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INVESTIGATION OF TRIBOLOGICAL PROPERTIES OF POLYMER GREASE MANUFACTURED FROM POLY ALPHA OLEFIN WITH BORON NITRIDE

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Abstract. Greases are a type of lubricant that has higher viscosity. Manufacturing greases are conducted by mixing base oils with calcium, sodium, or lithium mineral salts. Manufacturing process is complex and changes in parameters results significant change in Grease properties. The increase in mineral salts costs and their effect on nature caused researchers to look for alternative materials that can replace mineral salts. A novel method for manufacturing grease is to use polymers as thickener agents. In this study, 12% polypropylene was used to produce grease from poly alpha olefin. In order to increase grease's high-pressure properties, 2% hexagonal boron nitride was added. Manufactured grease was compared to lithium grease with hexagonal boron nitride addition. Both samples were tested on ball-on-disc tribometer on mirror polished 4140 and results were discussed.

Keywords. Grease, PAO6, lithium grease, hBN, polypropylene.

1. INTRODUCTION

Grease is a lubricant that is used to reduce friction, heating, distortion, torsion in gears and machines. Greases are used in a variety of engineering applications to maintain a lubricant between moving machine surfaces such as in bearings [1]. The most widely used greases today are lithium-based, developed by 1940's [2].

The grease composition includes a lubricant base oil, a thickener, an amide compound, and at least one of an α-hydroxycarboxylic acid metal salt, and an ω-hydroxycarboxylic acid metal salt [3]. Based on this information, it is possible to say that the main production route of greases is the use of mineral and metal salts. However, considering the possibility that the prices of mineral salts and metal salts will increase in the coming years due to the economic crisis in the world alternative methods of grease manufacturing are gaining popularity. Moreover, most of the lubricants on the market today are still produced petrochemically, that is, on the basis of fossil raw materials. Considering the expected scarcity of fossil raw materials and the consequent increase in the cost of products based on fossil raw materials, approximately 50 % of the mineral oil-based lubricants used in Germany and world are released into the environment every year as a result of leaks or accidents that cause environmental pollution caused by chemicals [4, 5].

Worldwide, the grease industry has been the third largest consumer of lithium for several decades [6]. The highly unpredictable availability and cost of lithium are other choke points for grease manufacturing [7, 8].

PAO – Poly Alpha Olefin (Poly Alpha Olefin) products are oligomers of hydrogenated olefin/alpha olefins cluster produced by catalytic polymerization. They have high purity, wax-free, isoparaffinic structures with relatively unbranched side chains [9]. Poly(alpha-olefin) s can be prepared via organometallic polymerization of C10–C18 alpha-olefins, with a non-metallocene catalyst and an activator, the polymer having good melt properties and thermoplastic elastomeric properties due to side-

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chain crystallization. Such properties include high melt strength, strong shear thinning and large stretchability [9, 10].

Polypropylene (PP) is a thermoplastic polymer with a wide range of uses, from parts used in the automotive industry to textile and food packaging. It is also a very important polymer for the grease industry. PP based greases are found to provide lower friction and higher longevity [11, 12].

Hexagonal boron nitride (h-BN) has emerged as a strong candidate for two-dimensional (2D) material owing to its exciting optoelectrical properties combined with mechanical robustness, thermal stability, and chemical inertness [13]. It has also been used in many applications, including corrosion inhibitor and catalysis.

In this study properties of PAO based polymer grease with addition of hBN as high-pressure additive was investigated.

2. MATERIALS AND METHODS

The base oil used in all the experiments was PAO 6 (obtained from Gemaoil, Turkey) and Lithium grease was used as the base oil supplied by Gemaoil from Turkey . Characteristics of base oil and lithium grease are given at Table 1, 2.

High purity nano sized hBN was obtained from BORTEK, Turkey. Pure isotactic polypropylene was obtained from Petkim.

Table 1. Characteristics of the PAO6 base oil.

Kinematic viscosity, mm^2 /s	Values
@40 °C	30.56
@100 °C	5.818
Viscosity index, g/cm^3	136
Density @ 20 °C, kg/cm^3	823.3

Table 2. Characteristics of the Lithium base oil.

NLGI NO	3
Soap Type	Lithium
Color	Light Straw
Dropping point °C	200 °C
Penetration, worked 60 stroke at 25 °C	220–250

2.1. Experimental procedure

Grease was manufactured according to patent pending Method invented by Ay et. al. Each base oil was mixed with 12% PP and 2% hBN. Produced Grease was homogenized and prepared for tribological tests.

Ball on disc test was conducted on AISI 4140 substrate. 0,5mm thick Grease was applied to substrate sample. 5 different load and speed conditions were tested for grease manufactured from POA6. The testing conditions are given at Table 3 and Table 4. Lithium grease without additives was tested at 5 N loading and 30 mm/speed.

Each test was conducted for one cycle.

Table 3. Test conditions for PAO6

TEST No	Speed mm/s	Load (N)	Hertzian Pressure (GPa)
N1	10	5	2.2
N2	30	5	2.2
N3	50	5	2.2
N4	10	2	1.6
N5	10	1	1.2

Table 4. Test conditions for PAO6.

	Poisson	**Elastic Modulus (GPa)**
WC	0.2	600
4140	0.27	190

3. RESULTS AND DISCUSSION

The ball-on-disc test results of grease manufactured from POA base oil is given at Figure 1. It is observed that decrease in speed resulted in higher friction coefficient. This change in friction is a result of high-pressure additive hBN in grease. hBN particles at low speeds and low pressure, act as third body particles. In order to hBN act as a solid lubricant nano layer of hBN has to move over each other. However, at lower loading conditions that increases friction.

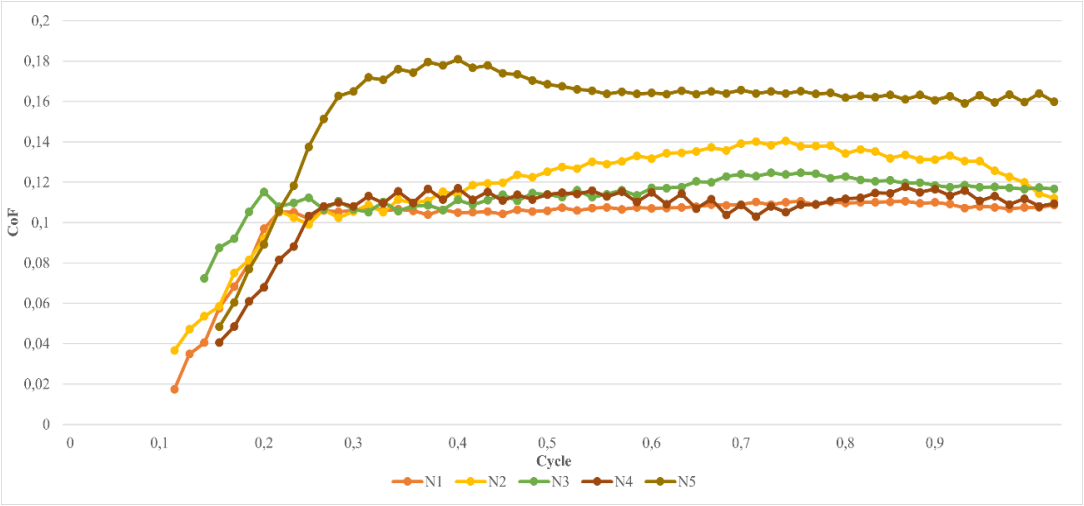

Figure 1. The ball-on-disc test results of grease manufactured from POA base oil.

In order to understand the performance of polymer grease with hBN a comparison with Lithium grease without any additives was conducted. At Figure 2 coefficient of friction versus distance graphs of both grease at the same condition can be seen. Inspecting the graph shows that POA6 grease has better tribological properties. The better tribological properties of polymer grease can be seen at average coefficient of friction graph at Figure 3. although base oils are different this is the result of hBN additive to the grease.

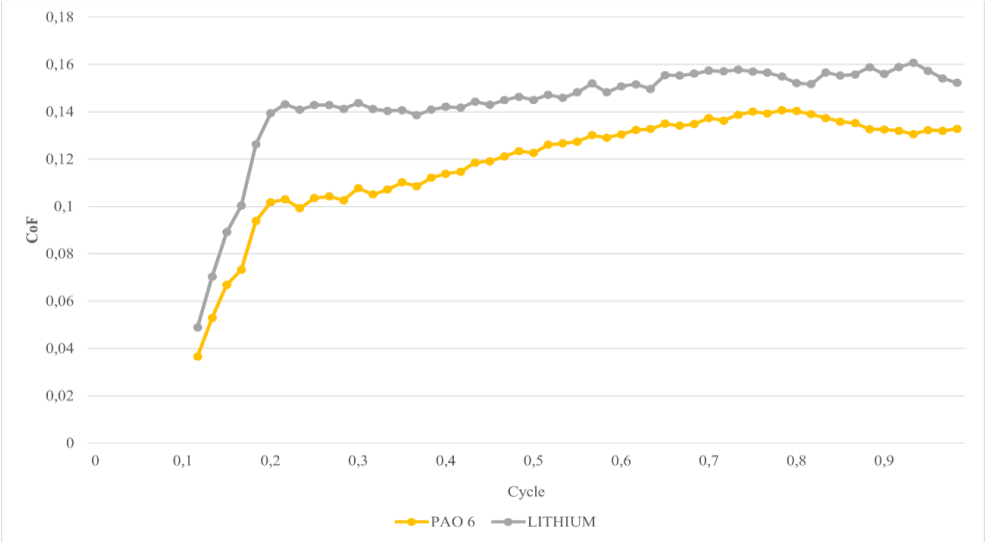

Figure 2. Coefficient of friction versus distance graphs of both grease at the same condition.

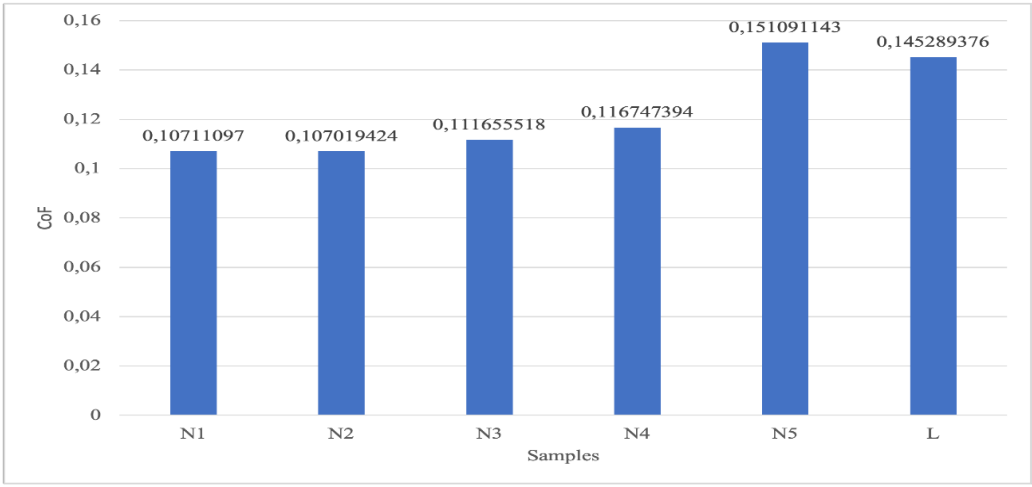

Figure 3. Average friction coefficients comparison (L – Lithium).

4. CONCLUSION

In this study polymer grease using POA6 as base oil with hBN additive was investigated and compared to Lithium grease without any additives. The results show that:

1. Polymeric grease has better tribological properties at high pressure and high-speed conditions.
2. hBN additive in grease result in an increase in friction coefficient at lower speeds and loads.
3. Polymeric grease with hBN additive has better tribological properties than Lithium grease.

This study shows that although more research is needed polymer greases with hBN addition might be a viable alternative to lithium greases.

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