International Journal For Technological Research In Engineering
Volume 5, Issue 3, November-2017 ISSN (Online): 2347 - 4718

ASSESSING THE LUBRICATION AND CUTTING OIL PERFORMANCE OF SELECTED VEGETABLE OILS BY THE MOST ECONOMICAL WAY

Ajit Surve
Assistant Professor
Maharashtra Academy of Naval Education and Training, Loni Kalbhor, Pune-412201

Abstract: The mineral oils are showing best performance as lubricant; but have disadvantages like the skin diseases, toxicity and environmental pollution etc. The previous study by the different scholars shows that, around 80% of all diseases were due to contact of skin with cutting fluids. The cutting fluids are complex in nature; cause irritation and allergy. To overcome these problems, the alternatives to mineral oils were explored by scientist and tribologist recently. The government regulations forcing the industrialists to reduce the use of mineral oil as base oil for lubricants and coolant and use biodegradable oils (such as vegetable oil) as base oil. The vegetable oil can be used as base oil for lubricants. It has certain advantages over mineral oils. Simultaneously, The characteristics like oxidation stability, ther-mal stability and hydrolytic stability are to improve. To improve these properties of vegetable oil, (as a lubricant) it is necessary to add some additives; for example antioxidant and nano-particles. To study the rheological and thermal characteristics of vegetable oils , some oil samples were prepared and tested by using some simple techniques . The present work describe an experimental investigation into the determination of viscosity , coefficient of friction , surface finish and cool ability of selected vegetable oils. It is found that the properties can be measured by some simple ways and confirm the results achieved by this experiment with the results of previous experts. The viscosity , coefficient of friction and surface finish can be improved by adding additives. These methods could be used by small scale lubricant manufacturers and end users for the purpose of primary screening of new oils. keyword: viscosity, vegetable oil, coefficient of friction, additives etc.

I. INTRODUCTION

Verification is the perfect proof of a theory, and here is the challenge thrown to the world by the Rishis.

-Swami Vivekanand

Lubricants made from mineral oil have certain disadvantages like air, water and soil pollution. [1] The various health hazards of the lubricants are development of nitrosamines in coolants, the effect of oil-fags and fumes, skin diseases caused by contacts with coolants, bactericide effects in connection with coolants, cancer generating substances in used engine oils, solvent containing products, heavy metal compounds in additives. The health hazard and water hazard (due to use of mineral oil as base oil for lubricant) need to minimize. An average of 35 million tons of lubricants per year is used.[2] About 1 % of the total mineral oil consumption is used to formulate lubricants. The preferred course of action to reduce toxicity is to increase biodegradability. Where it is possible to meet the requirement, the government promoted the use of recycled oils for government contracts and use of environmentally compatible oils. Austria is the only country with a law that bans the use of mineral oil based lubricants in particular applications i.e. chain saw oil. Using mineral oils as base oils increases the amount of greenhouse gases in the environment, which leads to global warming effect. [1] To overcome these problems the alternatives to mineral oils are explored by scientist and tribologist recently. These alternatives are synthetic lubricants solid lubricants and vegetable based lubricants.

Based on the cost , performance , health , safety and environment , a vegetable oil is alternative to petroleum oils.[3] To protect the environment, the lubricants which are environmentally more acceptable gain the importance. Water miscible and non-water miscible fluids are used as base fluids, for environmentally acceptable fluids. In addition to technical requirements, aspects of toxicology and industrial medicine will exert an important influence on the formulation of coolant. [4] The present work describe an experimental investigation into the determination of viscosity , coefficient of friction , surface finish and cooling ability of vegetable oil. In most areas of research, vegetable oil is preferred as the base oil for lubrication and other industrial uses, as mineral oil have disadvantages like toxicity and environmental pollution. The properties of the vegetable oils necessary to understand are flash point, fire point, viscosity, oxidation and thermal stability, etc. An attempt have been made to understand viscosity of various vegetable oils using a simple instrument ”Hand spinner”.

The various samples of vegetable oils tested. Trend model is formed so that the viscosity of unknown oil can be determined. For measuring coefficient of friction between the metal surface (M.S.) and aluminium or mild steel block using various samples, Leonardo Da Vinci’s friction apparatus is used [6][7][8]. The prepared samples were tested, on a radial drilling machine and the temperature is recorded for understanding cooling ability of various oils. The care was taken to keep constant feed and speed was limited to

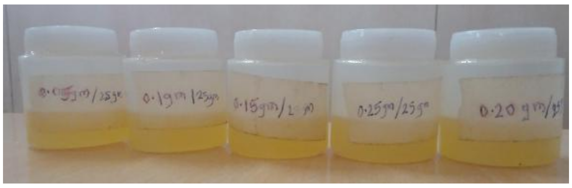

Fig. 1. Oil samples of boric powder and groundnut

195 rpm. After pre-drilled hole of 10 mm diameter; about 12 ml oil was used for drilling hole of 16 mm diameter. The difference in temperature used as the basis for measuring the ability to cool and adhesive or to decrease the friction.

II. MATERIAL AND METHODS

A. Lubricants

In groundnut oil, Boric powder mixed with different quantities, about eight different samples were prepared. The percentage of Boric powder was different for each sample. Every sample is kept for 15 days prolonged period so that the required chemical reaction to occur. Coconut oil, Sesame oil, Castor oil, SAE Two-Stoke oil (Workshop), etc. were used to compare results.

B. Groundnut oil and boric powder

The various samples prepared for groundnut oil and boric powder are given in Table I. The groundnut oil was purchased from Pandharpur, Maharashtra state, India. The prepared sam-ples (photograph), is as shown in Fig. 1.

TABLE I: GROUND NUT AND BORIC POWDER SAMPLES

S.N.	Groundnut	Boric powder	Name
1.	25mg	0.05mg (0.2 %)	GB1
2	25mg	0.1mg (0.4 %)	GB2
3	25mg	0.15mg (0.6 %)	GB3
4	25mg	0.2mg (0.8 %)	GB4
5	25mg	0.25mg (1 %)	GB5
6	25mg	0.3mg (1.2 %)	GB6
7	25mg	0.4mg (1.6 %)	GB7
8	25mg	0.5mg (1.8 %)	GB8

C. Other oil samples

The various other oil samples are given in Table II. The groundnut oil is the crude oil, prepared by traditional oil extraction method used in India ('Ghani'), purchased from Pandharpur, Solapur, Maharashtra state, India. The Area is well-known for the production of vegetable oil. The other samples were purchased from Kothrud, Pune, Maharastra state of India.

TABLE II: OTHER OIL SAMPLES

S.N	Oil	Extracted
1.	Groundnut oil	Ghani
2.	Sesame oil	Lakdi Ghani
3.	coconut oil	Lakdi Ghani
4.	Mustard oil	Lakdi Ghani
5.	Grease	Commercial
6.	Castor oil	home made extraction

*Lakadi Ghani or Ghani - Old Indian Technique of oil extraction.

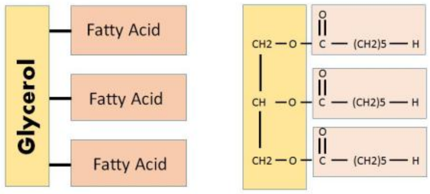

Fig. 2. Trigycerides

III. CHEMISTRY

A. Vegetable oil (Groundnut oil)

Triglyceride are the main constituents of vegetable oils. It is a compound made by one molecule of glycerol and three fatty acids. Refer fig. 2.

Fatty acid composition of Groundnut oil is
Unsat/sat ratio-4.0
Saturated
Palmatic acid [C16:0] -11
Stearic acid [C18:0]-02
Mono Unsaturated
Oleic Acid [C18:1]-48
Polyunsaturated
Linoleic acid (!6) [C18:2]- 32

Note: The percentages in the table above reflect the overall proportions of the fatty acid radicals in the triglycerides. If we had 33 representative triglyceride molecules containing 99 fatty acid radicals, the number of each fatty acid radical in these 33 molecules would be proportional to its percentage in the table.[5] Fully saturated fats are too waxy and solid. To increase the viscosity and other properties of the vegetable oils it si necessary to convert unsaturated bonds to saturated one. [5] Peanut oil has triglycerol containing one molecule of oleic acid and two molecules of linoleic acid. Both Oleic acid and linoleic acid are unsaturated fatty acids containing C-C double bonds.

B. Boric acid

The chemical formula of boric acid is H3BO3 or B(OH)3. The chemical structure is as shown in Fig.3. Adding the boric acid in groundnut oil chemically modifying the oil. The process may be the esterification or formation of glyceroboric acid.

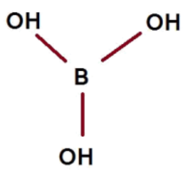

Fig. 3. Boric acid chemical structure

Fig. 4. Hand Spinner

IV. EXPERIMENTATION

A. Viscosity measurement

A simple device ”hand spinner” (refer Fig.4) was used to understand the changes in the viscosity of the oil samples.
The viscosity of oil samples was tested using the ”hand spinner”, and compared with the standard data. The results are as given in the Table III. Each test was repeated ten times to ensure repeat-ability

TABLE III: VISCOSITY MEASUREMENT

S.N.	Oil tested	Avg. time(s)	Ref. Vis.	Cal. Vis.
1.	Water	95	1	1.6
2.	Coconut oil	27	22.9	18.4
3.	Sesame oil	24	36.5	23.3
4.	Mustard oil	20	42.3	33
5.	Castor oil	5	311.5	480
6.	GB1	18.5	-	38.4
7.	GB2	19	-	36.5
8.	GB3	23.5	-	24.1
9.	GB4	25	-	21.6 *
10.	GB5	25	-	21.6
11.	GB6	25	-	21.3
12.	GB7	23	-	23.6
13.	Gb8	20	-	32.5
14.	Grease	3.4	-	1032
15.	Workshop oil	10	-	127
16.	Machine oil	34	-	11.6
17.	No Lubricant	82	-	2.2
18.	Groundnut oil	20	34.5	33.6

Viscosity in Centipoise

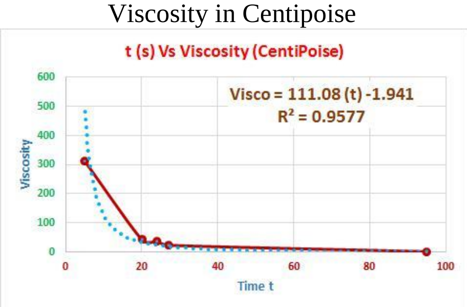

Fig. 5. Time ’t’ v/s Viscosity

Fig. 6. Determination of coefficient of friction

The trend analysis of ’The time’ vs ’The viscosity’, is as given in the Table III, and the relation is obtained using EXCEL (Equ. 1),

$$V iscosity = 111:01 \quad (t)^{1:941}: \tag{1}$$

Where , ”t” is the ’time in seconds’, measured from start to end of the spinner rotation . Every time , a constant force was applied to the ’hand spinner’ at the start of test. The Fig.5, shows the graphical relation between Time ’t’ and ’viscosity’. Viscosity is considered to be time to settle down the hand spinner. Hence viscosity is calculated as shown in Table III. The time required to settle down the spinner to rest was measured. Each time an equal amount of oil is poured into the spinner and equal force is applied for rotation.

B. Coefficient of friction measurement and evaluation

An instrument based on Leonardo Da Vinci’s friction apparatus is developed as shown in the Fig.6.[6][7][8] Every time, the thin oil layer was laid below the block and minimum and maximum force required to prevent the block from sliding down were recorded for certain inclination of the plane. The values of coefficient of friction using various samples are given in Table IV. Two different blocks made of aluminum and steel of the different dimensions were used as shown in Fig.7. Each sample was tested using both of these blocks.

Fig. 7. Blocks

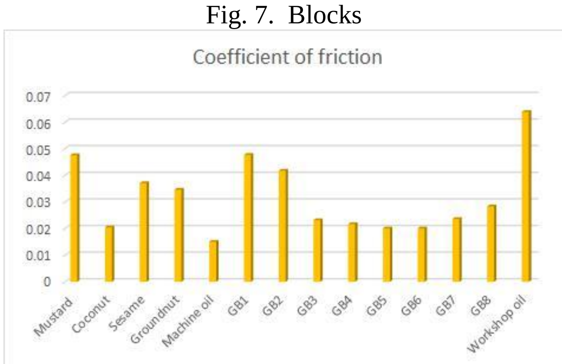

Fig. 8. Comparative study of coefficient of friction

The coefficient of friction is lower in case of machine oil. The coefficient of friction is higher in case of mustard oil and GB1. The value of coefficient of friction decreases depending upon concentration of boric acid. There is a drastic change in the value of coefficient of friction in GB3 compared to GB2. The reason may be a chemical modification of fatty oil due to addition of boric powder. Depending on the top surface of the plate and bottom surfaces of the block, the friction coefficient in the dry position is 0.38. The value of coefficient of friction was measured using steel and aluminum block. The two values were averaged, to fix value of frictional coefficient. The comparative values of coefficient of friction using various oils are as shown in Fig.8. The relation between coefficient of friction and viscosity is obtained for the best fit line. The Fig.9 shows the graph plotted between coefficient of friction ( ) and viscosity. The relation is power equation (Equ.2). Coefficient of friction,

$$= 0{:}125\ V^{0{:}9853}\ 0{:}004{:} \qquad (2)$$

Where "V" is the viscosity of the sample, in poise. The last term is the error term. The calculated values of coefficient

TABLE IV: COEFFICIENT OF FRICTION

S.N.	Oil	Coefficient of friction	Calc.
1.	Mustard	0.047	0.038
2.	Coconut	0.021	0.02
3.	Sesame	0.037	0.026
4.	Groundnut	0.035	0.039
5.	Machine	0.015	0.011
6.	GB1	0.048	0.045
7.	GB2	0.042	0.042
8.	GB3	0.023	0.027
9.	GB4	0.022	0.024
10.	GB5	0.02	0.024
11.	GB6	0.02	0.023
12.	GB7	0.024	0.026
13.	GB8	0.028	0.037
14.	Workshop	0.064	0.15
15.	Dry cond.	0.38	-

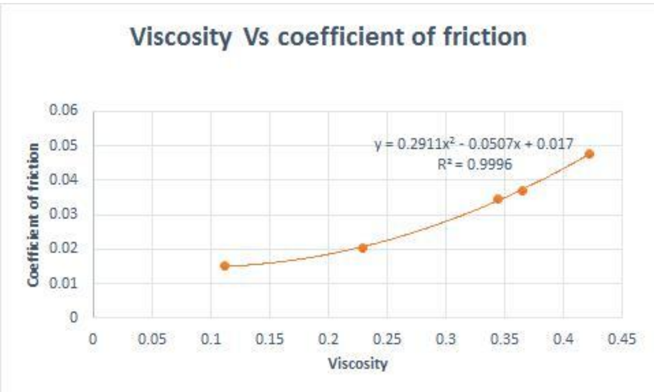

Fig. 9. Coefficient of friction Vs Viscosity

of friction from the viscosity are given in the Table IV. The calculated values are very close to the experimented values and the standard data.

V. COOLING ABILITY OF PREPARED SAMPLES

The number of 'MS jobs' was prepared for testing cooling ability of sample oils, as shown in the Fig.10. A hole of 10 mm diameters was initially passed, and then the hole of 16 mm diameters was drilled, so that the oil flow will be easier. The oil was poured by the spoon in the hole

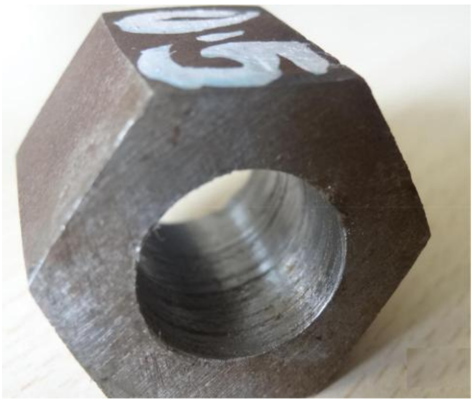

Fig. 10. Job after drilling hole of dia. 16mm using GB8 as coolant

Fig. 11. Oil feed, Temperature measurement and drilling

(to limit the quantity of oil). Only three spoons of the oil (12 ml) was poured during operation. The temperature of the 'MS job' was recorded (refer Fig.11).

The variation in temperature is the measure of coefficient of friction between the drill and the 'MS job' The values of coefficient of friction changes due to rise in temperature as well as relative motion. If the friction is less, the temperature rise will be less. The oil is acting as coolant and lubricant. It is observed that if the viscosity of the oil is higher, the temperature of 'MS job' is low, after drilling 16 mm dia. hole. When the water is used during drilling operation, the temperature is up to 64 0, and the lowest temperature 50 0 is recorded in commercial oil i.e. workshop oil. The Mustard oil, Groundnut oil and GB1 show the best cooling effect.

The observations are as given in the Table V.

The viscosity and temperature is co-related logarithmic-ally

TABLE V: TEMPERATURE NOTED, CALCULATED FROM VISCOSITY, AND CALCULATED FROM

S.N.	Oil	Temp.	Calc. form V	Calc. from
1.	Mustard	52	54.055	51.48
2.	Coconut	58	56.059	56.68
3.	Sesame	56	55.206	52.91
4.	Groundnut	52	54	53.44
5.	Machine	63.5	57.68	58.52
6.	GB2	51.2	53.73	52.24
7.	GB5	56.2	55.46	56.68
8.	GB6	56.3	55.51	56.68
9.	GB7	55.3	55.168	55.54
10.	GB8	52.2	54.104	54.60
11.	Workshop	50	49.64	49.9
12.	Water	64	64.058	-

(refer Fig.12)(Equ.3) ,

Temp: = 3:305 ln(V) + 65:528 + 0:084: (3)
Where, ”V” is 100 times the viscosity of oil; in Poise. The last term is error term. It is observed that, the cooling effect and lubrication is best, if viscosity is low. As well as compared to water as coolant; corrosion is less or totally absent. The vegetable oils have the potential, to be used as coolant and lubricant. The values of the temperature can also be calculated from the coefficient of friction and the relation is the power equation

Fig. 12. Viscosity Vs Temperature

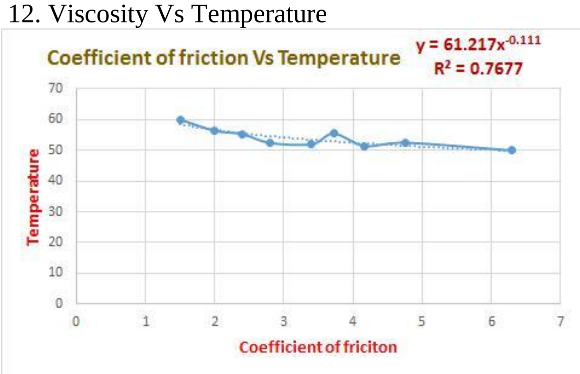

Fig. 13. Coefficient of friction Vs Temperature

(refer Fig.13).
The Equ. 4, describes the relation between coefficient of friction and rise in temperature.
Temp:(T) = 61:217 (MU)
0:111
+ 0:060008: (4)
where, ’MU’ is 100 times the calculated coefficient of friction from viscosity. The last term is error term. The average error is 0.550 C, over 100 error values. The values obtained from the coefficient of friction are very close to the actual observation. It shows that the coefficient of friction and viscosity both are parameters to decide the final temperature of ’MS job’ after drilling. But, the rise in temperature changes the viscosity of the oil. This may be helpful, to spread it more to achieve more cooling effect. The water as coolant evaporates easily, and workshop oil is added with other additives shows good ability as a coolant and lubricant. The vegetable oil (Groundnut oil, Mustard oil) coefficient of friction is very close to the workshop oil. So, it can be concluded that the vegetable oils are good lubricants and coolants. In addition of other additives (GB2, GB8); groundnut oil (vegetable oil) shows the better performance than commercial oil. The comparison between the coefficient of friction ( ), Vis-cosity and temperature is as shown in Fig.14

A. Surface finish of the drilled jobs
To understand the surface finish of the drilled job surfaces using different oils, a Sony camera of 18.2 MP is used. The images are cropped and enlarged view dimensions are mea-sured in millimeter using ’Digimizer’ software. The variation in the size of the drill lays in ’mm’ is considered to understand

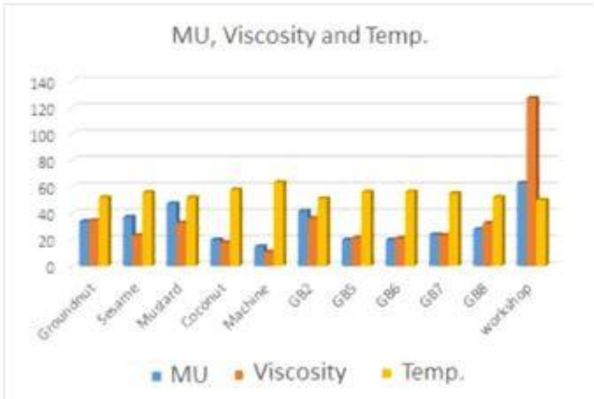

Fig. 14. Mu, Viscosity and Temperature

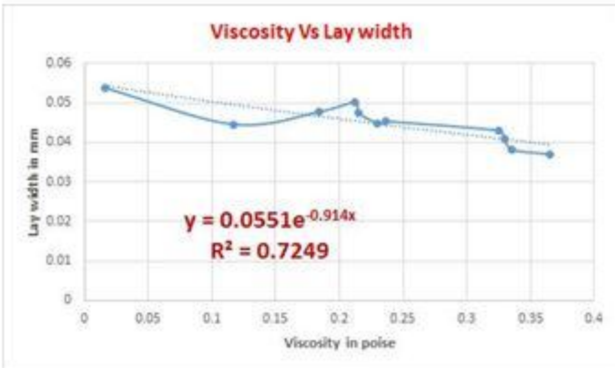

Fig. 15. Lay width Vs Viscosity

the irregularities on the surface. The data thus obtained is as given in the Table VI.

TABLE VI
LAY WIDTH IN MM ON THE SURFACE

Oil	Lay width	Oil	Lay width
GB2	0.037	Groundnut	0.038
GB5	0.047	Machine	0.045
GB6	0.050	Workshop	0.028
GB7	0.045	Mustard	0.041
GB8	0.043	Sesame	0.045
Coconut	0.048	Water	0.054
Dry	0.086	-	-

Fig. 15 shows the relation between lay width and the viscosity. The surface finish is higher when using workshop oil and lowest in case of dry or water. This may be due to reduction in friction and temperature rise during the process. While conducting the experiment using different oils, care is taken to keep same speed and feed. The speed of the machine is kept as low as possible i.e. 195 rpm. Fig. 16 shows the various patterns of surface of the jobs drilled using different oils. The variation in surface finish can be judged even by naked eyes. Better surface finish is obtained using Mustard, Sesame and 0.1 % boric acid added to 25gm groundnut oil (GB2).

The lay width have the dependency with the viscosity (Equ. 5),

$$\text{Laywidth} = 0{:}0551 \quad (e)^{0{:}914\, V} + 0{:}0013{:} \qquad (5)$$

Where, V is the viscosity in poise and final term is the error term.

Fig. 16. The lays on the surface of drilled hole of 16 mm dia.

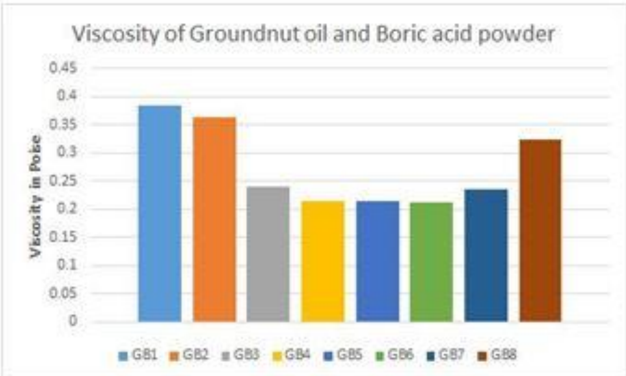

Fig. 17. Viscosity of GB sample oils.

VI. RESULTS AND DISCUSSION

A. Viscosity

From the Table III, it is observed that the viscosity value is decreasing, if the Boric powder is added in the groundnut oil. Boric Powder works as an additive. The chemical reaction occurred and the unsaturated fatty acid gets saturated (Refer section III). In case of GB1, the viscosity is 0.38 Poise, which is reduced up to 0.22 Poise in case of GB6 and then viscosity rises. Viscosity is 32.5 Centipoise in case of GB8. The change in viscosity is due to the addition of Boric powder, is shown in Fig.17. The viscosity in GB4, GB5 and GB6 is minimum, it means that the maximum quantity of boric powder added are limited to 0.25 gm-0.3 gm/ 25 gms of groundnut oil to get the minimum viscosity. When, the boric powder is mixed with groundnut oil, the properties of groundnut oil changes. If the concentration of boric powder is increased, the viscosity increases.

Comparing the viscosity of all sample oils; the castor oil has maximum viscosity, and coconut oil has minimum viscosity. The difference in viscosity is due to unsaturated fatty acids, which are less in coconut oil and more in castor oil. The results obtained are very similar to those of previous scholars' findings.

Refer Fig.17 and Fig. 18, for comparison of viscosity of

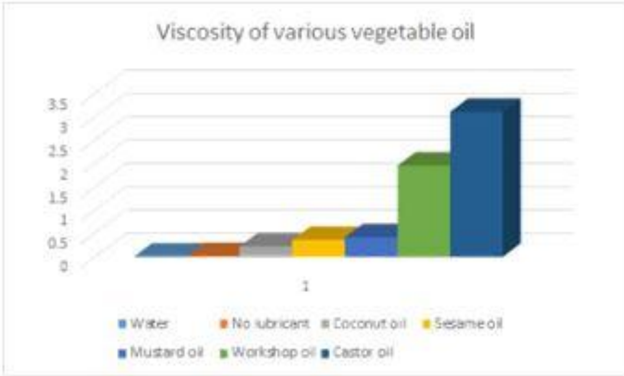

Fig. 18. Viscosity of vegetable oils

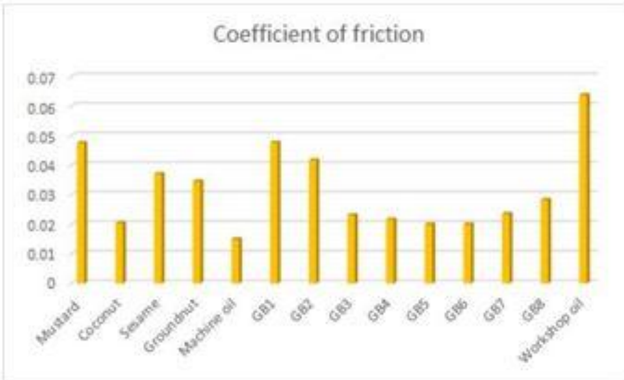

Fig. 19. coefficient of friction

various vegetable oils with water and dry condition. Viscosity of GB4, GB5 and GB6 is very close to the viscosity of coconut oil. On the other side, viscosity of GB1, GB2 and GB8 is higher, and very close to the viscosity of Mustard oil. It is concluded that the viscosity of the groundnut oil can be changed using boric powder. Here boric powder act as lubrication additive.

B. Coefficient of friction

The coefficient of friction for various oil samples is compared in Fig.19. For no lubricant condition the value of the coefficient of friction is higher around 0.38. The value decreases largely by using vegetable oil. The lowest value of is observed in machine oil. The descending order of for the sample oils is GB1 > Mustard oil> sesame oil> GB2 > Ground nut oil> Coconut oil> GB3> GB4> GB5. Fig. 20 shows the comparative study of coefficient of friction of vegetable oil and samples. There is considerable change in the value of between GB2 and GB3. This may be due to chemical modification and extra concentration of the boric powder. Whereas it is found that the coefficient of friction is nearly same as that of coconut oil with GB5 and GB6. The coefficient of friction depends on the viscosity of oil, and viscosity is dependent on the temperature. The temperature rise will increase the viscosity and hence will effect on the final surface finish. Larger the coefficient of friction, maximize will be the temperature, again changes the viscosity so more cooling effect. So it becomes necessary to understand what happens with vegetable oils under varied temperature.

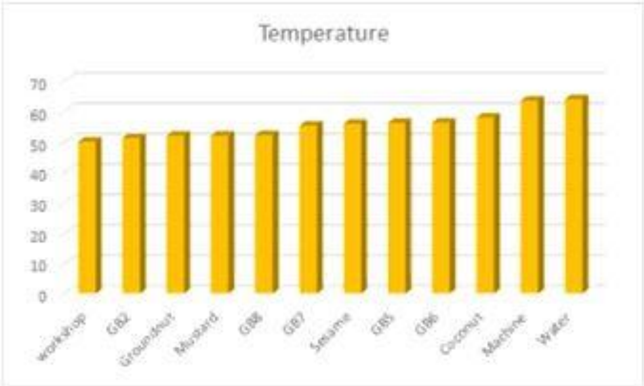

Fig. 20. Comparing the Temperature

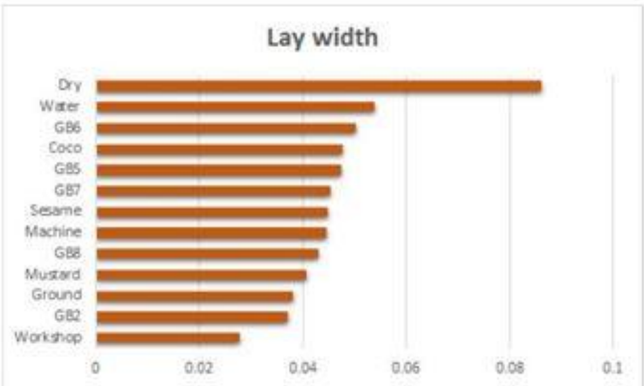

Fig. 21. Lay width

C. Cooling ability of prepared oil samples

The comparison of the temperature of MS jobs recorded immediately after drilling the hole of 16 mm diameter, is as shown in Fig 21. It is observed that the rise in temperature is higher in case of machine oil and water. Whereas, it is the lowest in case of workshop oil. If the viscosity of the oil is higher, the temperature is lower; otherwise it is higher. But too much viscosity also offers the resistance to flow, which will not act as good lubricant and coolant. Compared to water and workshop oil, (considering two ends of the scale-one is a good lubricant and other is good coolant) the better oils are sesame, GB7, GB5 etc., which have the viscosity close to 23.3, 21.55 and 23.57 centipoise respectively.

D. Surface finish of drilled jobs

The surface finish is found best in case of workshop oil and worst in case of dry drilling. The order of surface finish from higher to lower is workshop oil > GB2 > Groundnut oil > Mustard oil>GB8>Machine oil>Sesame oil>GB7>GB5> Coconut oil>GB6>water>Dry. The surface finish obtained is better when the vegetable oil is used, compared to water.

Because the oil acts as lubricant as well as coolant. Refer to Fig. 22, for better understanding of surface finish. Lay widths are largely affected by the viscosity of the medium. Water viscosity is low and workshop oil viscosity is higher, which clearly shows the relation of viscosity on the final surface finish obtained. More viscous oil conducts more heat, so reducing the temperature. Also, it acts as a lubricant so reducing the friction. The combine properties are in action while using oil during drilling operation. As the temperature rises during the process; the viscosity of oil increases and better performance can be obtained.

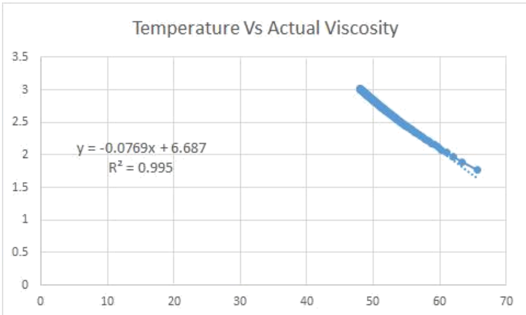

Fig. 22. Temperature Vs actual viscosity

TABLE VII: ACTUAL VISCOSITY AT DIFFERENT TEMPERATURE

Temp.	AV	Ref. Range
10	8.5	-
20	6.5	-
26	5.5	0.04.45-0.05.74
30	4.9	4
40	3.7	3.4-4.5
38	3.9	3-4.56
50	2.8	2.6-3.05
54	2.5	2.36-2.75
60	2.1	-
70	1.6	1.2-1.8
80	1.2	-
90	0.9	0.78-0.98
100	0.7	-

*Viscosity in Centipoise

E. Viscosity change with temperature

Through the experiment, whatever results were obtained; are used to find the relation of change of viscosity due to change in temperature. For this purpose, viscosity values are taken from the reference papers. The values, taken from research paper, are used to assure the calculated values. The relation is as given below,

$$AV = (CV)^{0:1} = 35:64: \qquad (6)$$

where 'AV' is the actual viscosity at a given temperature in centipoise and 'CV' is the calculated viscosity in centipoise (using hand spinner.) The actual viscosity and temperature relation is,

AV = 0:0769(T) + 6:687 (7)

Where, ’AV’ is the actual viscosity in centipoise and ’T’ is the temperature in degree centigrade. As the temperature increases, the viscosity also increases. The graph shows the change in the viscosity (Refer fig.20) The results obtained are very close to the values taken from various research papers. Refer Table VII.

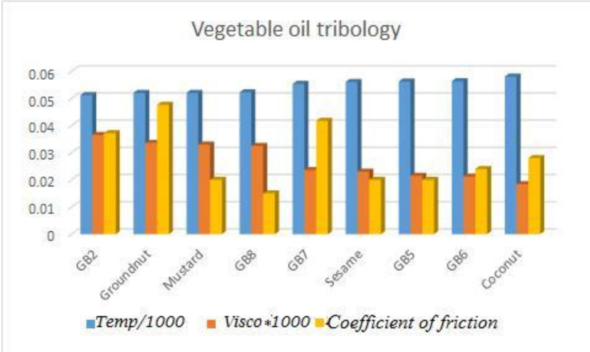

Fig. 23. Tribology properties of vegetable oil

VII. Conclusion

In this research work,

1) Simple methods were used to find tribological properties of vegetable oil.
2) Viscosity was measured by using hand spinner. The viscos-ity of vegetable oil depends on fatty acids contains. Viscosity is lowest for coconut oil and maximum for castor oil. The results matches with the values taken from various reference papers. The relation between viscosity and time is useful for finding the viscosity of any oil. Adding additives like boric acid powder in groundnut oil, reduces the viscosity first (up to concentration 0.3 gm/25 gm), and then increases.
3) Coefficient of friction was measured by using the apparatus prepared based on Leonardo Da Vinci’s method. The value of the coefficient of friction is minimum for machine oil. Coefficient of friction in the coconut oil, GB5, machine oil and GB6 is close to each other. The value of the coefficient of friction is maximum for workshop oil. It is found that, coefficient of friction is dependent on the viscosity. Relation between coefficient of friction and viscosity was obtained using best fit line. The additive (boric acid) used in groundnut oil reduces the value of the coefficient of friction. This is due to chemical modification of groundnut oil.
4) A test conducted on radial drilling machine, using oil samples, suggests that the vegetable oils are good lubricants and coolants. The additive like boric acid powder in groundnut oil, improves its performance as a lubricant and coolant. The lower temperature was recorded during drilling operation using groundnut, mustard, GB2, GB8 and workshop oil.
5) Surface finish is evaluated based on the lay width. The lay width is minimum for GB8 and maximum for dry condition or using water. The surface finish is considerably improved when vegetable oil is used as coolant. The evaporation rate is also low. The viscosity change due to change in temperature is the base for getting better and improved surface finish.
6) A comparative tribology of the sample oils is shown in Fig.23. The overall best properties are observed in GB2, which is 0.1 gm boric powder added in 25 gm groundnut oil. During drilling operation, when GB1 oil was used, minimum temperature was recorded and better surface finish is obtained. Minimum viscosity is observed in coconut oil, GB5 and GB6.
7) The coefficient of friction is minimum in coconut oil and GB5. Maximum temperature was recorded while using coconut oil, GB5 and GB6. GB2 and groundnut oil have high viscosity. Whereas, coefficient of friction is higher for Mustard oil.
8) It is also possible to determine, the change in viscosity of the vegetable oil at different temperatures. It is concluded that the viscosity of vegetable oil changes with rise in temperature. The change in viscosity is 0.01 Poise in the temperature range of 40-700C (Refer Fig. 22)
9) It is concluded that the vegetable oil has better potential to be used as lubricant and coolant for engineering operations. The results are matching to the conclusions by different experts. The surface finish is improved, friction is reduced and the temperature during process is also reduced; hence reducing the rate of evaporation of coolant.
10) These methods could be used by small scale lubricant manufacturers and end users for the purpose of primary screening of new oils.

VII. ACKNOWLEDGMENT

My special appreciation goes to my family - my family has been a consistent source of love, care, support and affection, a person could ever ask for. I would like to thank workshop staff of the Maharashtra Academy for Naval Education and Training, Loni Kalbhor, Pune (Specially Workshop superintendent Kiran naik, Shri. Gavram Shirode and Shri. Ranjit patil) who have been kind enough to advise and help in their respective roles. I thank all those who are directly or indirectly involved in shaping up of this research work. Finally, I thank the almighty God, without the blessings of whose, nothing would be possible.

REFERENCES

[1] D. N. Canter, “Special report: Boundary lubricity additives,” Tribology and lubrication technology, 2009.

[2] R. Ishida, R. Tsuboi, and S. Sasaki, “Effect of fatty acids on lubricity of vegetable oils,” 15th International Conference on Experimental Mechan-ics, 2012.

[3] S.A.Lawal, I. A. Choudhary, and Y. Nukman, “Application of vegetable oil-based metalworking fluids in machining ferrous metal- a review,” International journal of Machine tool and

Manufacture, 2011.
[4] W. J. Bartz, "Lubricants and the enviornment," Tribology internation, 1998.
[5] "Fats, oils, fatty acids, triglycerides," http://www.scientificpsychic.com/fitness/fattyacids.html, 2017.
[6] S. of tribologist and lubrication engineers, "Introduction to tribology." [Online]. Available: http://www.stle.org/files/Whatistribology/Tribology.aspx
[7] U. of Cambridge, "Study reveals leonardo da vincis irrelevant scribbles mark the spot where he first recorded the laws of friction." [Online]. Available: http://www.cam.ac.uk/research/news/study-reveals
[8] I. M. Hutchings, "Leonardo da vinci studies of friction," Sci-ence direct, Wear and http://www.ifm.eng.cam.ac.uk/uploads/Hutchings Leonardo Friction 2016 v2.pdf, 2016.
[9] M. Mahadi, I. Choudhury, M. Azuddin, and Y. Nukman, "Use of boric acid powder aided vegetable oil lubricant in turning aisi 431 steel," Science Direct, Advances in Material and Processing Technologies Con-ference Procedia Engineering, 184, 128 136, 2017.

LIST OF FIGURES

1 Oil samples of boric powder and groundnut
2 Trigycerides
3 Boric acid chemical structure
4 Hand Spinner
5 Time 't' v/s Viscosity
6 Determination of coefficient of friction
7 Blocks
8 Comparative study of coefficient of friction
9 Coefficient of friction Vs Viscosity
10 Job after drilling hole of dia. 16mm using GB8 as coolant
11 Oil feed, Temperature measurement and drilling
12 Viscosity Vs Temperature
13 Coefficient of friction Vs Temperature
14 Mu, Viscosity and Temperature
15 Lay width Vs Viscosity
16 The lays on the surface of drilled hole of 16 mm dia.
17 Viscosity of GB sample oils
18 Viscosity of vegetable oils
19 coefficient of friction
20 Comparing the Temperature
21 Lay width
22 Temperature Vs actual viscosity
23 Tribology properties of vegetable oil

LIST OF TABLES

I Ground nut and Boric powder samples
II Other oil samples
III Viscosity measurement
IV Coefficient of friction
V Temperature Noted, calculated from viscosity, and calculated from
VI Lay width in mm on the surface
VII Actual viscosity at different temperature

