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DEVELOPMENT AND CHARACTERISTICS OF HIGH BULK MODULUS OIL

TRACK OR CATEGORY

Synthetic and Hydraulic Lubricants

AUTHORS AND INSTITUTIONS

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INTRODUCTION

Hydraulic fluids have been developed based on a new concept of high bulk modulus oils. These new fluids are expected to improve hydraulic system performance. This study describes the unique properties of these fluids under high pressure.

MAIN BODY

The volume of liquids, such as water or mineral oils, is reduced when the liquids are compressed. Compression resistance is represented by the bulk modulus, where a higher bulk modulus indicates a liquid with compression resistance. In a hydraulic system, a higher bulk modulus liquid used as a pressure medium appears to have little loss due to compression. We developed the molecular structure of the base oil used for our new synthetic high bulk modulus oil by exploiting organic synthesis technologies and molecular dynamic simulations. Our aim was to reduce the intramolecular space, which would decrease the possibility of volume shrinkage. Figure 1 shows that the developed base oil has a much higher bulk modulus when compared to mineral base oils or polyalphaolefin (PAO), a representative synthetic oil.

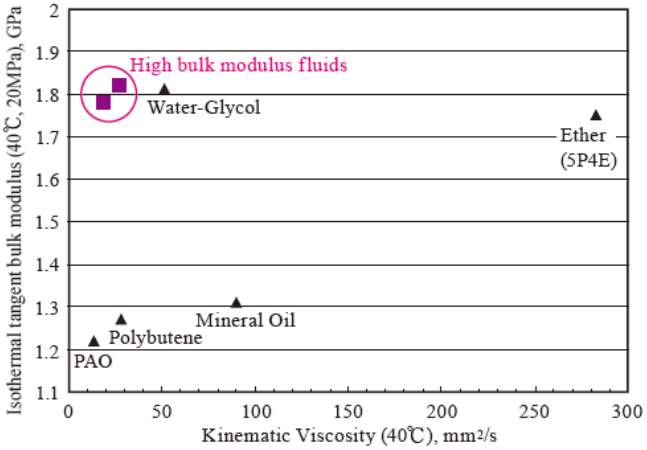

Figure 1 Comparison of bulk modulus and kinematic viscosity

A mineral oil and a high bulk modulus oil with the properties shown in Table 1 were used to conduct a pump efficiency experiment and a pressure responsiveness experiment [1].

Table 1 Properties of test oils

Property	Unit	High bulk modulus oil	Mineral oil
Bulk modulus (40℃, 35 MPa)	GPa	1.84	1.42
Density (15℃)	g/cm^3	1.167	0.862
Kinematic viscosity (40℃)	mm^2/s	37.23	31.37

The pump efficiency experiment was carried out using a piston pump at 30 MPa. We measured the discharge flow. Figure 2 shows that the discharge flow is 2% greater for the high bulk modulus oil than for the mineral oil. This result indicates that the loss of compression energy is small, leading to the expectation that this energy can be used to power actuators etc., thereby improving efficiency [1].

The pressure response experiment was carried out with a pressure control system at 35 MPa and 40°C. Figure 3 confirms that the pressure responsiveness was about 18% (10 ms) faster for the high bulk modulus oil than for the mineral oil [1].

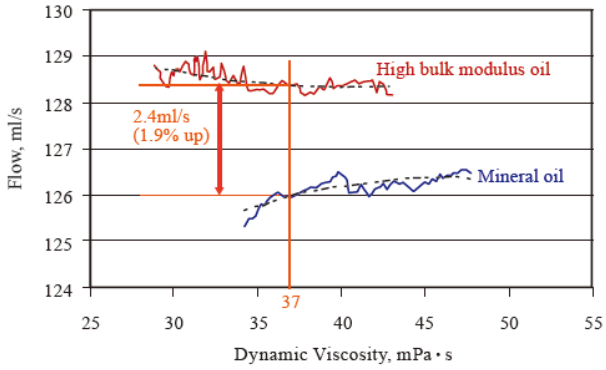

Figure 2 Results of pump efficiency experiment

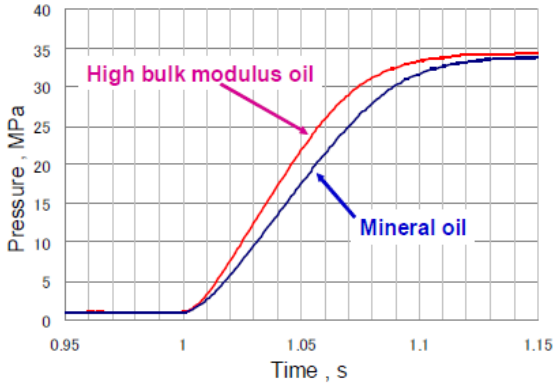

Figure 3 Results of pressure response experiment

An oxidation stability test was conducted by carrying out an adiabatic compression oxidation test [2] (JCMAS P045) using a high-pressure piston pump and two anti-wear hydraulic fluids: an experimentally formulated high bulk modulus oil and a conventional mineral oil. Table 2 shows properties of the oils before and after the test. Although the high bulk modulus fluid showed higher values with respect to increases in total acid number, they are within JCMAS. Millipore value and RPVOT confirm that nearly the same longevity is obtained with the high bulk modulus hydraulic fluid as with the conventional mineral hydraulic fluid.

Table 2 Result of oxidation stability test (JCMAS P045)

Property	Unit	High bulk modulus oil-based anti-wear hydraulic fluid		Mineral oil-based anti-wear hydraulic fluid	
Test time	hr	0	500	0	500
Total acid number	mgKOH/g	0.68	1.68	0.14	0.17
Color (ASTM)	-	L0.5	L5.0	L0.5	L4.0
Millipore (0.8 μm)	mg/100ml	0.2	8.4	0.0	6.4
RPVOT (150℃, 620kPa)	min	1179	535	539	190
Shell four-ball test (1800rpm) Welding load	N	1569	1569	1236	1236

A vane pump V104C wear test (ASTM D7043) was carried out using two anti-wear hydraulic fluids: an experimentally formulated high bulk modulus oil and a conventional mineral oil. Figure 4 shows that the high bulk modulus hydraulic fluid has excellent anti-wear properties.

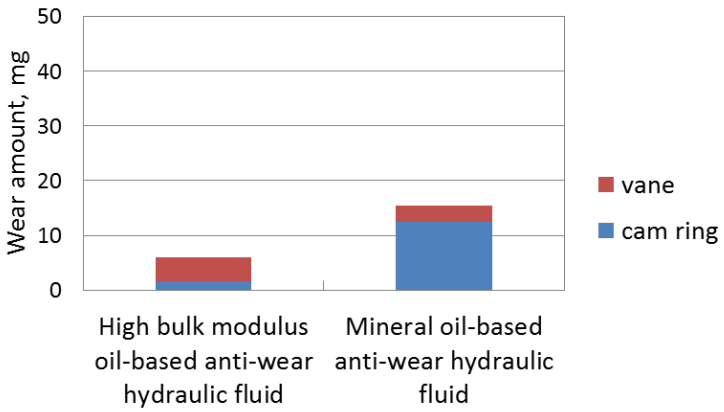

Figure 4 Result of anti-wear test (ASTM D7043)

In summary, high bulk modulus oil has the advantages of increased pump efficiency and pressure response. This new oil also has adequate practical performance in terms of oxidation stability and anti-wear properties.

ACKNOWLEDGMENTS

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KEYWORDS

Lubricants:Hydraulic Fluids, Base Stocks:Synthetic Base Stocks.