Mile Stojilković, Zorica Davidović

ISSN 0350-350X
GOMABN 54, 4, 357-362
Professional paper

THE EFFECT OF CERTAIN ADDITIVES ON THE FOAMING OF VEGETABLE OIL

Abstract

Vegetable oils, which are used as base oils for the production of environmentally friendly lubricants are triglycerides that make up the complex mixture of fatty acids with different chain length and number of double bonds. Triglycerides are rapidly biodegradable and have excellent lubricity properties. Advantages of vegetable oils compared to mineral are reflected in the following characteristics: toxicity, rapid biodegradability, good lubricity, high flash point, high viscosity index and low volatility. Disadvantages of vegetable oils compared to mineral are: poor oxidative stability, poor flow ability at low temperatures and poor hydrolytic stability that limits their application. Poor properties of vegetable oils can be improved by adding suitable additives. However, some additives affect the appearance of the foam, which is undesirable, because of the negative influence on the quality of the lubricant, and furthermore accelerates the oxidation process of the oil.

The paper presents the influence of the additives on the occurrence of foam and possible way of solving this problem. There were performed tests on foaming in different combination: vegetables oils without additives, a mixture of vegetable and mineral oils and vegetable oils with additives, and there are some interesting results.

Key words: *lubrication*, *vegetable oil, foamability, foaming, additives*

Introduction

Poor degradability of mineral oils in the environment presents their serious lack. In this regard, vegetable oils have a great advantage. The constituents of vegetable oils are triglycerides, composed of various fatty acids attached to a glycerol. The differences between the vegetable oils are mainly reflected in the different fatty acid composition, which differ in the number of carbon atoms and number of double bonds in the carbon chain. A large number of fatty acids are found in the composition of vegetable oils, so far it has been found more than seventy.

Research in the field of application of biodegradable oils indicates that vegetable oils have advantages and disadvantages compared to mineral oils:

• Advantages: non-toxicity, biodegradability, good lubricity, high flash point, high viscosity index and low volatility.

• Disadvantages: poor oxidative stability, unfavorable low-temperature characteristics and poor flowability, poor hydrolytic stability and high cost compared to mineral oils.

Table 1: Typical characteristics of different base oils

Characteristics	Vegetable oil	Mineral oil
Lubricity	high	low
Oxidation stability	poor	very good
Viscosity Index	excellent	satisfying
Hydrolytic stability	low	high
Polarity	high	low
Saturation of hydrocarbons	unsaturated	saturated
Flash point	very good	satisfying
Low temperature characteristics	poor	good
Miscibility with mineral oil	good	-
Tendency to swell seals	slightly	slightly
Impact on color	no affect	no affect
Tendency of sludge formation	poor	good

Poor characteristics of the vegetable oils may be improved by the addition of functional additives. Additives are substances that are added to base oils in order to improve or add some new features, increasing lifetime and technical properties of the oil in that way. Depending on the mechanism of action they can be divided into three basic groups:

• additives that improve the physical properties of lubricants: pour point depressants, viscosity index improvers, anti-foaming agents and extreme pressure additives,

• additives that improve chemical properties of lubricants: antioxidants,

• additives that protect the mechanical elements from the hazardous substances generated in oil: anti-corrosion additives, dispersants and detergents.

Experimental part and results

During the study of the vegetable oil characteristics of we came to the conclusion that some additives cause the development of foam. Under the foaming a tendency of oil to dissolve the air and builds the foam with it is considered. The foam has very negative effects on the quality of lubrication that results in disturbances in operation of technical systems, increased wear, accelerated oxidation and oil aging etc. One of the ways of solving the problem of oil foaming is to add anti-foam additives - anti-foaming agents. Anti-foaming agents prevent the formation of stable foam in the oil. They reduce the surface tension of air bubbles (bubbles burst) and thus contribute to the rapid degradation of foam.

This paper describes the influence of certain additives on foaming and possible way of solving this problem.

Tests were carried out regarding the foaming of different oil combinations: vegetable oils without additives, a mixture of vegetable and mineral oils and vegetable oils with additives. For these tests vegetable oils based on rapeseed, soybean and sunflower were used, which are produced by pressing and not by extraction. Different functional additives for oils were added to vegetable oils: for improving the pour point alkyl-ester based copolymer, EP additive, an additive for protection against wear, and an additive to improve the oxidation stability comprising the 2,6-di-tert-butilphenol, amine phosphate, and diphenylamine.

Laboratory analysis of the tendency to oil foaming was determined by ASTM D892 method; the apparatus is shown in Figure 1. The method determines the tendency to foam forming at defined temperatures in three separate steps (sequences):

• Sequence 1: in a sample of 190 ml of the oil to be tested, heated at 24.0 ^{o}C, the air is blown in for 5 minutes and the amount of foam was measured. The amount of foam is measured again after 10 minutes of inactivity.

• Sequence 2: the procedure is repeated with a new sample of the oil of 180 ml, but at 93.5 ^{o}C.

• Sequence 3: the same sample from the second step is examined after the fall of the foam, but under the conditions from the first Sequence.

Figure 1: The device for determining the propensity of oil for foaming

Tests on the foaming of the oil have brought interesting results. Pure vegetable oils, without additives, have good resistance to foam forming (0/0; 0/0; 0/0), Table 2. A mixture of vegetable and mineral oil free of additives produces good results regarding formation of foam, which means that adding of mineral oil does not affect the foaming.

Table 2: Results of laboratory analysis on foaming of vegetable oil with no additives

Foaming of oil	**Unit**	**Rapeseed oil**	**Soybean oil**	**Sunflower oil**
Sequence I, 24 ºC	mL	0/0	0/0	0/0
Sequence II, 94 ºC		0/0	0/0	0/0
Sequence III, 24 ºC		0/0	0/0	0/0

After the addition of additives there was intense foaming, Table 3. Also, in a mixture of vegetable and mineral oils with additives there was intense foaming, Table 4. Further laboratory analysis of oil with each individual additive, indicated that the foaming is caused by the pour point depressants (PPD) and extreme pressures additives (EP). The additives that protect against wear (AW) and oxidation (AO) did not affect the appearance of foam.

Table 3. Results of laboratory analysis on foaming of vegetable oils with additives but without defoamer

Foaming of oil	**Unit**	**Rapeseed oil + additives**	**Soybean oil + additives**	**Sunflower oil + additives**
Sequence I, 24 ºC	mL	350/140	380/120	440/210
Sequence II, 94 ºC		290/0	270/0	400/0
Sequence III, 24 ºC		390/190	350/130	300/110

Table 4. Results of laboratory analysis on foaming of a mixture of vegetable and mineral oils with additives but without defoamer

Foaming of oil	**Unit**	**Rapeseed oil + additives + 10% mineral oil**	**Rapeseed oil + additives + 20% mineral oil**
Sequence I, 24 ºC	mL	500/280	600/290
Sequence II, 94 ºC		680/0	350/0
Sequence III, 24 ºC		180/60	280/25

Solving the problem of foaming is approached by adding defoamer. Adding conventional defoamer did not give the required results. Better results are obtained by adding a silicone based defoamer (dimethylsiloxane) in an amount of 30 ppm, which improved Sequence II, and a second defoamer (alkylmethacrylate) in an amount of 80 ppm, which improved Sequence I and III.

But the results were still beyond the permissible values, see data in Table 5. Only after the addition of a silicone based defoamer (dimethylsiloxane) in an amount of 60 ppm and a second defoamer (alkylmethacrylate) in an amount of 160 ppm the good results were obtained. Results on foaming are given in Table 6.

Table 5: Results of laboratory analysis on foaming of vegetable oils with additives and defoamer (30 ppm dimethylsiloxane + 80 ppm alkylmethacrylate)

Foaming of oil	**Unit**	**Rapeseed oil + additives + AP**	**Soybean oil + additives + AP**	**Sunflower oil + additives + AP**
Sequence I, 24 ºC	mL	180/0	180/0	180/0
Sequence II, 94 ºC		50/0	50/0	50/0
Sequence III, 24 ºC		20/0	20/0	20/0

Table 6: Results of laboratory analysis on foaming of vegetable oils with additives and defoamer (60 ppm dimethylsiloxane + 160 ppm alkylmethacrylate)

Foaming of oil	**Unit**	**Rapeseed oil + additives + AP**	**Soybean oil + additives + AP**	**Sunflower oil + additives + AP**
Sequence I, 24 ºC	mL	25/0	15/0	30/0
Sequence II, 94 ºC		20/0	20/0	20/0
Sequence III, 24 ºC		20/0	20/0	10/0

Conclusion

From this study it is possible to draw the following conclusions:

• Mineral oil does not affect the foaming of vegetable oil.
• Characteristics of vegetable oils may be improved by adding suitable additives.
• There is an evident effect of certain additives on the foaming of vegetable oils.
• The problem of foaming of vegetable oils due to the effect of certain additives can be solved by adding suitable defoamer.
• Only after the addition of defoamer dimethylsiloxane in an amount of 60 ppm and a second defoamer alkylmethacrylate in an amount of 160 ppm the good results were obtained.

References

[1] S. Z. Erhan, S. Asadauskas: (2000) Lubricant basestocks from vegetable oils, Industrial Crops and Products, Vol.11, pp. 277-282.
[2] B. Kržan, J. Vižintin: Use and development of biodegradable oils in Tribology of mechanical systems, a guide to present and future, ASME Press, New York, 2004.
[3] M. Stojilković: Research of application of ecological oils in the tribological systems, Doctoral dissertation, 2014.
[4] M. Stojilković, D. Vukolov, M. Kolb: Tribology testing of biodegradable oils, Stručno znanstveni skup Maziva 2013, Rovinj.

[5] M. Stojilković, D. Golubović, D. Ješić: Ecotribology aspects in the lubricants application, 6th International Symposium on Exploitation of Renewable Energy Sources “EXPRES 2014”, Mart 2014, Subotica, Serbia.
[6] M. Stojilković, D. Golubović, D. Ješić: Tribological characteristics of biolubricants, 7th International Symposium on Exploitation of Renewable Energy Sources “EXPRES 2015”, Mart 2015, Subotica, Serbia.
[7] M. Stojilković: Tribological properties of vegetable oils, 2nd International Scientific Conference “COMETA 15”, December 2014, Jahorina, B&H.
[8] M. Stojilković, M. Kolb: Tribological properties of biodegradable universal tractor transmission oil, 14th International Conference on Tribology “SERBIATRIB ‘15”, May 2015, Belgrade, Serbia.

Authors
Mile Stojilković, NIS Gazpromneft, Serbia; e-mail: mile.stojilkovic@nis.eu
Zorica Davidović, Bargos Loa, Serbia; e-mail: bargos@bargos.co.rs

Received
23.10.2015.

Accepted
10.12.2015.

ISSN 0350-350X
GOMABN 54, 4, 357-362
Stručni rad

UTJECAJ NEKIH ADITIVA NA PJENJENJE BILJNIH ULJA

Mile Stojilković, Zorica Davidović

Sažetak

Biljna ulja koja se koriste kao osnova za proizvodnju ekološki prihvatljivih maziva su trigliceridi koji predstavljaju složenu smjesu masnih kiselina različitih duljina lanaca i različitog broja dvostrukih veza. Trigliceridi se biološki razgrađuju brzo, a imaju izvrsna svojstva podmazivanja. Prednosti biljnih ulja u usporedbi s mineralnim uljima očituju se u sljedećim karakteristikama: neotrovnost, brza biorazgradnja, dobra mazivost, visoko plamište, visok indeks viskoznosti i niska isparljivost. Nedostaci biljnih ulja u usporedbi s mineralnim su: loša oksidacijska postojanost, niska tecivost pri niskim temperaturama i loša hidrolitička postojanost koja ograničava njihovu primjenu. Loša svojstva biljnih ulja mogu se poboljšati dodatkom odgovarajućih aditiva. Međutim, neki aditivi uzrokuju pojavu pjenjenja, što je nepoželjno zbog negativnog utjecaja na kvalitet maziva, i ubrzavaju oksidaciju ulja. U ovom radu prikazan je utjecaj aditiva na pojavu pjenjenja i moguće rješenje tog problema. Provedeni su testovi pjenjenja na različitim uzorcima: biljna ulja bez aditiva, smjese biljnog i mineralnog ulja s aditivima, koji su dali neke zanimljive rezultate.

***Ključne riječi**: podmazivanje, biljna ulja, pjenjenje, aditivi*