7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Rheological properties of the boundary layer in lubricating greases

Maciej Paszkowski[1)*] Krystian Urbaniak

[1)]Department of Fundamentals of Machine Design and Mechatronic Systems,
Wroclaw University of Science and Technology, Poland
*Corresponding author: maciej.paszkowski@pwr.edu.pl

The paper presents the influence of the grease thickener and wall material on the thickness of the boundary layer and its rheological properties. Research has shown that soap greases have the greatest ability to form a boundary layer. The thickest boundary layer was formed by lithium greases. Lubricants thickened with overbased calcium sulfonate and bentonite did not form the boundary layer. The research was carried out with the use of rotational rheometer. The modified Yilmazer and Kalyon method was used to determine the thickness of the boundary layer.

Keywords: grease, thickener, adsorbent, rheology, boundary layer

1. Introduction

Wall effects play a major role in grease flow resistances. Through the proper selection of constructional materials one can reduce the resistance, by as much as 35% at lubrication system starting [1]. The wall effects occurring in greases also play a major role during the lubrication of active steel surfaces of friction junctions. Greases capable of forming a thickener-depleted boundary layer are characterized by greater lubricating ability during the elastohydrodynamic lubrication of rolling bearings owing to the fact that they form a durable superficial layer [2]. This particularly applies to greases thickened with fiber-shaped particles and low-to-moderate loaded friction junctions. In the literature on the subject one can also find information of the effect of grease slip itself in the vicinity of the structural components of rolling bearings on the lubrication of the bearings. The aim of the study is to evaluate the influence of the grease thickener and wall material on the rheological properties of the boundary layer and its thickness.

2. Materials and methods

Five types of greases of the same consistency class, thickened with various thickeners (lithium, calcium with 10 wt. % graphite, aluminum, overbased calcium sulfonate and bentonite) were tested. The boundary layer formation in the vicinity of various construction materials (adsorbents) was analyzed. The research was carried out with the use of a rotational rheometer. The modified Yilmazer and Kalyon [3] method was used to determine the thickness δ of the boundary layer. The plateau modulus G_N^0 was determined to evaluate the degree of cross-linking of the soap thickener in the boundary layer.

3. Results

Research has shown that the type of thickener and wall material have a huge impact on the thickness and rheological properties of the boundary layer. The thickest wall layer was formed by greases thickened with metal soaps. Sulphonate and bentonite greases did not form the boundary layer. Cross-linking of the thickener particles decreased with increasing thickness of the boundary layer. Table 1 shows the results of the boundary layer thickness and plateau modulus.

4. References

[1] Paszkowski, M., *"Grease flows in lubrication systems and friction junctions. Selected problems*", Wrocław University of Science and Technology Publishing Houser, Wrocław Poland, 2017, ISBN 978-83-7493-002-4.

[2] Couronne, I., Vergne, P., Mazuyer, D., Truong-Dinh, N., Girodin, D., „*Effects of grease composition and structure on film thickness in rolling contact"*, Tribology Transactions, 46 (1), 2003, 31-36.

[3] Yilmazer, U., Kalyon, D. M., *Slip effects in capillary and parallel disk torsional flows of highly filled suspensions*, Journal of Rheology, 33 (8), 1989, 1197-1212.

Table 1. Thickness and cross-linking of the boundary layer in lubricating greases

Adsorbents	Lubricating greases									
	Lithium complex		Calcium complex with 10% graphite		Aluminum complex		Calcium sulfonate		Bentonite	
	δ [μm]	G_N^0 [Pa]	δ [μm]	G_N^0 [Pa]	δ [μm]	G_N^0 [Pa]	δ [μm]	G_N^0 [Pa]	δ [μm]	G_N^0 [Pa]
Steel 316L	30,2	17 787	26,0	16 006	20,5	8 442	no slip	non-fibrous thickener	no slip	non-fibrous thickener
Aluminum 2014A	15,5	18 003	17,9	16 426	18,0	8 838	no slip	non-fibrous thickener	no slip	non-fibrous thickener
Polyamide 6 (PA6)	17,8	95 680	2,5	91 242	12,1	9 784	no slip	non-fibrous thickener	no slip	non-fibrous thickener
Polyoxymethylene (POM)	5,2	89 201	2,6	95 094	9,9	10 340	no slip	non-fibrous thickener	no slip	non-fibrous thickener