POSSIBLE MECHANISMS FOR ROLLING BEARINGS GREASES LUBRICATING FILMS GENERATION AND DETERIORATION

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Abstract: *Basically, rolling bearings greases are consisting of two main components: a lubricating liquid, generally oil, and a thickening agent. The most used lubricants of this type in rolling contacts lubrication are mineral oil and Lithium soaps based, their properties being improved by adding the appropriate additives for specific technical applications. Here it can be highlighted their particular constitutive aspect given by the soap three-dimensional network (consisting of twisted or flatted fibres) that contains the base oil. Both fibres elementary dimensions and the soap structural uniformity are different from a manufacturer to other being influenced by the processing technology, by the raw materials provenience or by the thickener quantity or the presence of additives.*

Lubricating greases behaviour is dependant on their initial structure and also by their rheology under the external loads influence, all this aspects having a strong influence on greases service life.

The paper presents a possible mechanism for greases lubricating film generation and failure, a hierarchy for their deterioration criteria being also proposed.

Key words: *lubricating greases, deterioration, structure, service life*

1. INTRODUCTION. GREASES LUBRICATING FILMS GENERATION

Greases wide use in rolling bearings lubrication determined researches on the complex factors assembly that have influences on contacts lubrication films and, especially, on their service life. In order to elucidate the lubricating modalities and to establish the greased rolling bearings service life he following steps must be realised: lubricating films generation, their thickness, films influence factors and its deterioration. For each influence factor optimal intervals must be established and rolling bearings greases service life must be determined.

Concerning the lubricating grease film generation it can be affirmed that the up to date information is disperse and, sometimes, contradictory. With time two researching tendencies could be highlighted. Some of them are considering the lubricant as being an unique entity that by various mechanisms is separating the contact surfaces [1, 2, 3, 4] ensuring a fully flooded lubrication. Other points of view are considering that lubricatings film generation is always controlled by the poor lubricant flow, the quantity being dependant on its composition and rheology, this situation corresponding to a starved/semi-starved lubrication regime.

First of these models is neglecting that a part of the fibrous structure is destroyed due to contacts heavy loads and some of these fibres are deposited on bearings raceways whose surfaces are separated by this small soap quantity. For films thickness calculus only the grease that passes the contact is considered, the solid soap deposited film being neglected for this first point of view. The experimental results show also that at contacts entrance initially there is no sufficient lubricant able to ensure a fully flooded lubrication [5]. This is one of the reasons for which the starved/semi-starved lubrication theory is more and more accepted, experimental results being in correlation with this hypothesis. Also this second model was developed in two directions. The first one considers that, initially, the whole lubricant volume is directed on raceways sideways from where the rolling contacts are continuous fed with lubricant. The second one considers that the lubricant is deposited on raceways sideways and that the contact is separated from the rest of the bearings elements, the lubricant expelling from the raceways being stopped by this grease barrier. Until this stage it can be affirmed that all these models are simple and they have no consistent experimental support, greases behaviour being very complex and governed by mechanisms that are dependant on lubricants components, their rheology and apparent viscosity, the rolling bearings internal geometry and functioning conditions having important influences in time [6, 7].

When considering greases in rolling bearings heavy loaded contacts lubrication EHD conditions are obtained the pressure distribution being similar with that for oil lubrication regimes. In opposite to oils, the grease film thickness is not constant in time being about 50% of base oil lubricating films thickness when fresh grease is taken into account and it becomes about (0.5-0.7) of base oil thickness after a period of stabilization. A global analyse of films generation [6, 7, 8] considers that the lubricating film depends on both greases rheology and on soaps structure properties, the proposed model that takes into account structures damaging and oil-soap separation being presented in figure 1.

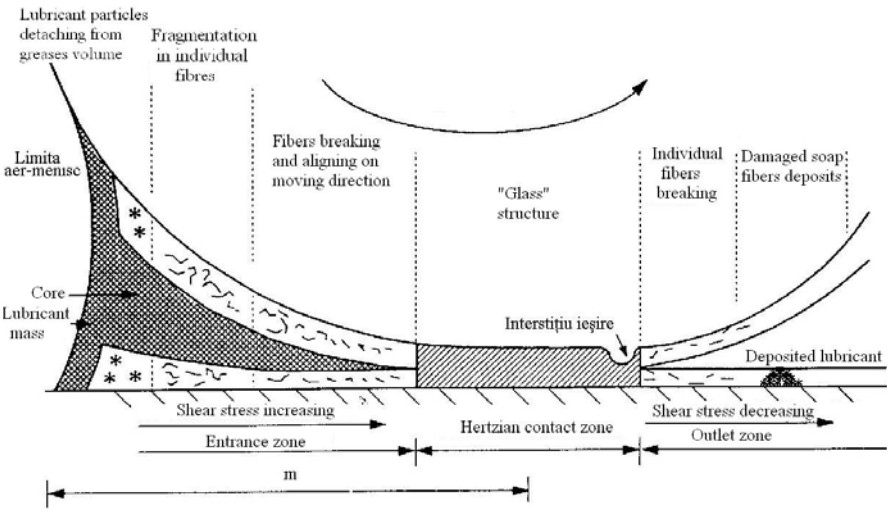

Fig. 1 *Grease film generation*

Based on experimental data it was established that greases starvation begins from 0,1 m/s sliding velocities, up to this value having a semi-starved or fully flooded lubrication (figure 2).

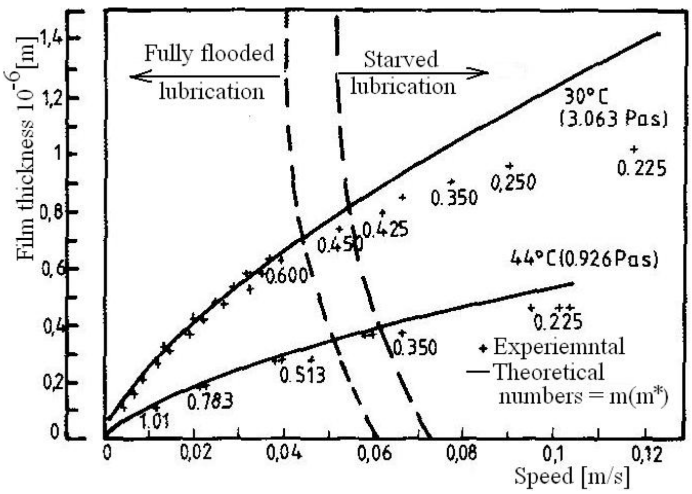

Fig. 2 *Lubricating regimes limits*

In heavy loaded and high speed conditions or with time, lubricants deterioration is increasing, its apparent viscosity becomes higher and less possibilities for contacts lubricant feeding occurs, the starvation phenomenon being more present.

2. DETERIORATION CRITERIA

For lubricating greases service life estimation damaging the criteria must be established. Due to the necessity of endurance investigations and to the complexity of the experimental rigs the researches in this filed were disperse and they were focused on lubricants physical/chemical characteristics evolution with time or on the influence of some bearings functioning parameters on their behaviour.

Among greases deterioration degree criteria the following are generally accepted:

- *the chemical criteria* (the antioxidant quantity, total or organic acidity, the molecular specific mass);
- *the physical criteria* (oil-soap separation, debris particles quantity);
- *the structural criterion* (soaps structure/composition evolution in time).

A synthesis of the rolling bearings greases possible deterioration modalities vs. different influence factors is presented in figure 3.

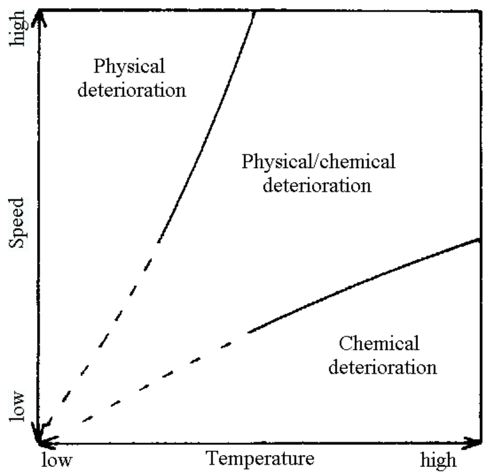

Fig. 3. *Deterioration criteria*

3. STRUCTURAL CRITERION ANALYSIS

The own researches established that the essential Lithium based greases deterioration factors are the structural architecture damaging and the oil-soap separation.

Fresh, intermediary and damaged (when films breakdown occurred) grease samples were collected. After specific preparation structure SEM photographs were done, the greases structure evolution being presented in figures 4-6. It can be observed that the fresh sample (figure 4) has a three-dimensional soap mesh with flat or twisted fibres and in its holes micro-oil drops are present. The middle test sample grease has the fibres oriented to the movement direction and small soap conglomerates begin to appear, some of meshes holes are destroyed and the oil-soap separation phenomenon is in its first stage of evolution (figure 5). When complete damaging occurred the lubricant is not able to ensure the contacts lubrication because of the oil-soap separation, the soap mesh being totally damaged and the oil expelled from bearings raceways (figure 6).

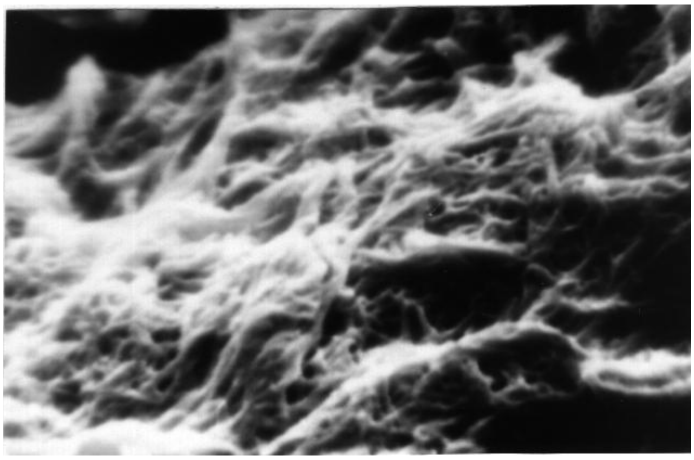

Fig. 4. *Fresh grease probe*

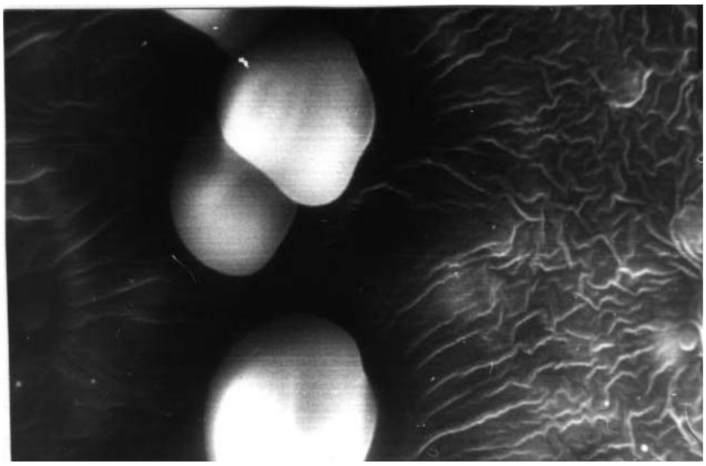

Fig. 5. *Middle test grease probe*

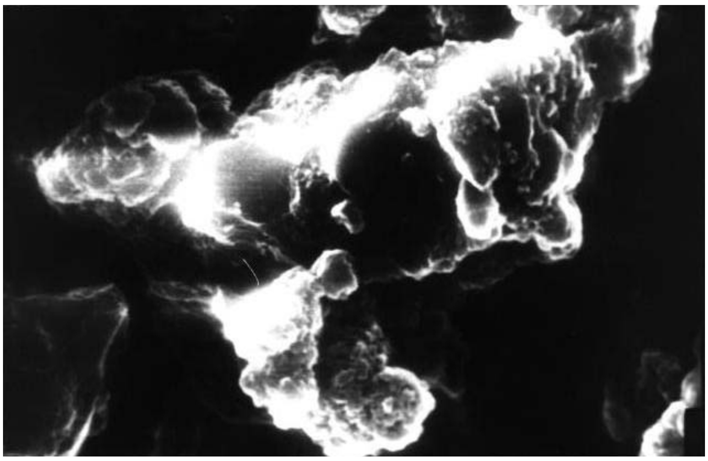

Fig. 6. *Damaged grease probe*

4. CONCLUSIONS

a. The rolling contacts greases lubricating film generation is a complex phenomenon and it depends on lubricants composition and structure but also on bearings functioning conditions.

b. Rolling bearings grease lubrication is a starved/semi-starved one beginning with 0.1 m/s sliding velocities.

c. The main rolling bearings greases deterioration reason is the soap mesh damaging and the oil-soap separation phenomenon.

5. REFERENCES

1. Jonkisz, W., Krzeminski-Freda, H., Pressure Distribution and Shape of EHD Grease Films, Proc. of. 5th Leeds-Lyon Symposium on Tribology, 1978, 88-91.
2. Jonkisz, W., Krzeminski-Freda, H., The Properties of EHD Grease Films, Wear, vol. 77, 1982, 277-285.
3. Kauglarich, J.J., Greenwood, J.A., Elastohydrodynamic Lubrication With Herschel-Bulkley Greases Model, ASLE Trans., 15, 1972, 269-277.
4. Cheng, J., Elastohydrodynamic Greases Lubrication Theory. An Numerical Solution in Line Contact, STLE Trib. Trans., 37, 1994, 711-718.
5. Cann, P.M.E., Understanding Grease Lubrication, Proc of the Leeds-Lyon Symposium, 1996 184-190.
6. Cann, P.M.E., Lubrecht, A.A., An Analysis of the Mechanism of Greases Lubrication in Rolling Element Bearings, Proc. Of 11th Int. Coll. Of Tribology, Esslingen, 1998, 561-569.
7. Cann, P.M.E., Grease Lubricant Film Distribution in Rolling Contacts, NLGI Spokesman, Vol. 61, 2, May, 1997, 22-29.
8. Williamson, B.P., An Optical Study of Grease Rheology in an EHD Point Contact Under Fully Flooded and Starvation Conditions, Proc. of Inst. Of Mech. Engrs., Vol. 209, 1995, 63-74.