International Journal of Research in Advent Technology, Vol.6, No.8, August 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Evaluation of Performance Deterioration of the Used Equipment Oil in Sliding Pair

J. S. Bhat[1], B.U.Sonawane[2]
[1]*Research Student & Assistant Professor, Department of Mechanical Engineering, K.I.T.'s College of Engineering, Kolhapur, Maharashtra. India.*
[2]*Associate Professor, Department of Production Engineering and Industrial Management, College of Engineering, Pune, Maharashtra, India*
Email: bhat.jitendra@gmail[1],bus.prod@coep.in[2]

Abstract- In this paper, we have mentioned about development of experimental setup for performance degradation of used equipment oil in sliding pair. The deterioration procedure of lubricating equipment oil mentioned. The goal of research paper is to recognize the deterioration process of equipment oil and examine the impact of degradation on the overall performance of gear oils used in worm gear box. An experimental test rig, which includes a single speed gearbox driven by means of AC motor (1 hp) is used for this evaluation. The gearbox runs under normal loading / operating condition as according to industrial application. Servo equipment oil HP 140 is used for overall performance assessment in worm gearbox. The oil sample was collected at different time interval from experimental setup. The performance of used equipment oil was analysed on the basis of oil properties. Further to this overall performance deterioration of used equipment oil will evaluate on the basis of tribological properties. Viscosity of oil is changes from 331.6 cSt to 308.5, 305.1 and 306.3 cSt at 40^0 C and from 25.6 cSt to 24.2, 24.1 and 24.2 cSt at 100^0 C for different operating condition 100,200 and 300 Hr. running of gearbox. The Total Acid Number (TAN) is changes from 0.2 mg KOH/g to 0.5, 0.7 and 0.8 mg KOH/g for different operating condition 100,200 and 300 Hr. running of equipment. Viscosity is displaying reducing trend because of friction in addition to total acid number is displaying increasing trend because of oxidation.

Index Terms- Oil Analysis, Tribological Properties, Deterioration

1. INTRODUCTION

Introduction should lead the reader to the importance of the phrase tribology was originating from the Greek phrase "tribos" that means rubbing, so the explanation would be "the science of rubbing". Dictionaries outline tribology as the science and technology of interfacing surfaces in relative movement and of associated topics and practices. Tribology is art of making use of operational evaluation to issues of exceptional financial significance, particularly, reliability, maintenance, and wear of technical device, starting from spacecraft to household appliances.[1-6]The primary function of lubricant is to reduce the negative impact of tribological approaches related with friction, wear and will increase in temperature of tribo-mechanical systems, consequently all types of maintenance consist of lubrication as a vital role of the entire maintenance procedure. Alternatively, the lubricant is a key element of the contact conjunction that contains data about the state of the entire machine, from perspective of tribological and different ageing techniques. Therefore, evaluation of the gear oil, based totally on an accurately described application, indicate a very powerful technique for monitoring the condition of industrial systems, presenting early caution symptoms of probable problems that may be result in breakdown of the industrial systems. Just like the mechanical components, the lubricant itself also can change and this results in changes of lubricating oil properties along with increased or decreased viscosity, contamination, deterioration, loss of load carrying ability, and many others. Lubricant oils are essential to the gearbox in industry.[7-11] It is useful to perform particular functions in order to maintain the gearbox working.[12-15] The primary necessities for equipment oils are suitable viscosity, oxidation and thermal stability, stable load-carrying competence, demulsibility (capability to shed water), safety against corrosion and rusting. Therefore, it's not unexpected that customers need a systematic grab the overall performance requirements of equipment oils. The research work has been mentioned on overall performance degradation evaluation of used oil. [17-20]

Ying Du et al [1] This paper give an explanation for that the primary motive of lubricating oil degradation prediction is to estimate the failure time when the oil no longer fulfils its functions. Researcher supposes that the state technique evolution of lubricating oil degradation may be modelled the use of a hidden Markov model (HMM) with 3 states: healthful state, unhealthy state, and failure state. The failure state is observable. while the lubricating oil is in service, vector statistics which can be stochastically associated with the deterioration state are obtained through a technique of Time series analysis (TSA) is implemented to the healthful quantities of the oil information histories to get the residuals because the observable process containing partial statistics to fit the hidden Markov model. The remaining useful life (RUL) of lubricating oil can be evaluated through explicit formulation of the characteristics which includes the conditional reliability function (CRF) and mean residual life (MRL) function in terms of the posterior probability.

Qunfeng Zeng et al [2] In this paper, Researchers have investigated effect of tribological properties of lubricating oil by using experiment. The process of degradation of oil is carried out experimentally. The viscosity and microstructure of oils working different mileages had been analyzed with the aid of viscometer. Friction and wear behaviours of the friction pair of the GCr15 metal ball and disc were conducted by using a ball on disc tribometer for different mileages equipment oils lubrication situations. From this paper is to recognize the deterioration procedure of equipment oil and examine the impact of degradation at the overall performance and microstructure of lubricant gear oils utilized in gear box. Feasible factors of degradation method as well as its have an effect on friction and wear behaviours are also mentioned. The outcomes exhibits the tribological properties of used oils based on strongly the microstructure and its degradation procedure of gear oil.

J.S. Karajagikar et al [3] the researcher looks at that vibration and Ferrography evaluation are the two essential condition monitoring strategies for equipment fault analysis and maintenance policy decision. An experimental setup, consisting of a single speed gearbox driven by means of AC motor (0.5hp) is used for this evaluation. The gearbox runs under regular loading/working condition as according to industrial application. It consists of gearbox lubrication oil (Castrol EP 90) monitoring for identifying presence of wear debris particles. Ferrography evaluation consists of direct studying Ferrography, which offers wear particle concentration.

S. Bhaumik et al [4]This paper explain comparison between mineral oil and Castrol oil on the basis of tribological properties .Anti-wear and extreme pressure properties were analysed for both oils. Mineral oil and castor oil showed surface degradation and increase in roughness after intermittent working during scuffing test. As a result, this paper indicates that the tribological properties of neat castor are not so good as that of mineral oil as well as observation of the effects indicates that both AW and EP properties of castor oil are much nearer to that of mineral oil.

S. Abusaad et al [5] The researcher checks out a new on line and effective method is evolved to analyse lube oil deterioration based on electrical parameters. The replacement of oil viscosity because of oil deterioration will motive corresponding modifications in both static power conservation and dynamic performance of a gearbox. Viscosity of oil is increased due to friction and churning.

Junda Zhu et al [6] The present paper, a complete survey of conditioning and monitoring of oil, analysis and prognostics strategies and systems was provided. Condition monitoring is the method of monitoring a parameter of situation such that a great change is indicative of a developing failure. An overview with exact assessment and comparison among the most current advanced sensors and systems is provided. The survey provided a perception into the contemporary status of oil health monitoring and mentioned the future path of lubrication oil diagnostics and prognostics improvement. The very last aim of all the designed sensing systems is to achieve lubrication oil on line physical condition monitoring and residual valuable life forecast. In line with the detail assessment of each lubrication oil degradation monitoring strategies, it is clear that viscosity and capacitance sensor have the excellent lubrication oil basic degradation function coverage, reasonable manufacture and maintenance cost.

Z. Peng, et al [7] this paper checks out the relationship between vibration analysis and wear debris analysis. This was carried out by using checking different working situation of an experimental setup, along with gearbox driven by means of motor. Worm gearbox turned into to begin with run under regular working situation as a comparative test. A sequence of assessments had been then carried out related to lack of right lubrication and by means of different contaminant particles introduced to different lubricants. The oil samples and vibration data is collected at regular interval. Wear debris analysis was compared with vibration analysis to check effectiveness of oil.

Vincenzo D'agostino et al [8] This paper provides an explanation for that performances of present day technology oils are no longer enough to fulfil the increasing necessities of automotive lubricated systems. Innovative nano sized based additives could efficiently act as friction modifier media in boundary and blended lubrication regime through their unique behaviours at interfacial scale. The selection of suitable lubricant additive is in a preliminary state, and more experimental research in physical and tribological properties are necessary. There is scope for studies work within the area of conditioning and monitoring of lubricating oil for performance evaluation of lubricant and remaining life prediction of degraded lubricating oil. The study of used oil on the basis of tribological properties is important to decide optimum lubricating oil replacement duration. The information about experimental setup, oil evaluation technique and outcomes are presented.

2. EXPERIMENTAL DETAILS

The experimental based technique collects information for remaining useful life estimation of lubricating oil through experiments, with a purpose to acquire a better insight and understanding of the lifetime and behaviour of equipment. Oil analysis is useful to evaluate the condition of lubricating oil. The information of experimental work is given below

2.1. *Gear Oil*

Gear oil (HP 140) is encouraged to vehicle, bus and public road truck hypoid, worm gear axles and spiral bevel gear for which high pressure gear oil is used. Oil samples of lubricant Servo gear HP 140 oils from the single speed reducing gearbox have taken for evaluation purpose. Samples have taken at predetermined running intervals of 100 hours. These types of samples have taken while a system is in operation, with known working conditions and collected from the same place

2.2 . *Experimental Setup*

Figure 1.indicates an experimental setup with controlled working parameters was set for performance deterioration of used gear oil HP 140

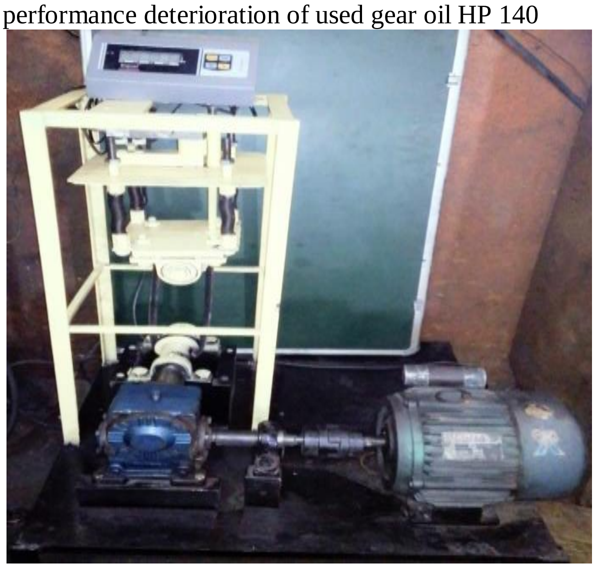

Fig. 1. Experimental setup for oil analysis

Speed reduction worm gearbox is intended for constant ratio along with right angle between output shaft and input shaft. This gearbox give three crucial advantages: lesser price, compacting nature and the capacity to attain higher ratios in a single reduction unit due to their variations in effectiveness mechanical competence, choice of worm gearbox in comparison with helical gearbox requires evaluation of the application. Input shaft and worm internal part are made up of solid bar stock of EN8 material and properly carried out heat treatment for strength, toughness and shock absorber. Gear wheel is made up of bronze alloy to withstand shock loads and effectively transmit regular load with a lower friction loss.

Table 1. Detail of single speed gearbox

Gearbox component	Description
Gearbox Model	Worm gearbox with 1:20 reduction
Style	WB(worm bottom)
Transmission capacity	0.5 HP
Oil capacity	650 ml

Open belt drive type load mechanism is to use load on gearbox through coupled at the output shaft. It includes V-Belt wound across the V-groove pulley. One side end of V-belt is attached to another V-groove pulley which is mounted on shaft of other side. This mechanism connected to single point load cell as shown in fig.1 the resistance torque is generated due to the friction between v-belt and pulley. Resisting torque is depending on the tension (load) difference and coefficient of friction among pulley and v-belt. Coefficient of friction between pulley and v-belt is consistent so resisting torque is varying with respect to tension (load) difference of both end of the v-belt. The tension (load) measure through single point load cell that are connected to the load mechanism. Oil sample was collected from experimental setup after every 100 Hr. of operating for the evaluation of oil.

2.3. *Oil Analysis Technique*

Oil analysis devices of kittiwake are informed operational and maintenance decisions about your crucial plant and equipment. Lubricating oils form a main cost component inside the process of all industrial equipment. The quality needs to be carefully monitored to protect the equipment. The capacity to check on-site, at the point of use, allows engineers to conduct oil evaluation fast and effortlessly. Oil samples of lubricant Servo HP 140 from the single speed reducing gearbox have taken for evaluation purpose. Samples have taken at predetermined running durations of 100 hours. These types of samples have taken while a system is in operation, with known operating conditions and gathered from the same place. [21]

2.3.1. *Viscosity*

Viscosity is oils most important property. Viscosity is indicating oil's resistance to flow and strength of oil film between surfaces. Viscosity has increased or decreased due to problems along with contamination, fuel dilution and shear thinning. Viscosity is extremely crucial for hydraulic oils, gear oils, engine oils and fuel oils. There are two type of viscosity measurement facility available with kittiwake oil test. Heated viscometer is calculating viscosity according to room temperature and unheated viscometer calculates at room temperature after which routinely changes to the suggested temperature. Viscometer is tilting in forward and backward direction to permit the ball to fall under gravity and viscosity of oil measured automatically. Unheated viscometer is given kinematic viscosity reading at 40°C; 100°C.Viscometers are given highly accurate results which will help to find out cause of failure. [21]

Fig.2. Unheated Viscometer Device

2.3.2. *Total Acid Number (TAN)*

Total Acid number or TAN is a degree of weak organic and strong inorganic acids available inside oils. Total Acid number is increased due to oil oxidation. Total Acid number can be monitor by using total Acid number device which is available in the range of 0-3 and 0-6 TAN [21]

Fig. 3. Total Acid Number (TAN) Device

3. RESULTS AND DISCUSSION

3.1. *Viscosity of Lubricating Oils*

Viscosity has decreased due to shear thinning or dilution of fuel similarly viscosity increased due to oil oxidation or degradation. The impact of increased or decreased viscosity can be prolonged oil drain periods, excessive working temperatures and presence of water or another oxidation catalyst.The accelerated viscosity may be the result of extreme contamination with solids including soot or dirt. Lubricant oil with the incorrect viscosity will cause overheating, increased wear, and in the end breakdown of equipment's. Repeatability is required to get accurate results for analysis of lubricating oil. We have taken more than one reading for each property of oil. The experimental outcomes suggest that the physical properties of oil under different running condition. The kinematic viscosity at 40^0 C of fresh or unused oil (HP 140) is 331.6 cSt. The kinematic viscosity at 40^0 C of used oil (HP 140) are 308.5,305.1 and 306.3 cSt for different running condition 100,200 and 300 Hr. running of gearbox and The kinematic viscosity at 100^0 C of fresh or unused oil is 25.6 cSt. The kinematic viscosity at 100^0 C of used oil are 24.2, 24.1 and 24.2 cSt for different running condition 100,200 and 300 Hr. working of gearbox. Viscosity is showing decreasing trend due to friction. It indicates that increased wear because of friction.

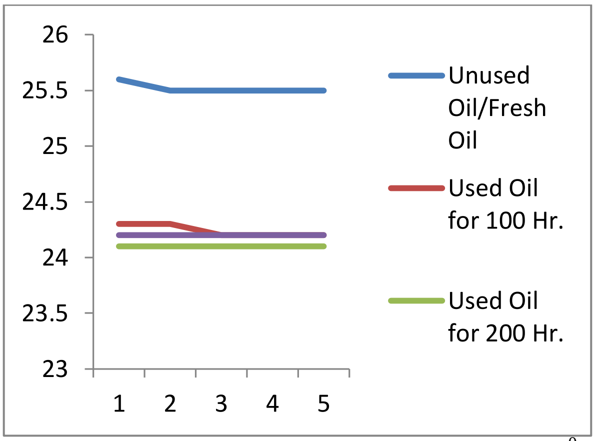

Fig. 4.Variation in Kinematic Viscosity (cSt) @ 100^0 C at Various Operating Condition

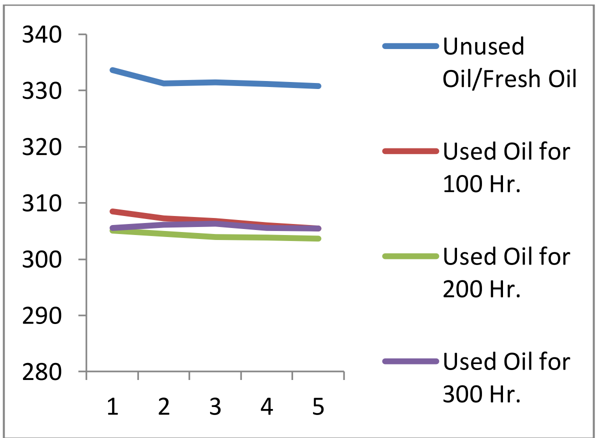

Fig. 5.Variation in Kinematic Viscosity (cSt) @ 40^0 C at Various Operating Condition

3.2. *Total Acid Number (TAN) of Lubricating Oils*

Total Acid number (TAN) is very important parameter for conditioning and monitoring of oils. The results of total acid numbers will help us to decide residual life of lubricant. The sum of acidic compounds within the lubricants is called (TAN) that's described as number of milligrams of potassium hydroxide similar to the acidic compounds. (TAN) is a direct indication of oil oxidation considering the fact that acids generated during oil oxidation are directly predicted by titrating with base. The acidic concentration (TAN) of lubricant is usually expressed as the amount in milligrams of potassium hydroxide (KOH) required neutralizing all of the acidic by means of products in one gram of lubricant sample.

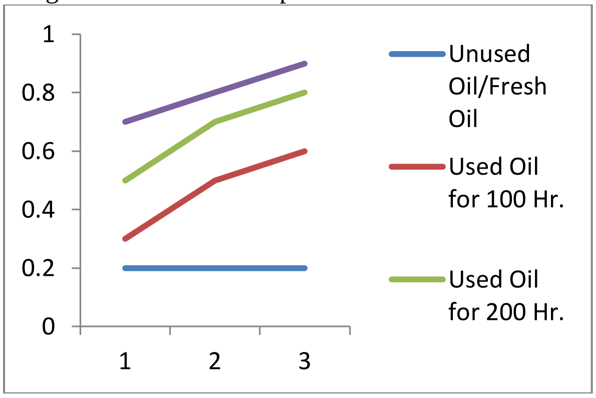

Fig. 6.Variation in Total Acid Number (TAN) mg KOH/g at Various Operating Condition

Total Acid number (TAN) of fresh or unused oil (HP 140) is 0.2 mg KOH/g. the total Acid number (TAN) of used oil (HP 140) are 0.5, 0.7 and 0.8 mg KOH/g for different running condition 100,200 and 300 Hr. running of gearbox. Total Acid amount (TAN) is displaying increasing fashion due to oxidation.

4. CONCLUSION

Fig.4 to 6 shows changes in Viscosity and total Acid number (TAN) of oil with respect to different running condition of equipment. Viscosity is 331.7 cSt at 400 C and 25.5 cSt at 1000 C of fresh oil. Viscosity has been changes from 306.8, 304.2 and 305.8 cSt at 400 C as well as 24.2, 24.1 and 24.2 cSt at 1000 C after each 100 Hr. running of equipment because of increased friction. Total Acid number (TAN) is 0.2 mg KOH/g of fresh oil. total Acid number (TAN) has been changes from 0.5, 0.7 and 0.8 mg KOH/g after every 100 Hr. running of equipment because of oxidation.

In this study constant speed and load being implemented on to the single speed worm gearbox system. Oil evaluation techniques have been used to analyze the performance deterioration of used equipment oil (Servo HP 140) in sliding pair (single speed worm gearbox).Total Acid quantity (TAN) over time under controlled operating situation has been increased because of oxidation hence oil performance will change due to deterioration. Viscosity of oil is indicates the reducing trend because of increase in friction.

The evaluation of oil will provide the guidelines about situation of lubricating oils. In addition, study of Ferrography evaluation will offer the information of wear rate, oil condition, type of wear mechanism, source of wear. Study of tribological properties will be used to discover influence of deterioration procedure of lubricating oils on system. The results of oil evaluation will be useful to decide the optimum lubricating oil replacement period and implementation of effective preventive maintenance.

Acknowledgments

The authors are thankful to Chougule Engineering Works, Kolhapur for the financial and technical support for the present research work. Special thanks to Department of Production Engineering & Industrial Management, College of Engineering Pune and Department of Mechanical Engineering, K.I.T.'s College of Engineering for providing Laboratory and Library facilities.

REFERENCES

[1] Ying Du, Tonghai Wu, Viliam Makis, Parameter estimation and remaining useful life prediction of lubricating oil with HMM, Wear 376-377, pp.1227–1233, 2017.

[2] Qunfeng Zeng, Guangneng Dong, Yanling Yang, Tonghai Wu ,Performance Deterioration Analysis of the Used Gear Oil, Advances in Chemical Engineering and Science 6, pp.67-75,2016.

[3] J.S. Karajagikar, Vikas P. Sojitra and B.U. Sonawane, Investigate the Condition of Single Speed Worm Gearbox using Ferrography and Vibration Analysis, Proceedings of 6th International & 27th All India Manufacturing Technology, Design and Research Conference (AIMTDR-2016) College of Engineering, Pune, Maharashtra, INDIA, ISBN: 978-93-86256-27-0, 2027-2032, 2016.

[4]S. Bhaumik ,S.D Pathak, A Comparative Experimental Analysis of Tribological Properties Between Commercial Mineral Oil and Neat Castor Oil using Taguchi Method in Boundary Lubrication Regime, Tribology in Industry Vol. 38, No. 1,pp.33-44,2016.

[5] S. Abusaad, K. Brethee, M. Assaeh, R. Zhang,F. Gu,A.D. Ball, The detection of lubricating oil viscosity changes in gearbox transmission systems driven by sensorless variable speed drives using electrical supply parameters,11th International Conference on Damage Assessment of Structures, Journal of Physics: Conference Series 628012078,pp.1-8,2015.

[6] Junda Zhu, David He, Eric Bechhoefer, Survey of Lubrication Oil Condition Monitoring, Diagnostics, and Prognostics Journal of Chemical Science and Technology, Vol. 2, Issue 3, pp.100-115,2013.

[7] Z. Peng, N.J. Kessissoglou, M. Cox, A study of the effect of contaminant particles in lubricants using

wear debris and vibration condition monitoring techniques, Wear 258,pp.1651–1662,2005.

[8] Vincenzo D'agostino, Mario Pisaturo, Adolfo Senatore, Lubricants For Frictional Pairs In Automotive Systems: A Review Of Requirements And Current Investigations, ANNALS of Faculty Engineering Hunedoara, International Journal of Engineering, ISSN: 1584-2665, 2016.

[9] B.R.Ambre, D.S.Bajaj, Investigation of Wear and Load Carrying Capacity of Polyamide Composites for Gear Application, International Advanced Research Journal in Science, Engineering and Technology 2nd International Conference on Advances in Mechanical Engineering (ICAME-2016) Amrutvahini College of Engineering, Sangamner Vol. 3, Special Issue 1,pp.54-58,2016.

[10] J. Kosiba, S. Cornak, J. Glos, J. Jablonicky, V. Vozarova, A. Petrovic J, Monitoring oil degradation during operating tests, Agronomy Research 14(5), pp.626–1634,2016.

[11] M. Ismon, I. Zaman, M. I. Ghazali, "Condition Monitoring of Variable Speed Worm Gearbox Lubricated with Different Viscosity Oils", Applied Mechanics and Materials, Vols. 773-774, pp.178-182, 2015.

[12] Rushil H. Sevak, Saurin Sheth, Study and Investigate Effect of Input Parameters on Temperature and Noise in Gearbox Using DOE, International Journal of Engineering Development and Research, Volume 2, Issue 2,ISSN: 2321-9939,pp.2273-2277,2014.

[13] H Shah and H Hirani, Online condition monitoring of spur gears, The International Journal of Condition Monitoring, pp 1-8, 2014.

[14]R.K. Upadhyay, Microscopic technique to determine various wear modes of used engine oil, Journal of Microscopy and Ultrastructure, pp.111–114, 2013.

[15]Al-Osaimy A.S., Elhabib O.A., Ali W. Y., Inspecting Metallic Wear Particles Contaminating Lubricating Automotive Engine Oils, International Journal Of Control, Automation And Systems Vol.2 No.3, ISSN 2165-8285, pp 15-22,2013.

[16] M.C. Isa, N.H.N. Yusoff, Hasril Nain, Mohd Subhi Din Yati, M.M. Muhammad, Irwan Mohd Nor ,Ferrographic analysis of wear particles of various machinery systems of a commercial marine ship, The Malaysian International Tribology Conference 2013, MITC2013,Procedia Engineering 68,pp.345 – 351,2013.

[17] Sivarao, Samsudin A.R, Tin S.L, Hasoalan, Taufik, Yuhazry, Abdul Alif, Robert K.M, Sivakumard, C.F. Tan, Promising Techniques of Automotive Engine Lubrication Oil Monitoring System – A Critical Review towards Enhancement, The International Journal of Engineering And Science (IJES), Volume 1,Issue 2, ISBN: 2319 – 1805,pp 228-233,2012.

[18]S. Peric, B. Nedic, Monitoring Lubricant Performance in Field Application, Tribology in Industry Vol. 34, No 2,pp. 92-100,2012.

[19] T.H. Loutas, D. Roulias, E. Pauly, V.Kostopoulos, The combined use of vibration, acoustic emission and oil debris on-line monitoring towards a more effective condition monitoring of rotating machinery, Mechanical Systems and Signal Processing 25,pp.1339–1352,2011

[20] Z. Peng, N. Kessissoglou, An integrated approach to fault diagnosis of machinery using wear debris and vibration analysis, Wear 255,pp.1221–1232,2003.

[21] www.kittiwake.com