SUNFLOWER BASED GREASE FOR HEAVY DUTY APPLICATIONS

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ABSTRACT

There is a great consumption of grease in an excavator. This large amount of lubricant is poured directly to the environment in specially sensitive areas. A grease based in sunflower oil and polymer thickener has been developed. An extensive tribological characterisation has been carried out in order to ensure a good compromise between EP and AW properties so that the grease could be used in two different applications: in the reduction gear (crown) and in the articulations (bushing/pin). The performance of the grease has been compared with two reference mineral lubricants.

1. INTRODUCTION

Replacing mineral oils with biodegradable and non-toxic products is one of the ways to reduce adverse effects on the ecosystem caused by the use of lubricants. The problem is especially serious in systems working with total loss lubrication in environmentally sensitive areas. An excavator working in quarrels, roads, river neighbourhoods, forestry… use hundreds of kilograms of greases a year and they are poured directly to the environment.

There are mainly two different elements in the excavator with heavy duty lubrication requirements. One is the reduction gear in the crown that allows the spinning movement of the cabin. The articulations (bushing/pin) in the working arm also need grease lubrication, especially the ones closer to the mobile shovel.

The utilisation of vegetable oils for producing biodegradable and non-toxic lubricants is becoming more and more popular in order to reduce the environmental impact of such products. However, there is a great challenge in producing greases for heavy duty applications, as those mentioned.

Fig. 1: Excavator R944 (45 Tn)

2. LUBRICANTS

There are two reference greases based in mineral oil. “Mineral 1” is a grease with soap thickener and EP additives. It is commonly used in both parts (gear and articulations) in small excavators (20 Tn). “Mineral 2” is a grease with solid additivation (graphite) and more extreme pressure properties. It is used in the reduction gear of big excavators whereas Mineral 1 lubricates the articulation, where more anti-wear properties are necessary. Gears are heavily loaded and work at load speeds, which increase the tribological demands for the lubricating products.

After an intensive experimental work a biogrease has been developed based on high oleic sunflower oil, viscosity improver, synthetic ester and polymer thickener. New additive package along with an EP-booster have been used in the final formulation. In this work two different biogreases are presented: “Biogrease LV” is the “laboratory version” of the ecological grease. “Biogrease FV” is the “final version” of the grease: it is manufactured in industrial conditions.

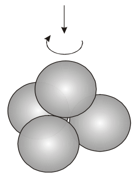


Fig. 2: Four Ball tests

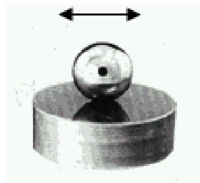


Fig. 3: Reciprocating tests

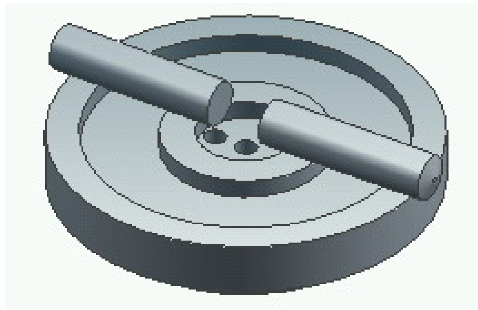


Fig. 4: Rolling/Sliding. Simulation of gears

3. EXPERIMENTAL

In a “Four Ball” tribometer (Fig. 2) two kind of standard tests have been carried out:

◊ ASTM D2266: to measure anti-wear properties.

◊ ASTM D2596: to compare extreme pressure properties.

These tests are preformed with standard 100Cr6 steel balls. With the SRV tribometer reciprocating sliding tests (Fig. 3) have been carried out in standard conditions (ASTM D5707) using 100Cr6 steel balls and discs.

In order to simulate contact geometry in gears we used a testing configuration developed for a Falex MultiSpecimen (Fig. 4). Two rollers rotate over a steel disc with two tracks. There is a line contact geometry and a combination of rolling/sliding (the sliding relative to the disc tracks is 31.3%). Rollers were made of 17CrNiMo6 steel (60-62 HRc and Ra: 0.6 µm), as the material of the pinion. Discs were manufactured with 42CrMo4 steel (50 ± 3 HRc and Ra: 0.4 µm) as the crown material in the excavator. Testing conditions were selected to promote the activation of EP additives: low speeds (146 rpm; 0.2 m/s), high loads (500 lb, 1.53 GPa maximum hertzian pressure), 100ºC of initial temperature and 5 hours of testing time.

4. FOUR BALL TESTS

Results of anti-wear and extreme pressure properties are represented in the Fig. 5. It is clear that the grease “Mineral 2” exhibit excellent tribological characteristics in these tests: the smallest wear scar (425 µm) and the highest welding load (800 Kg).

The Biogrease Final Version presents also good performance in these tests. Wear is slightly higher than with the reference greases, but it remains in good values, even better than the laboratory scale product (Biogrease LV).

5. SRV ANTIWEAR TESTS

In the Fig. 6 we can observe the evolution of the coefficient of friction during the SRV tests. The reference greases are undistinguishable showing low values of friction with a smooth and continuous graphic. The laboratory scale biogrease present some peaks related with microweldings.

The Table 1 collects the results of mean coefficient of friction and wear scars. The Biogrease FV produce slightly higher friction than LV, however it can be considered a better lubricant because there are no peaks I n the friction plot. Values of

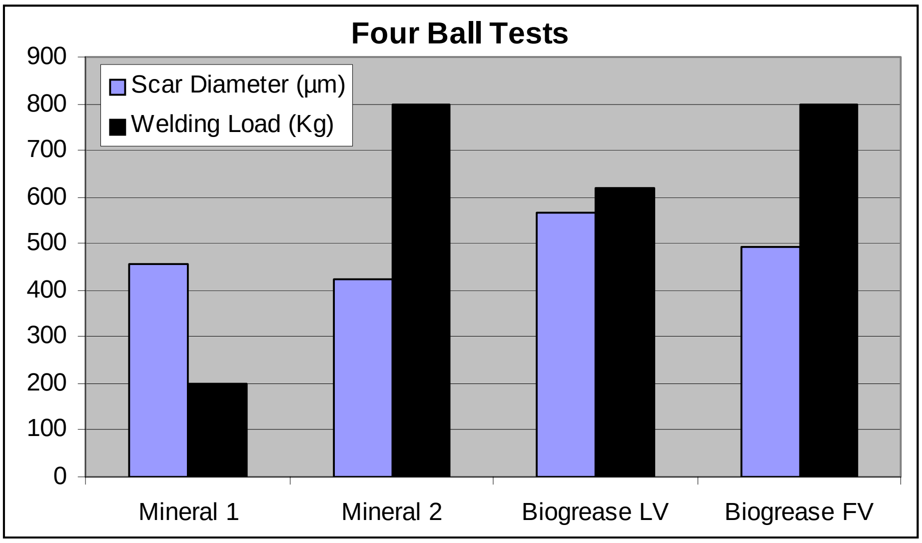


Fig. 5: Four Ball results

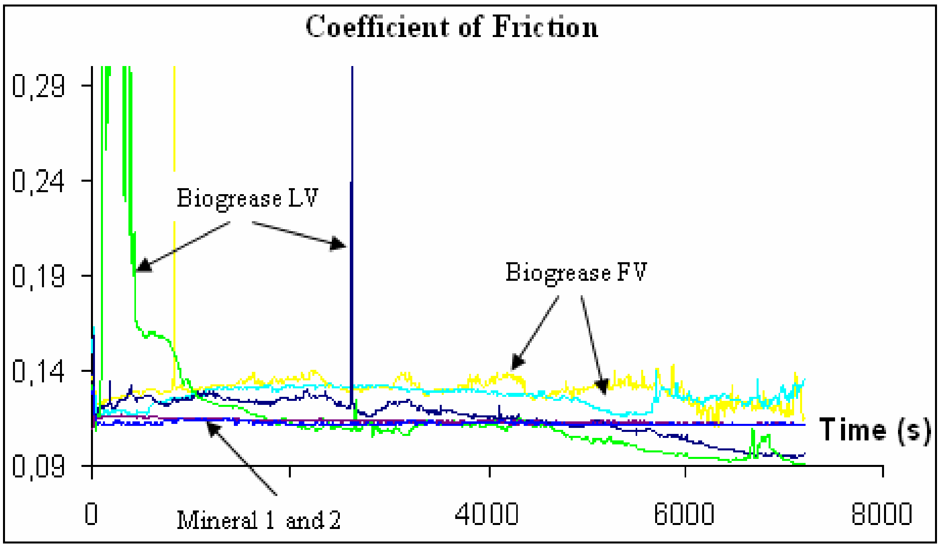


Fig. 6: SRV Friction Plots

friction and wear are higher than with reference greases, but they can be considered as good.

In the Fig. 7 there are some pictures of wear scars. It can be seen that there is more abrasion when the laboratory version of the Biogrease is used instead of the final version. Reference greases show less wear.

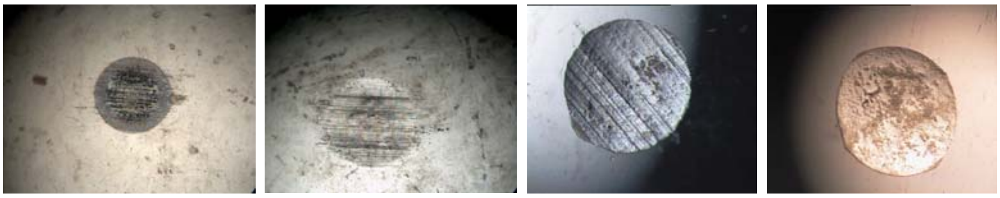
Table 1: SRV results

Greases	ASTM D5707	
	<COF>	Wear Scar Ball (mm)
Mineral 1	0.114	0.432
Mineral 2	0.113	0.528
Biogrease LV	0.119	0.873
Biogrease FV	0.129	0.744

6. FALEX ROLLING/SLIDING: GEAR SIMULATION

Rolling/Sliding tests simulate in a laboratory scale the conditions suffered in gear teeth. In the Fig.8 results of wear in the specimens are represented.

As it was expected the grease “Mineral 1” produces more wear than the grease “Mineral 2” as this grease is more suitable for heavily loaded gears. Biogreases show excellent behaviour preventing wear in this test. It has to be noticed that polishing and slight abrasion is the wear mode with these biogreases, as it can be seen in the pictures of Biogrease FV (Fig. 9). With the reference greases (Mineral 1 & 2) some spalls also appeared.



Mineral 1 | Mineral 2 | Biogrease LV | Biogrease FV

Fig. 7: Pictures of Wear Scars

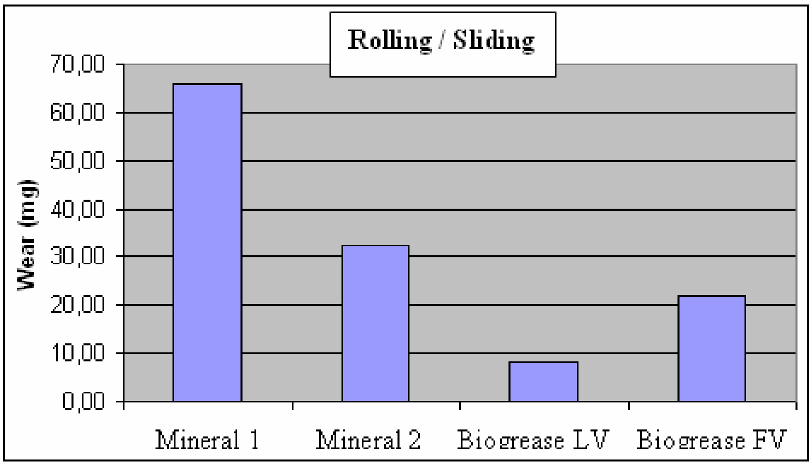


Fig.8: Wear in Rolling/Sliding tests

Mineral 1 | Mineral 2 | Biogrease Ca-P | Biogrease FV

Fig. 9: Pictures of tested specimens

As an illustrative example, in the Fig. 9 another picture is presented. This correspond to a test made with a biogrease including calcium phosphate as solid additives (BioG-Ca-P). This biogrease was discarded because of the spalling wear produced.

7. ENVIRONMETAL PROPERTIES

The Biogrease Final Version has been formulated taking into account the requirements of the Swedish Standard 155470. The Biogrease FV accomplished the environmental requests to be classified as class B. This ecological lubricant obtain a value in ultimate biodegradability of 62% (OECD 301F). The classification according to Daphnia Magna test (OECD 202) is “not harmful” (EL50 > 1000 mg/l).

8. CONCLUSIONS

The tribological performance of the biogrease final version is similar to the biogrease made in a laboratory scale. After an intensive tribological testing campaign a biogrease based in sunflower oil and polymer thickener has been developed. In the laboratory this Biogrease shows a performance close to the reference mineral greases. Rolling/sliding tests simulate properly the final application reflecting practical conditions which helps in adjusting formulation based in those results.

In this paper only a small part of the complete study has been presented. Not only tribological considerations were taken into account. A complete physico-chemical characterisation was also carried out showing that greases with low consistency perform better in tribological experiments. After this laboratory testing campaign the biogrease was validated in full scale bench tests, confirming the results presented in this paper.

ACKNOWLEDGEMENTS

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