GE06
Prospect of Mustard and Coconut Oil as Environment Friendly Lubricant for Bangladesh

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***Abstract*—Environment friendly lubricant is the key demand in 21st century for the issue of global climate change. Vegetable based lubricant is one of the environment friendly lubricants. Mustard and coconut oil are most common vegetable oil in subcontinent including Bangladesh. These are renewable and easily accessible from any region. This study investigated the aspect of these vegetable oils as lubricant. Physical properties, rheological behavior and phase diagram of these oils are examined and compared a conventional mineral oil. Vegetable oils expressed as good boundary lubricant, they have good lubricity, comparatively good friction and wear property, and excellent viscosity index. But, low temperature fluidity of coconut oil is not good. This study also investigated the high pressure behavior and their phase diagrams are drawn. Results concluded that mustard and coconut oil could be used as base oil for environment friendly lubricant.**

INTRODUCTION

It is well known that mechanical systems often employ lubricants, the majority of which are petroleum based, to decrease component friction and surfaces wear. Increased concerns about environmental damage caused by mineral oil based lubricants, has created a growing worldwide trend of promoting vegetable oil as base oil for automobile lubricants. Bartz [1] explained details about the effect of lubricant application on global environment. Now a days, due to rising of petroleum based oil prices, the diminishing supplies of natural resources, global climate change and increased environmental sensitivity, various alternatives to petroleum based lubricants are currently being explored. Such alternatives include synthetic lubricants and vegetable based lubricants. Synthetic lubricant is much expensive than vegetable oils. The popularity of vegetable oil as lubricant increases day by day. There are many researches on vegetable oils, especially on rapeseed oil, soybean oil, sunflower oil and palm oil. Castor oil is widely applied vegetable oil as lubricant. Among the vegetable oils, mustard and coconut oils are widely used in subcontinents. Usually people in subcontinent like Bangladesh used mustard oil for cooking purpose and coconut oil for hair oil. This study investigated the probability of mustard and coconut oil as lubricant. Jayadas et al. [2] modified coconut oil with various additives and used as base oil for industrial lubricants. Several tribological experiments as like viscosity and density measurement, 4-ball wear test, friction test, high pressure rheological test, EHL performance, etc. of pure mustard and coconut oil were done and compared with a conventional mineral oil. Results found that these vegetable oils have high viscosity index, good lubricity, better boundary lubrication property and environment friendly, but low temperature fluidity is not good enough.

EXPERIMENTAL

Physical Properties of the sample oils

Physical properties of mustard and coconut oil are given in Table 1. Properties of a mineral oil P150N is also given for comparison. Viscosity index of both mustard and coconut oil is higher than the mineral oil P150N.

TABLE 1: Physical properties of tested oils

Oil name	Density ρ (g/cm^3)	Kinematic Viscosity ν (mm^2/s)		Viscosity Index (VI)
	15°C	40°C	100°C	
Mustard oil	0.9180	44.1	9.4	205
Coconut oil	0.9260	27.6	5.9	165
Mineral oil (P150N)	0.8663	28.6	5.1	105

Measurement of boundary lubricant property

Friction and wear properties of the sample oil were measured as the boundary lubricant property. 4-ball wear test and Soda type pendulum test were done to measure the frictional and wear property of mustard and coconut oil. These have good lubricity and low coefficient of friction has been found.

High pressure rheological test

There are many researches on vegetable oil but high pressure rheological study of vegetable oils is not enough. Mia et. al [3] presented high pressure tribological behavior of several vegetable oils as lubricant. They found that pressure viscosity coefficient of vegetable oils showed lower values compared with mineral oil and due to low pressure viscosity coefficient these can be used in elastohydrodynamic lubrication. High pressure viscosity and high pressure density of mustard and coconut oil were examined in this study. Pressure viscosity coefficient of the sample oil was calculated from the high pressure viscosity measurement. Solidification pressure corresponding to a temperature was found from the high pressure density measurement. Phase diagram of the sample oils was drawn using the experimental results.

RESULTS AND DISCUSSION

Mustard and coconut oils showed high viscosity index, which is an essential property of lubricating oil. The viscosity at 100 °C is very close to meeting SAE30 grade requirements and at 40°C is in between the ISO32 and ISO46 viscosity grades. Causes of higher viscosity index compare to mineral oil can be explain by the fact that hydrogen bonding becomes less substantial with increasing temperature. The effect of viscosities continued on the high pressure. Pressure viscosity coefficient of coconut oil is almost same as P150N oil but it is lower in case of mustard oil. Pressure viscosity coefficient α at 40°C is shown in Table 2.

Experimental results on friction and wear test are also shown in Table 2. High wear scar area has found for coconut oil due to its low pressure resistance capacity but lubricity of coconut oil is good and it showed lowest coefficient of friction.

TABLE 2: Experimental results of tested oils

Oil name	Pressure viscosity coefficient α, GPa^{-1}	Wear scar area A, mm^2	Friction coefficient μ
	40°C		
Mustard oil	9.46	0.2945	0.0921
Coconut oil	13.09	0.5081	0.0880
Mineral oil (P150N)	12.65	0.3126	0.1330

Again solidification of the sample oil was observed from the density pressure relation. Tangent bulk modulus can found by differentiating the density-pressure curve and viscoelastic solid transition point can be obvious from the abrupt change of bulk modulus with respect to pressure as shown in Fig. 1. Solidification point of mustard and coconut oil at 40°C temperature has found as 0.762 GPa and 0.189 GPa correspondingly, whereas solidification point of P150N oil at 25°C temperature has found as 0.78 GPa. The solidification temperature at atmospheric pressure of Mustard oil, coconut oil and P150N oil has found as -26°C, 7°C and -36°C respectively. This results have found by lowering the samples temperature flowing the liquid nitrogen. Finally phase diagram of the sample oils is drawn. The phase diagram of mustard oil and coconut oil comparing a mineral oil is shown in Fig. 2. Phase behavior is almost same as like P150N, temperature level is different only.

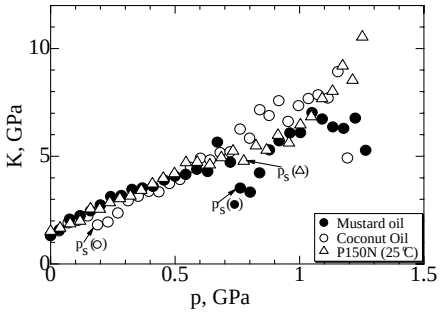

Fig. 1 Pressure-bulk modulus relation for identifying the solidification point.

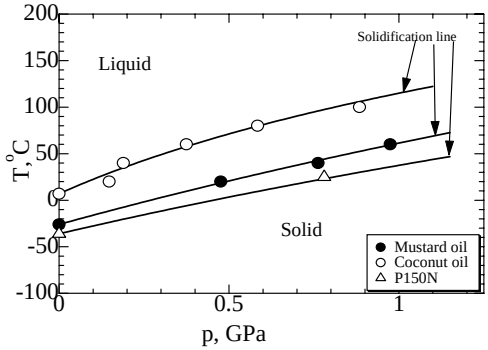

Fig. 2 Phase diagram of mustard and coconut oil

CONCLUSION

Mustard and coconut oils are available in Bangladesh. For the global climate issue to reduce carbon emission, mustard oil and coconut oil can be used as lubricant for friendly environment. Their boundary lubrication property is good enough though low temperature fluidity of coconut oil is not good, but it can use by adding some additives. These vegetable oils can also be used in moderate high pressure application can be replace the mineral oil as like P150N oil to meet the global warming crisis.

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REFERENCES

[1] W. J. Bartz, "Lubricants and the environment," *Tribology International*, Vol. 31, No. 1-3, 1998, pp. 33–47.

[2] N. H. Jayadas, K. P. Nair, "Coconut oils as base oil for industrial lubricants- evaluation and modification of thermal, oxidative and low temperature properties," *Tribology International*, Vol. 39, No. 9, Sep. 2006, pp. 873-878.

[3] S. Mia, S. Hayashi, N. Ohno, "High pressure tribological behavior of vegetable oils as lubricant," *Proc. of ICME2007*, Dhaka, Bangladesh, 29-31 Dec. 2007, FL-7.