

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Wear Performance Analysis of Cottonseed Oil as a Lubricant with Boric Acid Additive

Trishul P Kulkarni¹, Sanket S Sonawane², Bhagwan G Toksha³, Jagdeep M Kshirsagar⁴

Assistant Professor, Department of Mechanical Engineering Maharashtra Institute of Technology, Aurangabad, India¹

U.G. Student, Department of Mechanical Engineering, Maharashtra Institute of Technology, Aurangabad, India²

Assistant Professor, Department of Physics, Maharashtra Institute of Technology, Aurangabad, India³

Associate Professor, Department of Mechanical Engineering, Maharashtra Institute of Technology, Aurangabad, India⁴

ABSTRACT: The present work is carried out as first stage of exploration of effect of boric acid nanoparticles on wear performance with green oils. In this study, green lubricant combinations were prepared by homogeneously mixing coarse micrometre-scale boric acid powder additives with cottonseed oil. Lubricants of base cottonseed oil and cottonseed oil with three concentrations of boric acid 0.5%, 1% and 1.5 % were prepared. Wear experiments were carried out on four different lubricants with virgin cotton seed oil and three concentrations. The prepared lubricants were employed on a pin-on-disc apparatus under ambient conditions. Based on the experiments, the boric acid additive lubricants significantly outperformed base cottonseed oil lubricant with respect to wear performance. In fact, the boric acid powder-based lubricants exhibited a wear rate more than an order of magnitude lower than base lubricant. It was also found that the oil with a 1% boric acid powder additives exhibited better wear performance than the other two selected concentrations. In case of 0.5% concentration, the improvement in performance is lower than 1.0% while higher concentration the sedimentation is the issue.

KEYWORDS: Tribology, Nanoparticles, pin-on-disc, Lubricants

I.INTRODUCTION

There is a ever growing, tremendous demand and consumption of automobile oils as lubricant[1]. Due to growing environmental concerns about pollution caused by non-degradable lubricants and their disposal issues industrial community is looking towards green lubricants as an alternative [2]. The conventional lubricants are non-biodegradable and not environment friendly[3]. There is an increased demand for multifunctional, environmentally friendly lubricants with enhanced tribological performance. The development of green lubricants to replace petroleum-based products is an emerging area of research in the industrial community. In machining industry oil based cutting fluids are extensively used, which includes mineral, synthetic and semi-synthetic cutting fluids. These cutting fluids are non-biodegradable which have adverse environmental effects and health concerns to the operators handling them [4].

To reduce the adverse environmental effects associated with the use of cutting fluids, vegetable based oils are being used as base oil to produce new kind of cutting fluids. It has been reviewed recently by W. Liew Yun Hsien that vegetable oils are best to be used as base fluid for eco-friendly lubricants because of their excellent lubricity, biodegradability, viscosity-temperature characteristics, low volatility, non-toxic, non-harmful to health of operators, not a fire hazard with not smoke or fog [4].

Over the years, solid lubricants are being used to reduce friction and wear in sliding contacts as an alternative to conventional liquid lubricants[5]. Solid lubricants are usually lamellar solids that have low interlayer friction and can provide excellent durability and lubricity at very slow speeds, whereas liquids may break down if the pressure is extreme and severe wear or scuffing proceeds. Extremely low friction coefficients are feasible with some solid

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

lubricants, and when combined with liquids, such low friction may persist over much longer sliding distances or much heavier loads. Due to some health, economic, environmental, and disposal issues encountered with liquid lubricants, efforts are being made to develop and implement powder lubricants that come from natural resources. These lubricants, such as boric acid powder, have excellent lubrication properties without requiring expensive disposal techniques. Boric acid is also self-lubricating. The effectiveness of boric acid (H_3BO_3) can be attributed to its low friction and shear strength values. The shear strength value of boric acid available in literature is 23MPa, and its coefficient of friction is less than 0.02 in ambient environments [6].

Among different vegetable oils which can be used as lubricants and cutting fluids, cottonseed oil is one of most suitable candidate to be used as lubricants and cutting fluid due to its long, heavy and dipolar nature create a dense homogeneous and strong lubricating film [7]. This gives cottonseed oil a great capacity to sustain under high pressure. Further availability of cottonseed oil in large scale makes it suitable to be used as base oil for producing green lubricants.

In the present work an attempt has been made to analyse the effect of boric acid (H_3BO_3) additive in cottonseed oil on wear characteristics of Aluminium, being common engineering material. Experiments are carried out to study the wear characteristics of this material under various concentrations of cottonseed oil with boric acid (H_3BO_3) additive.

II. RELATED WORK

There are many researches based on the effects of vegetable oil on various processes parameters in machining. Results available in literature include better surface finish, reduced wear, less consumption of energy by using vegetable oil [8], the common conclusions of all these studies suggest that the vegetable oil can be used in industry applications. B. Ozcelik studied the use of vegetable based cutting oils and investigation was done in reducing thrust force and improve surface finish at different spindle speeds and feed rates during drilling [9]. M. Anthony Xavier, from the study based on coconut oil, concluded that coconut oil performed better than the other cutting fluids in reducing the tool wear and improving the surface finish [10]. Erdemir [11], studied the lubrication effect from mixture of boric acid with oils and greases and concluded that lubricity of conventional oils and greases can also be improved by adding concentrates of boric acid. Mia and Ohno investigated the aspect of vegetable oils as lubricant by comparing and examining the physical properties and studying phase diagram of mustard and coconut oil with conventional mineral oil. Lubricity of coconut oil is good and it showed lowest coefficient of friction [12]. Kabir et al [13] carried out an experimental study on a green particulate–fluid lubricant with the help of pin on disk and concluded that the boric acid-canola oil lubricant mixture demonstrated excellent potential for use as lubricants in industrial applications such as sheet metal forming. Alla M. Petlyuk [14] studied the oxidation stability and tribological behavior of vegetable oil hydraulic fluids. By using vegetable based cutting oil it is possible to reduce the power consumption, cutting force also a considerable increase in tool life can be seen than using conventional cutting fluid. B. Ozcelik [15], performed experiments to investigate the Optimization of surface roughness in drilling using vegetable based cutting oils developed from sunflower oil. K.M. Rao et al [16], focuses on application of eco-friendly nanofluids in machining. And they represent the performance of nano solid lubricant suspensions in vegetable oils in turning of AISI 1040 steel in minimum quantity lubrication (MQL). Onche et al [17] developed different cutting fluid emulsions of about 10% concentration from fixed oils and the performance of each of the developed cutting fluid was evaluated by a direct comparison with conventional cutting fluid. The ability of each sample to perform effectively as a lubricant during turning operation has been determined. It was found that cutting fluid developed from groundnut oil performed best as coolant at all experiment speeds. M. Agrawal et al [18] studied the Experimental Investigations into Wear Characteristics of M2 Steel using cottonseed Oil and thus concluded that cottonseed oil can be proposed as a metalworking fluid in industry, it showed comparatively good result in terms of wear and coefficient of friction at various loads and speeds. Also it is biodegradable, less pollutant, easily available and cheaper as compared to conventional metal working fluid.

From the literature survey, the need of alternative as well as biodegradable fluid has been highlighted. Over the years, many researchers have been working on the viability of various biodegradable fluids in metalworking as well as various industrial lubrication. Coconut, canola, mustard, palm, groundnut, cotton seed oils have been tested and the findings shows great promise to exploit the potential of these oils in many applications. The main reason to use boric

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

acid (H_3BO_3) in cotton seed oil is that both these are bio-degradable and eco-friendly. Also boric acid powder is used as an solid lubricant powder in many of the cases[19]. The Environmental Protection Agency has established that boric acid is benign and is not classified as a pollutant under the Clean Water Act. Material safety data sheets show no serious illnesses or carcinogenic effects resulting from exposure to boric acid solutions or aerosols. In the present work it has been tried to found the effect of boric acid(H_3BO_3) additive in cottonseed oil on wear characteristics of common engineering material aluminium which is light in weight and cheaper. To the best of our knowledge, however, no reports on use of “Boric acid (H_3BO_3) as additive in cotton seed” oil have been made. In context to Indian scenario cottonseed oil is available abundantly in India especially in Maharashtra and Gujarat. Moreover, cost of this vegetable oil is cheaper as compared to others as well as boric acid (H_3BO_3) powder is also easily available and cheaper as compared to other additives.

III. EXPERIMENTAL INVESTIGATION

In the present study, the effect of boric acid(H_3BO_3) additive in base cottonseed oil of various concentrations on wear performance was investigated using a Magnum make, PIN ON DISC FRICTION and WEAR TEST RIG – TE-165-SPOD at Marathwada Institute of Technology, Aurangabad research facility center. Cottonseed oil procured from local market and AR grade boric acid powder were used. Lubricants with specific concentrations of boric acid (H_3BO_3) in the cotton seed oil were prepared using a magnetic stirrer to get uniform dispersion of particles for 24 hours. Four different lubricants were prepared by combining boric acid (H_3BO_3) powder in cottonseed oil weight percentage, (1) 0 %wt. of boric acid powder (2) 0.5% wt. of boric acid powder (3) 1% wt. of boric acid powder (4) 1.5% wt. of boric acid powder.

Once various concentrations lubricants were prepared, wear experiments were carried out on the lubricants using pin-on-disc-apparatus at ambient conditions. The pin-on-disc investigation used spherical Aluminium pins was held against the counter face of a rotating disc Aluminium disc with wear track diameter 57 mm. The pin was loaded against the disc through a dead weight loading system. The wear test for various concentrations of lubricants was conducted on pin-on-disc for various speeds and loading conditions. The pin was 30 mm in length and 10 mm in diameter. The surfaces of the pin samples were slides using emery paper (80 grit size) prior to test in order to ensure effective contact of fresh and flat surface with the aluminium disc. The samples and wear track were cleaned with acetone and weighed (up to an accuracy of 0.0001 gm using microbalance) prior to and after each test. The wear rate was calculated from the weight loss technique and expressed in terms of wear volume loss per unit sliding distance. In present investigation, the variables set are as follows:

1. Load (2, 4 and 6 kgf)
2. Speed (600,900 and 1200 rpm)
3. Distance of pin from disc centre (57mm)
4. Time (5 minutes-constant throughout one run)

Total 9 trials have been conducted for each concentration of lubricant. In addition to this each experiment was conducted twice to eliminate the pure error and average weight loss of aluminium pin was recorded.

IV. EXPERIMENTAL RESULTS

As discussed above experiments were performed to determine effectiveness of addition of boric acid (H_3BO_3) in cotton seed oil on wear performance. Figure 1, 2, 3 shows wear performance with varying load for different concentrations at three disc speeds namely 600, 900, and 1200 RPM.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

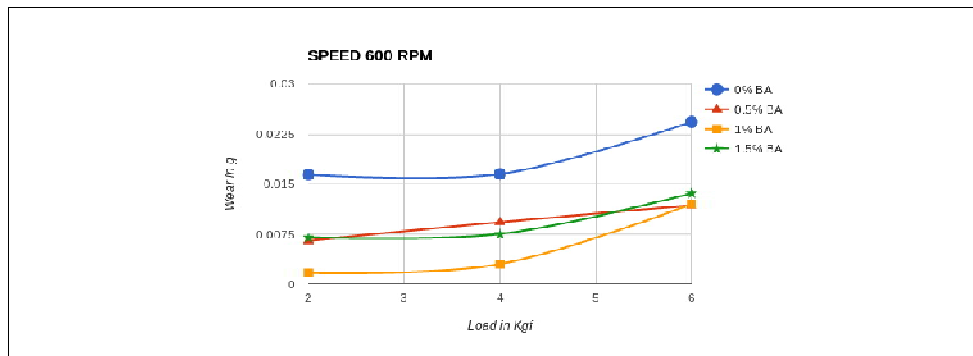


Figure 1. Wear performance with varying load for different concentrations at 600 RPM

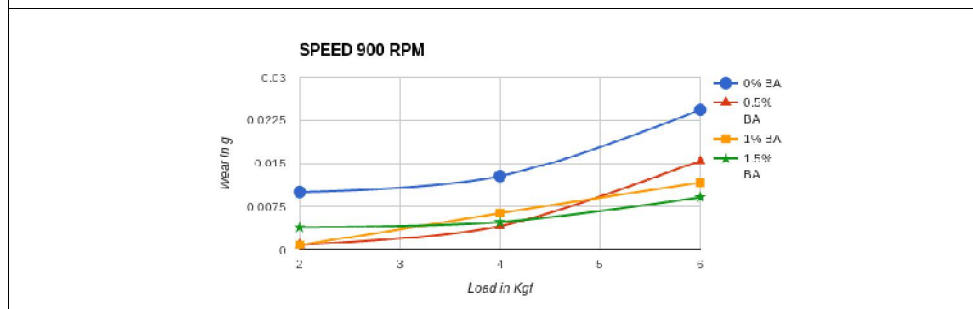


Figure 2. Wear performance with varying load for different concentrations at 900 RPM

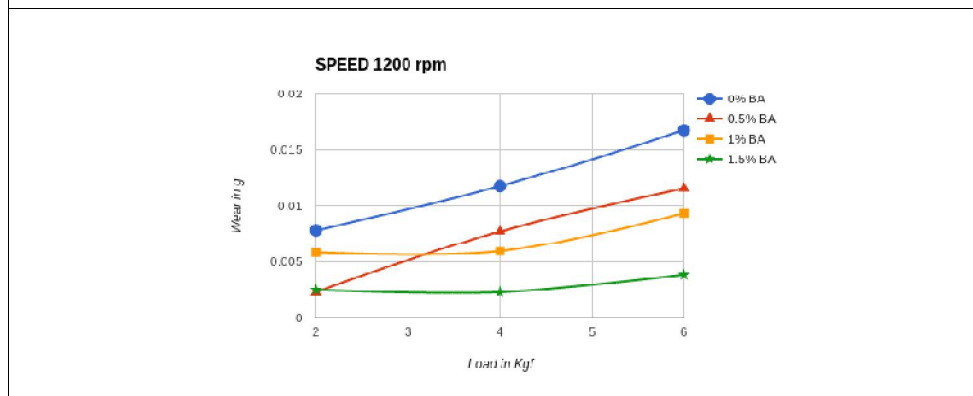


Figure 3. Wear performance with varying load for different concentrations at 1200 RPM

As shown in figure 1, 2 and 3 for specific speed wear increases as load is increased for every concentration of lubricant. It is observed that there is significant decrease in wear with boric acid additive in cottonseed oil for all concentrations at specified speeds. The boric acid powder-based lubricants exhibited a wear more than an order of magnitude lower than base lubricant. At speed 600 RPM 1% of boric acid (H_3BO_3) concentration in cottonseed oil gives the lowest wear as compared to other concentration, whereas at 1200 RPM speed 1.5% of boric acid (H_3BO_3) concentration in cottonseed oil gives the lowest wear.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

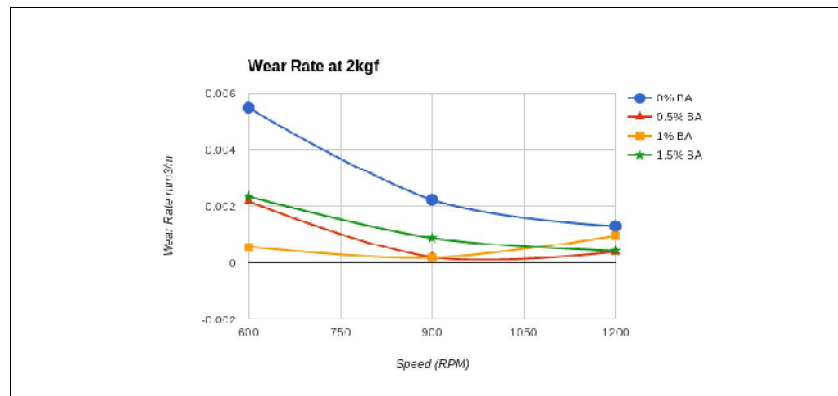


Figure 4. Wear rate with varying speed for different concentrations at 2kgf.

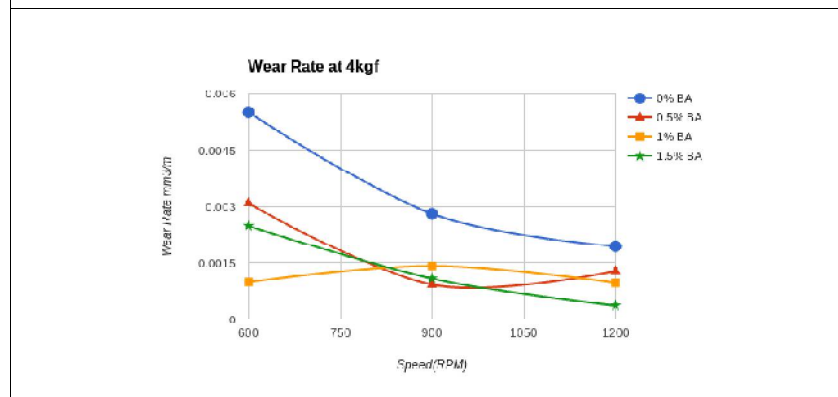


Figure 5. Wear rate with varying speed for different concentrations at 4kgf

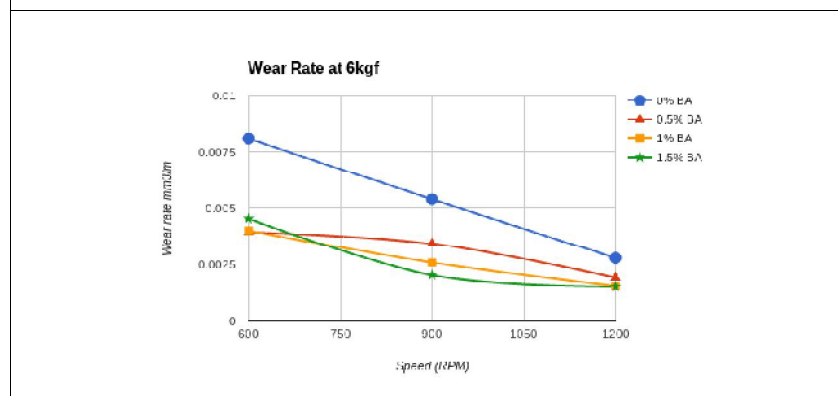


Figure 6. Wear rate with varying speed for different concentrations at 6kgf

It can be observed from figure 4, 5 and 6 that addition of Boric acid powder have more significant wear reduction at lower speeds as compared to higher speed for various loading conditions. It can be seen from the figure 4, 5, and 6 that at high load and low speed wear rate for pure cottonseed oil is high, whereas wear rate decreases as speed increases, it can be attributed to hydrodynamic effect in which increased speed is responsible for maintaining the oil

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

film at contact zone, but at lower speed film breaks and there is boundary lubrication conditions, whereas in case of colloidal solution of boric acid in the cottonseed oil at high load and low speed wear rate is observed significantly low as boric acid particles are believed to be carried to the vicinity of the contact zone by liquid media and then dragged into the contact interface which helps to maintain the lubricant film at lower speed.

Lubrication Mechanism of colloidal solution of Boric Acid in cottonseed oil:

During sliding, solid particles of boric acid are believed to be carried to the vicinity of the contact zone by liquid media and then dragged into the contact interface. Once they enter the contact zone, they are smeared on the real contact spots to form a very thin boundary film. Because of their high chemical affinity, these smeared particles may react with contact spots and hence establish a strongly bonded layer. Once bonded, they can protect these spots against further wear and reduce friction because of their easy shear. The molecules that make up these nanoparticles may possibly rearrange themselves in a plate-like boric acid structure to enhance the anti-friction and wear properties of the sliding surfaces.

V. CONCLUSION

Speed and load have been varied in a wide range to study their combined effect on the wear behavior of specimen material under varying concentrations of boric acid in cottonseed oil. Based on the present investigation, following conclusions can be drawn:

1. Wear was found to be increased with the increased load for all the wear test conditions. This is attributed to the decreased separation in the contacting sliding area on which opposite asperities compresses each other.
2. The cotton seed oil performed better with 1% wt. concentration of boric acid under varying load; however, no significant difference has been found at higher loading for all the concentrations. It might be attributed to capacity of cotton seed oil for providing a dense, homogeneous and strong lubricious film which provides better support to varying load in presence of boric acid.
3. At low speed 1% wt. concentration of boric acid oil performed better as compared to base cottonseed oil and other concentrations of boric acid additive, however as speed increases cottonseed oil showing with all selected concentrations shows better result. It might be attributed to high lubricating property of cotton seed oil resulting from hydrodynamic effect.
4. At higher speed the stable lubricating film is a virtue of hydrodynamic effect, at lower speed addition of boric acid has played a significant role in maintaining the stable lubricating film resulting in lower wear rate.
5. Hence, it is concluded that cottonseed oil with 1% wt. concentration of boric acid as a lubricating fluid showed comparatively good result in terms of wear at various loads and speeds. Also cottonseed oil being biodegradable, less pollutant, easily available and cheaper has advantage over conventional lubricating fluid. The results are well in agreement with literature available.

It is concluded that solid lubricants can provide excellent durability and lubricity at very slow speeds, whereas liquids may break down if the pressure is extreme and severe wear or scuffing proceeds.

REFERENCES

- [1] Michael R. Lovell, M. A. Kabir, Pradeep L. Menezes, C. Fred Higgs, "Influence of boric acid additive size on green lubricant performance," Phil. Trans. R. Soc. Vol. A 368, pp. 4851–4868, September 2010.
- [2] Zitte LF, Awi-Waadu GDB, Okorodike CG, "Used-Oil Generation and Its Disposal along East-West Road, Port Harcourt Nigeria," International Journal of Waste Resources, Int J Waste Resour, 2016.
- [3] M. J. Fuentes, R. Font, M. F. Gomez-Rico, I. Martin-Gullon, "Pyrolysis and combustion of waste lubricant oil from diesel cars : decomposition and pollutants," J Anal Appl. Pyrol, vol. 79, pp. 215-226, May 2007.
- [4] W. Liew Yun Hsien, "Towards Green Lubrication in Machining," Springerbriefs in Green Chemistry for Sustainability, 2015.
- [5] N. Suresh Kumar Reddy, P. Venkateswara Rao, " Experimental investigation to study the effect of solid lubricants on cutting forces and surface quality in end milling," Volume 46, Issue 2, pp. 189–198, February 2006.
- [6] P. Deshmukh, M.R. Lovell, W.G. Sawyer, A. Mobley, "On the friction and wear performance of boric acid lubricant combinations in extended duration operations.," Wear , Vol 260, pp. 1295–1304 , 2006.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

- [7] N.L. Gunjal, D.S. Bajaj, A.K. Mishra, "Performance Evaluation of Cottonseed Oil as a Lubricant," International Advanced Research Journal in Science, Engineering and Technology Vol.3, Special Issue 1, March 2016.
- [8] Y.M. Shashidhara, S.R. Jayaram, "Vegetable oils as a potential cutting fluid—An evolution," Tribology International, Volume 43, Issues 5–6, pp. 1073–1081, May–June 2010.
- [9] E. Kuram, B. Ozcelik, E. Demirbas, and E. Şik, "Effects of the Cutting fluid types and Cutting parameters on Surface roughness and Thrust force," Proceedings of the World Congress on Engineering 2010, London, U.K., Vol II WCE 2010, June 30 - July 2, 2010.
- [10] M. Anthony Xavier, M. Adithan, "Determining the influence of cutting fluids on tool wear and surface roughness during turning of AISI 304 austenitic stainless steel," Journal of Materials Processing Technology, Volume 209, Issue 2, Pages 900–909, January 2009.
- [11] A. Erdemir, "Lubrication from mixture of boric acid with oils and greases," US Patent 5,431,830, 1995.
- [12] Sobahan Mia, Shinichiro Hayashi, Nobuyoshi Ohno, "High pressure tribological behaviour of vegetable oils as lubricants," Proceedings of the International Conference on Mechanical Engineering, December 2007
- [13] M. A. Kabir, C. Fred Higgs, Michael R. Lovell, "A Pin-on-Disk Experimental Study on a Green Particulate-Fluid Lubricant," Journal of Tribology, Volume 130, Issue 4, October 2008.
- [14] Alla M. Petlyuk, Richard J. Adams, "Oxidation Stability and Tribological Behavior of Vegetable Oil Hydraulic Fluids," Journal Tribology Transactions, Volume 47, Issue 2, 2004.
- [15] Babur Ozcelik, Emel Kuram, Erhan Demirbas, Emrah Şik, "Optimization of surface roughness in drilling using vegetable-based cutting oils developed from sunflower oil," Industrial Lubrication and Tribology, Vol. 63 Issue: 4, pp.271-276, doi: 10.1108/00368791111140486
- [16] Krishna Mohan Rao. G, Padmini. R, Vamsi Krishna. S (2008) "Performance evaluation of eco-friendly nanofluids in machining,". Recent Advances in Robotics, Aeronautical and Mechanical Engineering.
- [17] Sunday Albert LAWAL, Matthew Sunday ABOLARIN, Benjamin Iyenagbe UGHEOKE, Emmanuel Ogo ONCHE, "Performance Evaluation of Cutting Fluids Developed from Fixed Oils," Leonardo Electronic Journal of Practices and Technologies, Issue 10, January-June 2007, pp. 137-144.
- [18] Sachin M. Agrawal, Subhash Lahane, N.G. Patil, P.K. Brahmkar, "Experimental Investigations into Wear Characteristics of M2 Steel Using Cotton Seed Oil," Procedia Engineering, Volume 97, 2014, Pages 4-14.
- [19] Carlton J. Reeves, Pradeep L. Menezes, Tien-Chien Jen, Michael R. Lovell, "Evaluating the tribological performance of green liquid lubricants and powder additives based green liquid lubricants," Proceedings of the STLE 2012 Annual Meeting & Exhibition STLE 2012, May 6-10, 2012, St. Louis, Missouri, USA STLE 2012- 1244338.