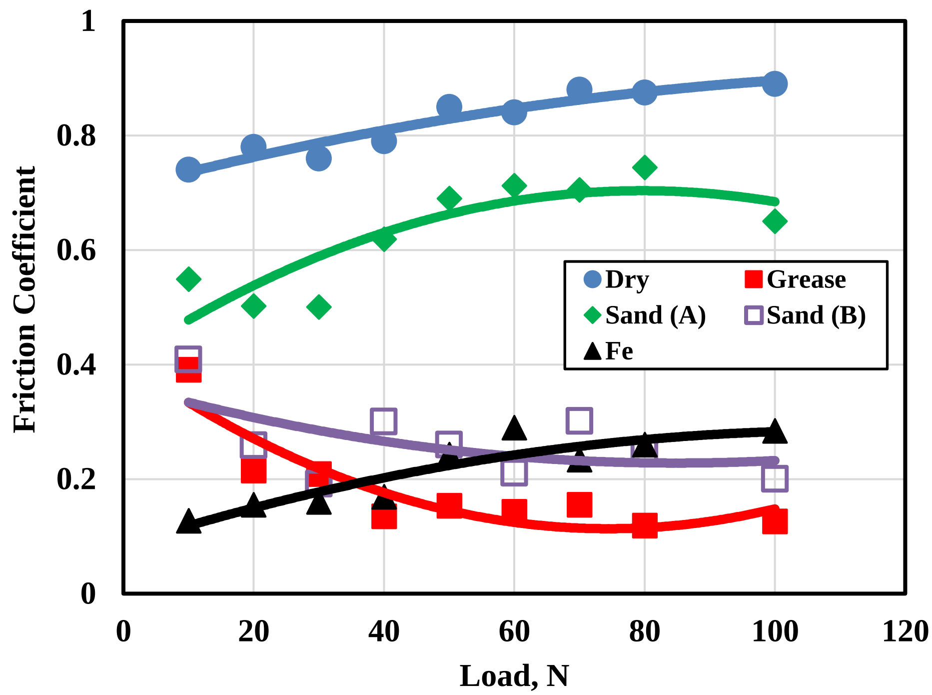

Fig. 9Friction coefficient curves with load measured with pin on disk test.

Friction coefficient versus the variation of normal load presented in Fig. 9, indicates that friction coefficient increases with the increase of normal load within the observed range. Decreased surface roughness and wear debris are believed to be responsible for the increase of friction with the increase of normal load. The friction force between the surfaces increases their temperature. This effect results in adhesion and increases the deformation at the surface layers, leading to further loss of the metal.

CONCLUSIONS

The tribological behavior of the contact by pin on disk and ring on ring tests in the dry and Li based grease with micro particles of Fe and sand is investigated. The applied normal load was in the range of 25 to 100 N. Speeds used were between 50 to 800 rpm. It is observed that micro particles of Fe have shown good friction and wear reduction characteristics even at concentrations of 2 wt. % and 4 wt. %. It was found that, the use of micro particles in lubricating greases such as Fe powder, different size of sand particles enhanced the tribological properties which reduced vibrations compared to Li based grease free of solid particles. Tests under dry conditions also increased wear and friction coefficient more than that observed for grease dispersed by micro particles.

REFERENCES

1. Samy A. M. and Ali W. Y., "Developing the tribological properties of lithium greases to withstand abrasion of machine elements in dusty environment", International

Journal of Scientific & Engineering Research, Volume 4, Issue 10, pp. 1176 – 1181, (2013).
2. Elhabib O. A. and Ali, W. Y., "The effect of Tin as solid lubricant dispersing Lithium grease in reducing friction coefficient and wear in dusty environments", 1 – 2 / 2013, 65, Jahrgang, METALL, pp. 568 – 573, (2013).
3. Ezzat F. M., Youssef, M. M., Abd-El Aal, G. M., and Hakim, k. A., "Effect of Operating Conditions on Wear of Diesel Engine Liner and Rings", Proceedings of The 5th International Conference of the Egyptian Society of Tribology, Cairo University, EGYPT, 10-12 April, pp. 355 - 363, (1999).
4. Ali W. and Mousa, M., "Experimental Study of Wear and Friction Caused By Abrasive Contaminants and Fuel Dilution in Lubricating Oil", 5th International Congress On Tribology EUROTRIB 89, Helsinki, Finland, pp. 437 - 431, June 13, (1988).
5. Cann P. M. "Grease degradation in a bearing simulation device", Tribol Int; 39, pp. 1698 – 1706, (2006).
6. Cann P.M, Webster M.N., Doner J. P., Wikstrom V., Lugt P., "Grease degradation in ROF bearing tests", Tribol Trans, 50 (2): pp. 187 - 197, (2007).
7. Couronne I., Vergne P., Mazuyer D., Truong-Dinh N., Girodin D., "Effects of grease composition and structure on film thickness in rolling contact", Tribol Trans; 46 (1), pp. 31 - 26, (2003).
8. Donzella G., Faccoli M., Ghidini A., Mazzu A., Roberti R., "The competitive role of wear and RCF in a rail steel", EngFract Mech,72, pp. 287 - 308, (2005).
9. Miettinen J., Andersson P., "Acoustic emission of rolling bearings lubricated with contaminated grease", Tribology International 33, pp. 777 – 787, (2000).
10. Nikas G. K., Sayles R. S. Ioannides E., "Effects of debris particles in sliding/rolling elastohydrodynamic contacts", In: Proceedings of the Institution of Mechanical Engineers;212, (J5), pp. 333–43, (1998).
11. Roylance B. J., Hunt T. M., "Wear Debris Analysis", Coxmoor Publishing Company, Oxford, UK, (1999).
12. Braron T. "Engineering Condition Mointoring", Addison Wesley longman, (1996).
13. Miettinen J., Andersson P., "Acoustic emission of rolling bearings lubricated with contaminated grease", Tribology International, Vol. 33, pp. 777 – 787, (2000).
14. Serrato R., Maru M.M., Padovese L.R., "Effect of lubricant viscosity grade on mechanical vibration of roller bearings", Tribology International, Vol. 40, pp. 1270-1275, (2007).
15. Nabhan, A.," Vibration analysis of adding contaminants particles and carbon nanotubes to lithium grease of ball bearing "The 22-nd International Conference on Vibroengineering – Moscow, Vibroengineering Procedia, Vol. 8, pp. 28-32, (2016).
16. More Y.Y., Deshmukh A.P., "Study of Effect of Solid Contaminants in Grease on Performance of Ball Bearing by Vibrationan Analysis", International Journal of Innovations in Engineering Research and Technology [IJIERT], Vol. 2, Issue 5, (2015).