

The Influence of Shear Thinning Behavior on Lubricating Grease Consistency and its Effect on Oil Separation

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ABSTRACT

The results of this study show that the shear thinning rate of the clay-thickened synthetic hydrocarbon-based lubricating greases did not show significant variations. The results did correlate with the consistency and structure of the studied greases. Their structure also collapsed at high temperatures and shear rates.

INTRODUCTION

Lubricating grease consistency has for years been evaluated with cone penetration test ASTM-D217 which measures the distance in tenths of a millimeter to which a standard metal cone will penetrate into the grease surface under standard conditions. This single numerical value has proven to be inadequate to estimate the true consistency of lubricating greases under dynamic conditions and it ignores the non-newtonian flow behavior characteristic to greases. In the past years rheology has been introduced as a new means to better understand and evaluate the true behavior of lubricating greases as it takes into account the influence of shear rate, shear stress and time. By measuring the viscosity with both rotational and capillary rheometer it is possible to see the effect of shear rate on grease consistency which strongly influences the lubricating capability of greases under load.

The main focus of this study is on evaluating the possible influence of shear thinning rate on oil separation at different temperatures as at presently used oil separation test of lubricating greases is done only at 177°C at static conditions.

MATERIALS AND METHODS

The viscosity of three commercial lubricating greases widely used in aviation is measured with Anton Paar Physica MCR 301 rotational rheometer at three different temperatures to evaluate their shear thinning behavior.

All of the greases are clay-thickened synthetic hydrocarbons with small amounts of additives, e.g. corrosion inhibitors and antioxidants. The viscosity is measured at 25°C, 100°C and 177°C as this temperature range mostly covers the conditions the greases are used in.

Viscosity and shear stress were measured with plate-plate geometry with a diameter of 25 mm and logarithmically increasing shear rate from 10^{-3} to 100 1/s.

RESULTS AND DISCUSSION

At room temperature there were no significant variations in the shear thinning rate between the grease samples as illustrated in Fig.1, even though grease no. 2 was notably softer than the other two samples at low shear rates.

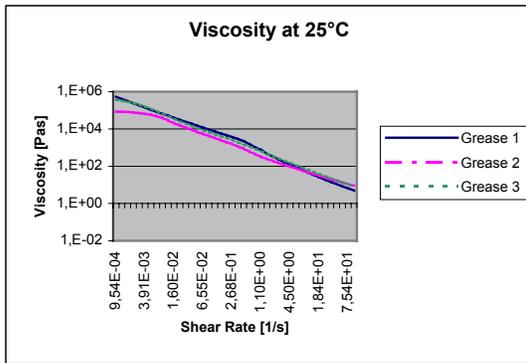


Figure 1. Viscosity of the grease samples at 25°C.

At higher temperatures the greases start to soften due to the lower viscosity of the base oil. It would be tempting to assume that the shear thinning rate will be more rapid than at room temperature. As illustrated in Fig. 2 the temperature seems to have little effect on the shear thinning rate even though viscosities at high shear rates are a bit lower than at room temperature.

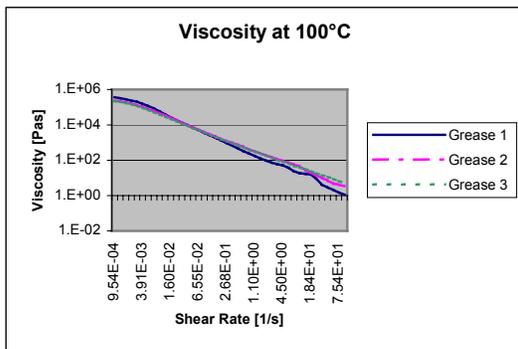


Figure 2. Viscosity of the grease samples at 100°C

At maximum operating temperature the effects of heat and shear were evident at high shear rates. Again there were no prominent variations in shear thinning rates between the samples but a sudden plunge of viscosity is observable in Fig.3 for greases 1 and 3.

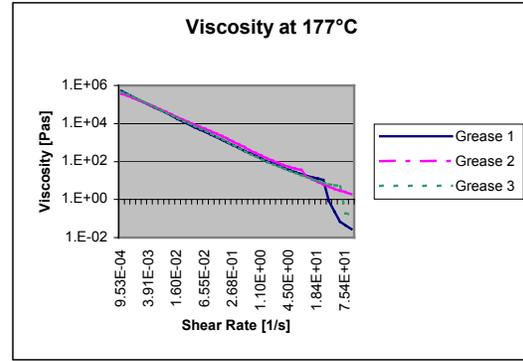


Figure 3. Viscosity of the grease samples at 177°C

The collapse is probably due to the breakdown of the steric structure of the greases and the oxidation of the base oil, as it could clearly be seen that after measurements at 177°C the greases had lost most of the base oil and appeared to be dry and pulpy.

CONCLUSIONS

The attained results correlated with the assumed behaviour of the greases based on their appearance in original storage containers. Grease no. 1 was the thickest of the greases but had lost more of its base oil than the other greases during storage. According to the results of the measurement the shear thinning rate of grease no. 1 was somewhat faster than the others and in addition the structure of grease no.1 collapsed more rapidly than the others. All of the greases lost their consistency at high temperatures at high shear rates even though they are supposed to lubricate properly even at maximum operating temperature.