



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: VI Month of publication: June 2019

DOI: <http://doi.org/10.22214/ijraset.2019.6176>

www.ijraset.com

Call:  08813907089

E-mail ID: ijraset@gmail.com

A Review Study on Gearbox Performance Enhancement

Dhiren Sathwara¹, Nimesh Patel²

¹M.E. Student, ²Assistant Professor, Mechanical Engg, Hansaba College of Engineering and Technology, Sidhhpur

Abstract: Gearbox is mainly used to transmitting the power from one to the other rotating shaft. Mainly their application is to increase and reducing the rpm of the output shaft and for that reducing and increasing the torque respectively. It is referred to the metal casing in which number of gears is made from different materials assembled and sealed. Due to loading and unloading condition this gears generate lot of heat, noise due to loading and friction between them. To resolve this problems lubrication oil plays an important role, gearbox gear assembly is submerged into the oil sump and lubrication was carried out by rotation of gear itself in which gear oil film was made between rotating parts. Gear oil properties are an important factor for research to enhance the performance of gear box and transmission system of the respective machine. For that here several review of the research work has been carried out in this study.

Keywords: Gear oil, Gear box, transmission, lubrication, efficiency

I. INTRODUCTION

A gearbox is a set of gears for transmitting power from one rotating shaft to another. They are used in a wide range of industrial, power plant, automotive and home machinery application. A gear heads are available in different sizes, capacities and speed ratios. Mostly their main function is to convert the input provided by an electric motor into an output of lower rpm and higher torque or high rpm and lower torque.

It is referred to the metal casing in which a number of gears are sealed. These gearboxes are constructed from a variety of materials depending on their end use and the kind of industry they are being used in the product has numerous industrial applications for providing high torque and smooth speed reductions.

Consequently, one needs to be able to regulate both the power output and the speed range over which the machine is at any given time likely to be required to operate. In this way the torque at the machine be balanced against demands for either a steady speed load or overload condition. The continuous transmission of the torque in gearbox increase the wear and temperature between to rubbing surface of gear teeth.

In gearbox the lubricants use to provide two primary benefits first to reduce the friction between teethes and second to remove heat generated from the gear operation.

The lubricant is also often used for lubricating the various bearing found in the gearbox. The correct selection of lubricant for use in a gear system is very important to provide slip-free power transmission at high mechanical efficiency, with good reliability, low maintenance, and long life. If the lubricant film is not maintained with the consequent increase in temperature causing distress and wear of the material surface. In the gear system to maintain the continuous film with consequent increase in temperature of the gear oil and loading condition the higher viscous lubricant is required, But the higher viscosity oil cause churning effect at high speed rotation of the gear teeth.

The lowest particle viscosity oil should be selected to minimise friction losses and churning effect at high speed. There for the selection of lubricant oil in gear box system for different manufacturing industrial, power plant, automotive and home machinery application are very difficult. The selection of perfect oil is required to do some experimental work or analyses of increase the temperature of oil with increase the velocity of gear.

II. PROBLEM STATEMENT

From the literature survey it is seen that the power losses calculation is important for increase the gear performance. The power losses in gear system are depends on types of gear oil and operating condition of gear system. There are number of gear oils are available in the market. But the selection of the gear oil is very difficult task for industries to increase the performance with economy.

III. OBJECTIVES OF WORK

From problem statement the objective of work is to find out power losses. We use three different parameters like different types of loading conditions on gear box, different rpm and different types of gear oil like vegetable oil, organic oil etc. for the optimization purpose in ANSYS. Our main objective is to reduce the power losses and increase the life time of gear oil in the gear box so for this purpose we have to perform the following steps needs to be perform.

- A. Modelling of gearbox.
- B. Mathematical calculations
- C. CFD analysis of gear oil in ANSYS.
- D. Optimization of different parameters.

IV. LITERATURE REVIEW

D.J. Hargreaves, and Anton Planitz ^[1] have worked on “Assessing the energy efficiency of gear oils via the FZG test machine” In this study; Energy efficient lubricants are becoming increasingly popular. For each oil was being evaluated, the rig was run for ten minutes at a load stage of ten. Six extreme pressure (EP) industrial gear oils of mineral base were tested. The difference in power requirements between the best and the worst performing oils was 2.77 and 3.24kw respectively. This equates to a 14.6% reduction in power, a significant amount if considered in relation to a high powered industrial machine. The oils of superior performance were noticed to run at reduced temperatures.

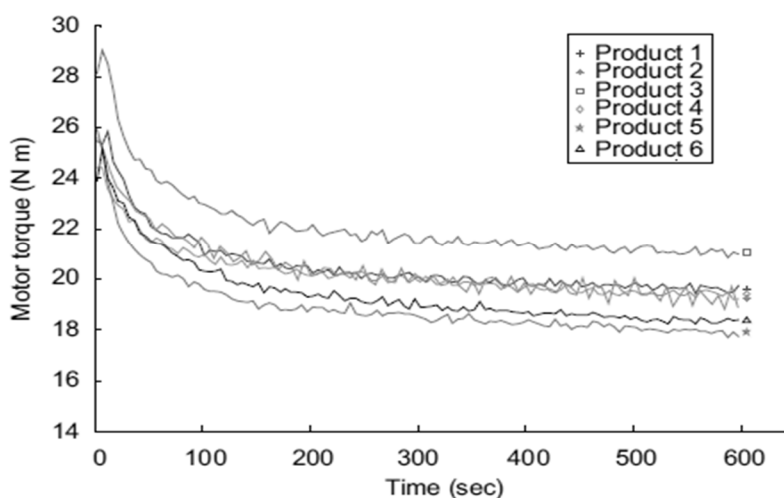


Fig.1 The motor torque data for test runs using each of the six gear oils. ^[1]

Luis Magalhaes, RamiroMartins, CristianoLocateli, JorgeSeabra ^[2] have worked on “Influence of tooth profile and oil formulation on gear power loss” In this study, the power losses reduction is obtained using two different approaches, using lower modulus helical gears and significant positive profiles shifts and using gear oil formulations with different base oils. It was found that lowering gear teeth module are smaller and more numerous. Dynamic excitation is different so noise and vibration change. Three gear oils, M1 (mineral), P1 (polyalolephines) and E2 (ester), formulated with different base oils, were selected.

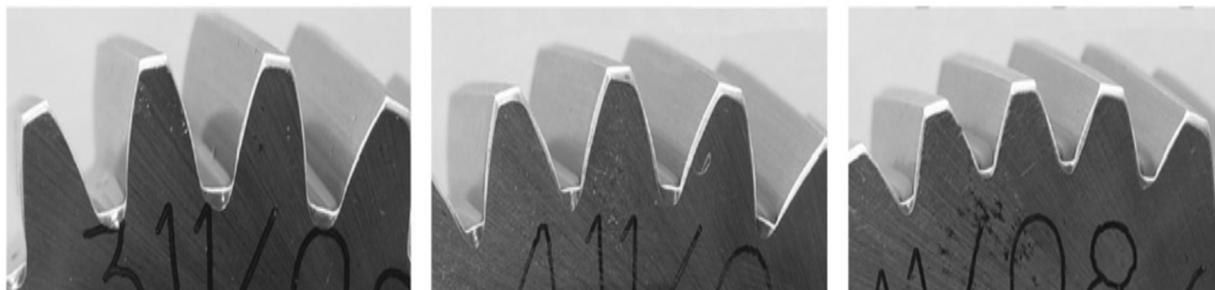


Fig.2 Pinion teeth of gears 311, 411 & 611 (from left to right). ^[2]

Boris krzan , joze vizintin^[3] have worked on “tribological properties of an environmentally adopted universal tractor transmission oil (UTTO) based on vegetable oil” universal tractor transmission oil is multipurpose tractor oil formulated for use in transmissions, final drives, wet brakes and hydraulic systems of tractors employing a common oil reservoir. The results of a series of tests performed to evaluate vegetable based oils are presented. Performances of test oils were demonstrated by using high frequency test device, four-ball test rig, and FZG spur gear test rig. For final tests a laboratory hydraulic system and a spur gear test rig were used. On the basis of the paper results conclude that Ester based oils show lower friction coefficient than higher additivated mineral based oils but promote higher wear.

Table 1 Test oils properties

Product	Kinematic viscosity at 40°C (cst)	Kinematic viscosity at 100°C (cst)	Oil code
Rapeseed oil	209	10.4	R
sunflower oil	203	10.6	S
Synthetic ester	211	10.9	E
Mineral oil	150	9.2	M

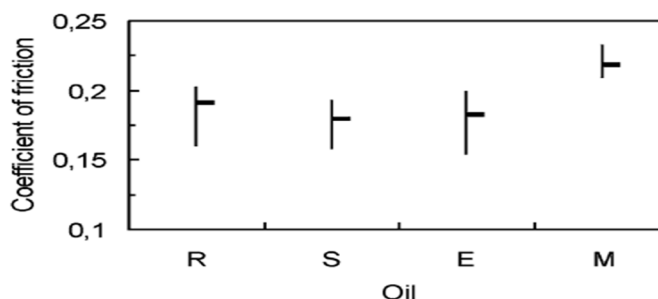


Fig.3 Friction test results.^[3]

Laboratory hydraulic system test results show that the high oleic sunflower oil formulation could match mineral based universal tractor transmission oil for applications where operating temperatures are reasonable (70 °c in steady state). Investigations in a spur gear test rig show better thermal oxidative stability for mineral universal tractor transmission oil compared to the high oleic sunflower universal tractor transmission oil formulation at constant operating test oil temperature of 80 °c.

Pedro M.T. Marques, Carlos M.C.G. Fernandes, Ramiro C. Martins, Jorge H.O. Seabra^[4] have worked on “Power losses at low speed in a gearbox lubricated with wind turbine gear oils with special focus on churning losses” In this study, gear oils were tested for power loss behavior in a two stage multiplying gearbox, on a back-to-back test rig with recalculating power. The tests were performed at low input speeds and high input torques.

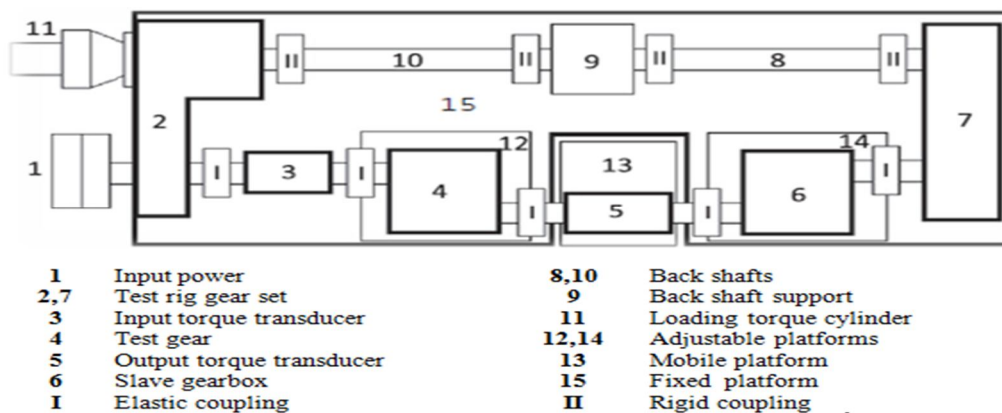


Fig.4 Top view schematic of the gearbox test ring.^[4]

M. Kalin, J. Vizintin^[5] have worked on “The tribological performance of DLC-coated gears lubricated with biodegradable oil in various pinion/gear material combinations” in this study Biodegradable oils possess good tribological properties and are less harmful to the environment than conventional oils. The results show that the contacts of the W-DLC/W-DLC-coated gears could importantly reduce the oil temperature across the whole range of loads and could provide satisfactory wear resistance up relatively high loads (about 1.4 GPa).

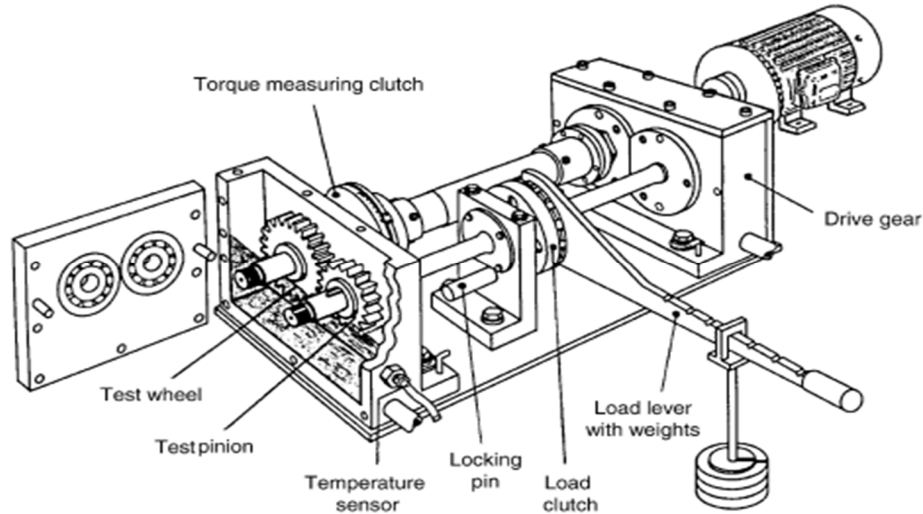


Fig.5 Schematic representation of the FZG test-rig principle.^[5]

On the basis of the work results, concluded that Experimental conditions and by using high quality biodegradable oil, the contacts of W-DLC/WDL- coated gears could importantly reduce the oil temperature and provide satisfactory wear resistance up to A contact pressure of about 1.4 GPa. Despite the reduced temperature and friction even at higher loads (1.4–1.8 GPa, i.e., FZG stage 10–12), these conditions cannot be recommended for self-mated coated gears because it will result in high wear of the coating and lead to premature wear-through of the coating. All the material combinations that consist of one or two steel gears result in higher oil temperatures than the WDL- / W-DLC-coated gears over the whole range of loads and did not vary significantly for the various combinations.

Carlo Gorla, Franco Concl, Karsten Stahl, Bernd-Robert Hohn, Klaus Michaelis, Hansjorg Schultheib, Johann-Paul Stemplinger^[6] have worked on “Hydraulic losses of a gearbox: CFD analysis and experiments” In this study, efficiency is becoming a main concern in the design of power transmissions. For this reason CFD (computational fluid dynamics) simulations were performed in order to understand the influence of geometrical and operating parameters on the losses in power transmissions. The results of the model were validated with experimental results. The results of the experiments confirm that the CFD represent valid method to predict power losses. The error in the predictions for the analyzed cases is always lower than 8 % in particular the tip diameter has been changed from 96.5 to 102.5 mm while the tooth width has been changed from 20 to 40 mm.

Bernd-Robert Hohn, Klaus Michaelis and Michael Hinterstoiber^[7] have worked on “influence factors on gearbox power loss” In this work different methods are discussed for power loss reduction. No load losses can be reduced, especially at low temperatures and Part load conditions when using low viscosity oils with a high viscosity index. This in turn influences the cooling properties in the gear and bearing meshes. Bearing systems can be optimized when using more efficient systems than cross loading arrangements with high preload. Low loss gears can contribute substantially to load dependent power loss reduction in the gear mesh. Besides operating conditions no load gear losses mainly depend on immersion depth in sump lubricated gearboxes as well as on lubricant viscosity. And also conclusions that, in some applications only the simple change to a highly efficient lubricant can save some 20% power loss.

Timothy L, Krantz, Ahmet Kahraman^[8] have worked on “an experimental investigation of the influence of the lubricant viscosity and additives on gear wear” in this study the influence of lubricant viscosity and additives on the average wear rate of spur gear pairs was investigated experimentally. The gear specimens of a comprehensive gear durability test program that made use of seven lubricants covering a range of viscosities were examined to measure gear tooth wear. In general, the wear rate was found to be inversely proportional to the viscosity of the lubricant and to the lambda ratio, lubricants with similar viscosities but differing additives.

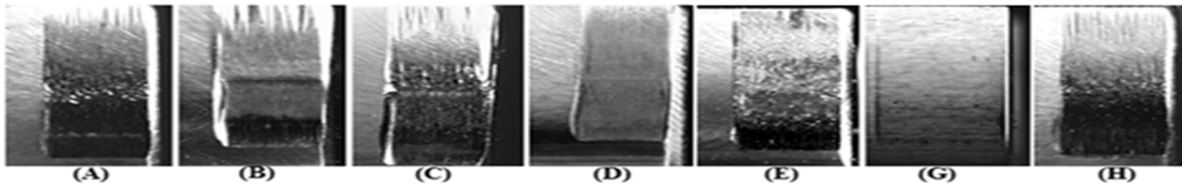


Fig.6 Worn surfaces of the test gears for each of seven lubricants. [8]

The influence of lubricant viscosity and additives on the wear rate of spur gear pairs was investigated experimentally. The gear specimens from a comprehensive gear durability test program that includes seven different lubricants were inspected to demonstrate the influence of the lubrication condition on gear tooth surface wear. The results indicate that the wear rates are strongly related to the viscosity of the lubricant. Lubricants with larger viscosity result in larger lambda ratios and lower wear rates.

James Kuria, John Kihui^[9] have worked on “prediction of overall efficiency in multistage gear trains” this paper presents a mathematical model for determining the overall efficiency of a multistage tractor gearbox including all gear, lubricant, surface finish related parameters and operating conditions is presented. Sliding friction, rolling friction and windage losses were considered as the main sources of power loss in the gearing system. Rolling frictional losses decrease with increased load while windage losses are only significant for gears running at very high speeds (greater than 3000 rpm). Windage losses result from the lubricant being flung off the gear teeth as the gears rotate and the expulsion of the lubricant from the tooth spaces as the gears come into mesh.

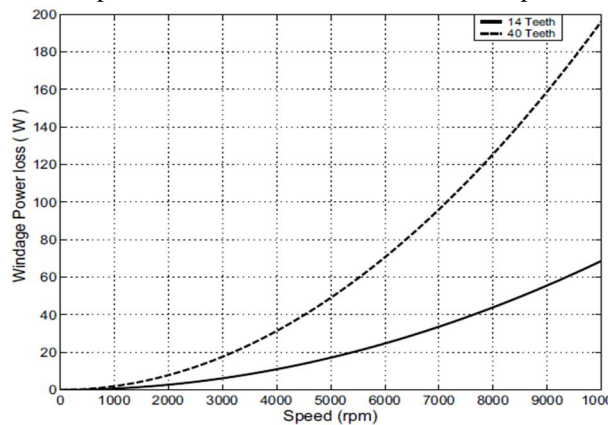


Fig.7 Windage power loss as a function of speed for gear. [9]

Churning losses are defined as the action of the gears moving the lubricant inside the gear case. Conducted experimental tests of windage on a number of gear diameters, pitches, face width and environmental effects and an empirical formula based on these results was developed as shown in equation (2.1) of windage power loss (P_w)

$$P_w = C_4 \cdot C \cdot \rho \cdot N^{2.85} \cdot D^{4.7} \cdot \nu^{0.15} \cdot \lambda \quad \dots (2.1)$$

where, C_4 is a constant ($=1.12 \times 10^{-8}$), C is a constant that is dependent on the face width to diameter ratio, ρ is the density of the gear operational environment (Kg/m^3), D is the pitch diameter of the gear (m), ν is the kinematic viscosity of the lubricant (m^2/s), and λ is a constant related to the type of housing surrounding the gear [$\lambda = 1$ (open); $= 0.7$ (loose enclosure); $= 0.5$ (close enclosure)]

.On the basis of the paper results finally conclude that overall efficiency of a gear system is the first step in improving the efficiency of the system. One way to conduct efficiency improvements is to carry out analysis on the effect of gear design parameters, lubricant properties and housing arrangement on the efficiency of the gear system.

G Koffel, F Ville, C Changenet, P Velez^[10] have worked on “Investigations on the power losses and thermal effects in gear transmissions” In this work, it is generally accepted that the total power loss in gears can be decomposed into contributions of friction between the teeth, lubrication. For low- to medium speed transmissions, tooth friction is recognized as the main source of dissipation for gears and can significantly influence the temperature equilibrium of a gearbox. Power losses in geared transmissions are generated by rotating elements, mainly gears and bearings. As far as gears are concerned, the sources of dissipation have been identified: tooth friction (for both sliding and rolling), lubrication (dip or jet lubrication), pumping of a gas-lubricant mixture during meshing, and losses associated with windage effects. From this experiment and work it is confirmed that tooth friction appears as the main source of dissipation in low-medium-speed gear transmission. To accurately evaluate these power losses, it is necessary to develop a thermo mechanical model that includes a precise description of the tooth contact frictional properties.

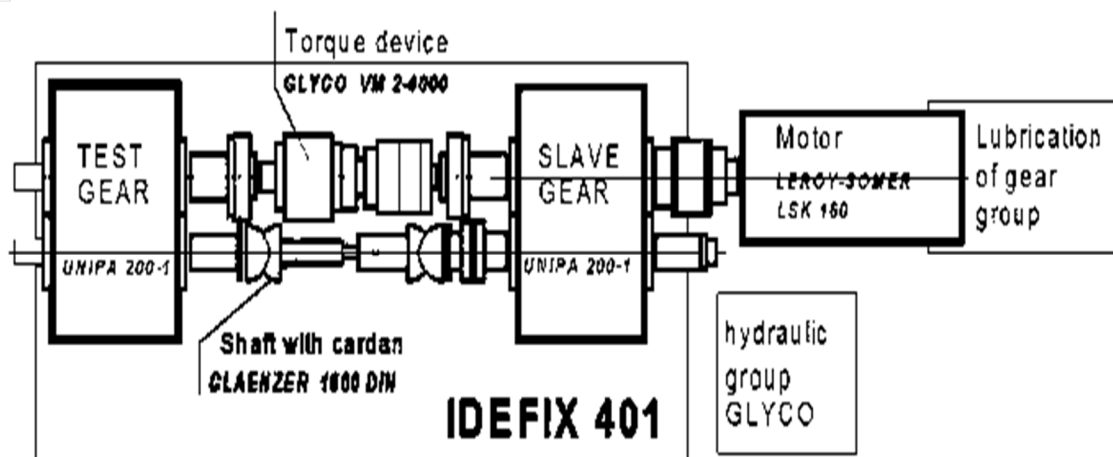


Fig.8 Test bench ^[10]

The lubricant temperatures at the tooth contacts should also be precisely determined since it controls part of the dissipation process. Two specific models have been presented and combined, which rely on the formula for tooth friction and on a thermal network for local temperature calculations. The theoretical results compare well with the measurements obtained from an industrial test rig and stress the fact that thermo-mechanical couplings cannot be ignored in power loss simulations.

V. LITERATURE SUMMARY

On the bases of literature review it can be seen that gear box performance depends on many parameters like gear teeth geometry, gear material, lubricant of gear, loading and working condition. Among of the above parameters the gear teeth geometry, material and lubricant oil are very important factor for incense and decrease the performance of gear system. Also from literature survey, it is known that there are lots of research works done on design of teeth geometry, developing new material and different types of gear oil. The gear oil selection processer is very difficult task in industrial application for incense performance of gear system. In lubricant oil the lubricant viscosity is most important factor for selection of gear oil in different industrial application. During working condition the heat is generated, when the two teethes are meshes together. Because of the heat generation inside the gear box, the viscosity of the oil is decrease and that is ultimately changed in oil properties.

REFERENCES

- [1] Hargreaves, D.J. and Planitz, A., 2009. Assessing the energy efficiency of gear oils via the FZG test machine. *Tribology International*, 42(6), pp.918-925.
- [2] Magalhães, L., Martins, R., Locateli, C. and Seabra, J., 2010. Influence of tooth profile and oil formulation on gear power loss. *Tribology International*, 43(10), pp.1861-1871.
- [3] Kržan, B. and Vižintin, J., 2003. Tribological properties of an environmentally adopted universal tractor transmission oil based on vegetable oil. *Tribology International*, 36(11), pp.827-833.
- [4] Marques, P.M., Fernandes, C.M., Martins, R.C. and Seabra, J.H., 2013. Power losses at low speed in a gearbox lubricated with wind turbine gear oils with special focus on churning losses. *Tribology International*, 62, pp.186-197.
- [5] Gorla, C., Concli, F., Stahl, K., Höhn, B.R., Michaelis, K., Schultheiß, H. and Stemplinger, J.P., 2013. Hydraulic losses of a gearbox: CFD analysis and experiments. *Tribology International*, 66, pp.337-344.
- [6] Michaelis, K., Höhn, B.R. and Hinterstoißer, M., 2011. Influence factors on gearbox power loss. *Industrial lubrication and tribology*, 63(1), pp.46-55.
- [7] Krantz, T.L. and Kahraman, A., 2004. An experimental investigation of the influence of the lubricant viscosity and additives on gear wear. *Tribology Transactions*, 47(1), pp.138-148.



10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)