BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi“ din Iaşi,
Tomul LVI (LX), Fasc. 4A, 2010
Secţia
CONSTRUCŢII DE MAŞINI

SLEWING BEARING LUBRICATION & MAINTENANCE

BY

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Abstract: Is presented a mathematical model developed by SIRCA SA and RIMA Spa for the slewing rings lubrication and the re-lubrication charts.

Key words: slewing rings, lubrication, maintenance, kinematic viscosity, chart lubrication

1. Introduction

Slewing ring bearings are used in applications for transferring/ supporting axial, radial, and moment loads, singularly or in combination, consisting of rings mounted with threaded fasteners, and usually having a gear integral with one of the rings. Typically, slewing ring bearings are used in excavators, crane, wind power turbine and other oscillating service.

The lubricants normally recommended by slewing ring manufacturers are greases or oil bath lubrication for slowly rotating continuous operating enclosed bearings, where adequate sealing of the bearing enclosure exists. Grease can be defined as the lubricant of solid or semi-solid state that contains the thickener, and some greases contain various special ingredients. Base oil in the grease is the main ingredient which actually provides lubricating function, and it forms 80-90% of grease. Generally, the mineral oils with higher viscosity are used for the locations requiring the lubrications of high load, low speed, and high temperature. Slewing Rings are a particular case of a SSRB structure and the quasi-static and the quasi-dynamic parameters are computed according to

[15,16,17,18,19]. To appreciate the lubrication regime C1 parameter developed by Marckho [1] is used. As a alternative the Houpert [4] criteria can be used. At low rotational speeds grease lubricants may not provide elasto - hydrodynamic lubrication, and the regime lubrication is affected by the surface asperities. In these conditions a correct lubrication oil / grease have to be chosen.

Usually in the large slewing rings bearings the surface roughness tend to be uniformed to 1-1.5 μm. The slewing ring life reduction factor is function of film parameter λ, Fig 1 [1].

To substitute the roughness effect an adequate ISO VG oil base for grease have to be chosen. The kinematics viscosity values according to ISO VG are presented in Fig.2 [14].

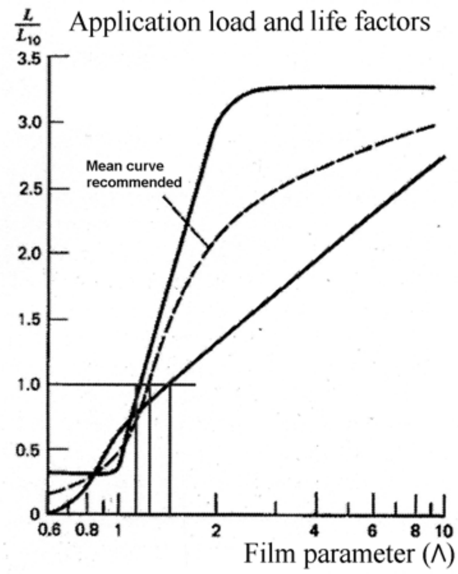

Fig. 1 - Life reduction factor as function of film parameter λ [1]

ISO Viscosity Classification:

Viscosity class ISO	Viscosity at 40 °C mm^2/s	Limits of kinematic viscosity at 40 °C mm^2/s min.	max.
ISO VG 2	2.2	1.98	2.42
ISO VG 3	3.2	2.88	3.52
ISO VG 5	4.6	4.14	5.06
ISO VG 7	6.8	6.12	7.48
ISO VG 10	10	9.00	11.0
ISO VG 15	15	13.5	16.5
ISO VG 22	22	19.8	24.2
ISO VG 32	32	28.8	35.2
ISO VG 46	46	41.4	50.6
ISO VG 68	68	61.2	74.8
ISO VG 100	100	90.0	110
ISO VG 150	150	135	165
ISO VG 220	220	198	242
ISO VG 320	320	288	352
ISO VG 460	460	414	506
ISO VG 680	680	612	748
ISO VG 1000	1000	900	1100
ISO VG 1500	1500	1350	1650

Fig. 2. - Viscosities classifications [14]

A correct lubrication can increase the slewing ring life and that is function of load, temperature, pitch diameter, rotational speed and ball diameter. The film parameter λ is given according to Zhou (2) formulae and it is function about the roughness and the minimum film thickness.

The minimum film thickness is computed according to Hamrock and Dowson (3*)* relations for isothermal steady state full flooded conditions and elliptical point contact geometry.

Literature presents some charts to choose the kinematic viscosity [1] at 40°C and the relubrication intervals [13,14], according to figure 3 and fig 4. The life span of grease is a period from the start of bearing operation to bearing failure due to its insufficient lubricating action. The lubrication intervals are determined by the values of kf.n.dm, which can be obtained from the speed formula related to bearings, and the different values of kf have been assigned to various kinds of bearings. For 4PCBB [15] and 6PCBB[16] kf=1.6. If it is just recharged again with grease, then only a part of whole grease gets to be replaced, therefore, the recharging intervals should be shorter than the lubrication intervals (Generally, between 0.5tf and 0.7tf).

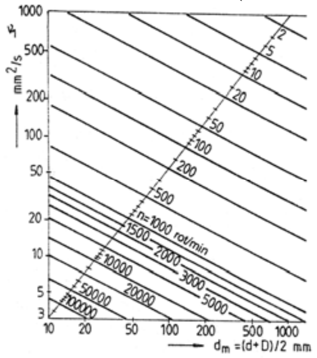

Fig. 3 - Reference kinematic vs bearing dm and speed [1]

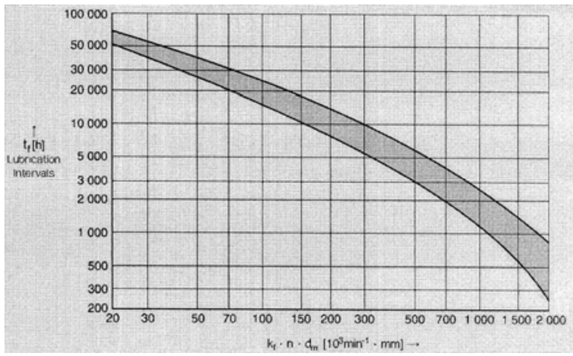

Fig. 4 - The lubrication intervals recommendations [13, 14]

2. The lubrication chart

The chart lubrication presented in [1], fig 2a can be a approximate as $\nu := -\ln(dm)\cdot\left(646.89\cdot rpm^{-0.836}\right) + 6013.9\cdot rpm^{-0.835}$. The interpolation formula is useful for a fast interpolation chart and also to be included in a computer code. The graphical representation of the preview function is shown in figure 5.

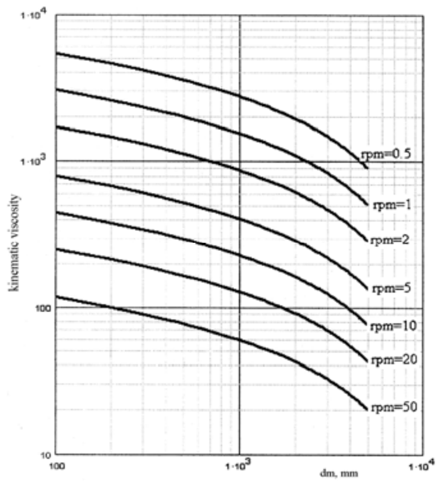

Fig. 5 - Approximation of the kinematic viscosity function of dm and rpm

For the usually rotational speed, Sirca [18] and Rima [19] recommends to use the chart form figure 6, according with the temperature working range, ISO VG class at 40°C, fig. 1b and the interpolation formula presented in fig. 5.

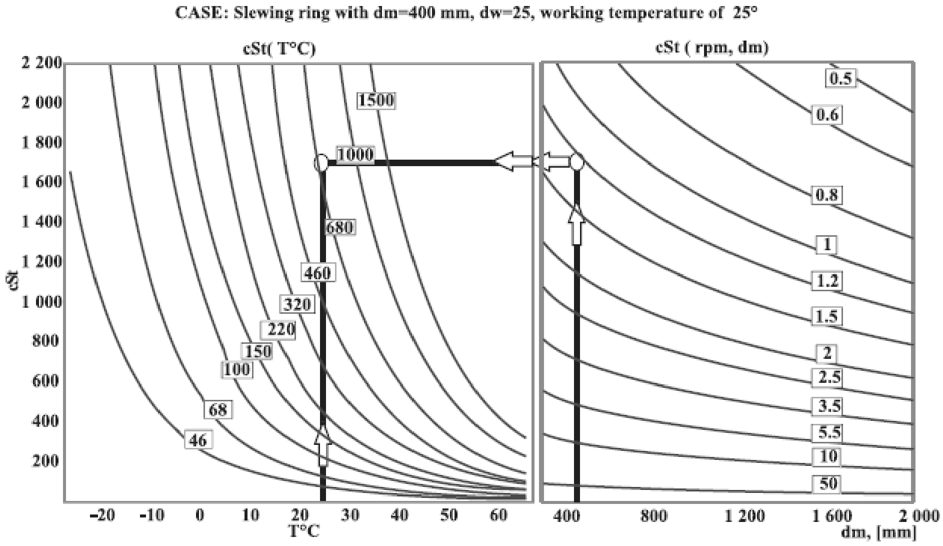

Fig. 6 - The lubrication chart

There are many cases when the rotational speeds are very low as for example in the large cranes. Till now does not exist a public chart from where the users can choose a lubricant for slow rpm, less than 2 rpm. To satisfy the film parameter criteria results that a small conformity can help a bearing lubrication process, according to figure 7. The ball diameter augmentations can occur to a small kinematic viscosity, Fig. 8.

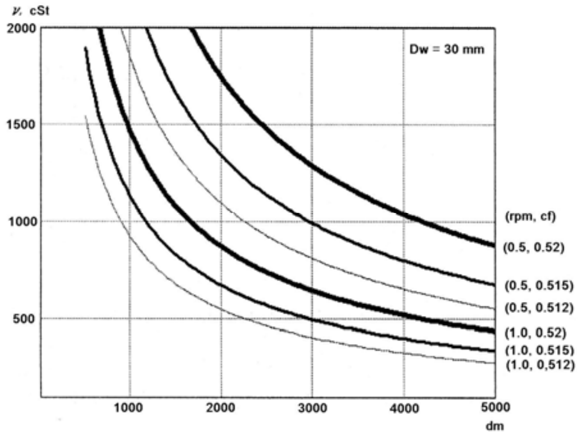

Fig. 7 - The effect of the conformities in the grease/oil analysis very low speed

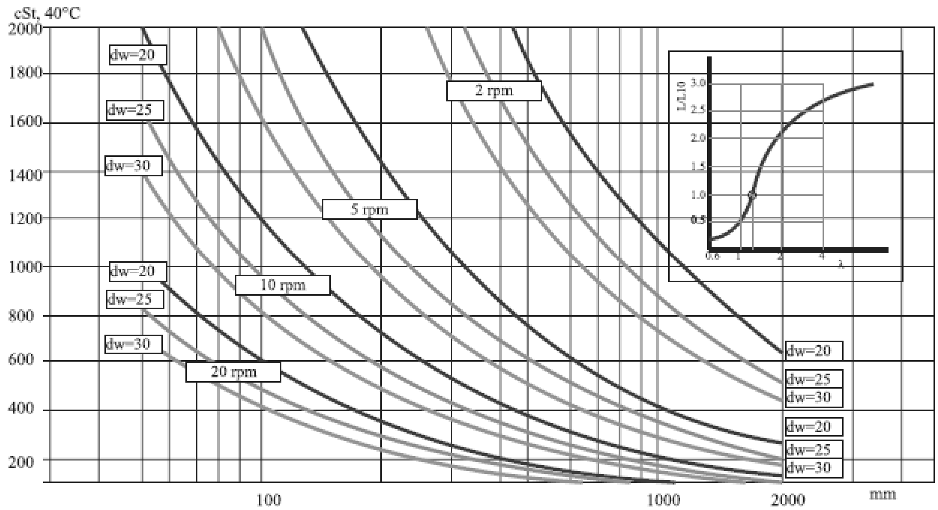

Fig. 8 - The effect of the ball diameter in the grease/oil analysis very low speed

The analytical data’s shows that for large slewing rings by increasing the ball diameter and decreasing the conformities an lubricant with a lower kinematic viscosities can be chosen between the existing usually ISO VG class

Sirca and Rima indicate grease re-lubrication periods between 50 and 100 hours of operation for these bearings when used in outdoor environments. For typical applications such as construction machinery, where low speed, intermittent rotation is involved, suggested frequency of lubrication is every 50 operating hours on excavators and every 100 operating hours on cranes [5,6].

Operating hours refers to total time that the machine is in use, not to bearing rotation. For other applications, an interval of every 100 operating hours is suggested as a starting point. If, during relubrication, it is seen that the exiting grease is in good condition and free of contaminants, the interval may be extended.

Some numerical relations are presented in literature, as for example [1,7]. Sirca and Rima takes into account the relubricating time as function of the working conditions and indicate a simply way to establish the re-lubrication chart, according to Fig. 9 and Fig. 10.

For applications where the bearing is loaded near its capacity, SIRCA and RIMA recommend the use of an EP2 grade if the working temperature is >0°C. EP2 with MoS_2 additives may also be used. For temperatures under 0°C , Grade 0 is recommended. For lightly loaded bearings (under the red line form figure 11 for example) the EP grade is not necessary. That corresponds to loads lower like 33% form the maximum limit load chart.

The lubricants recommended by SIRCA have high viscosities in order to establish the appropriate oil film separation of the rolling elements and the gear tooth surfaces for elastohydrodynamic lubrication. Some examples of greases, according to the literature are given in the Table 1.

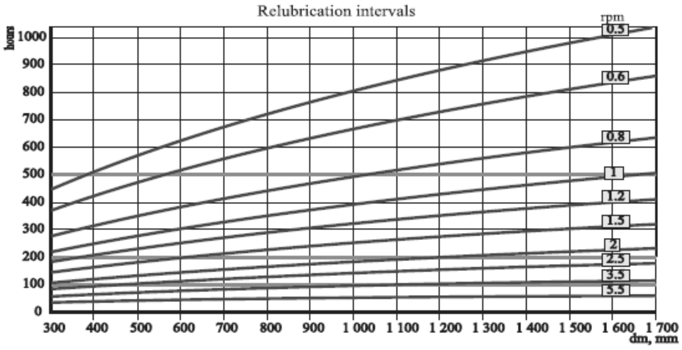

Fig. 9- Sirca re-lubricating interval chart for p=2700MPa

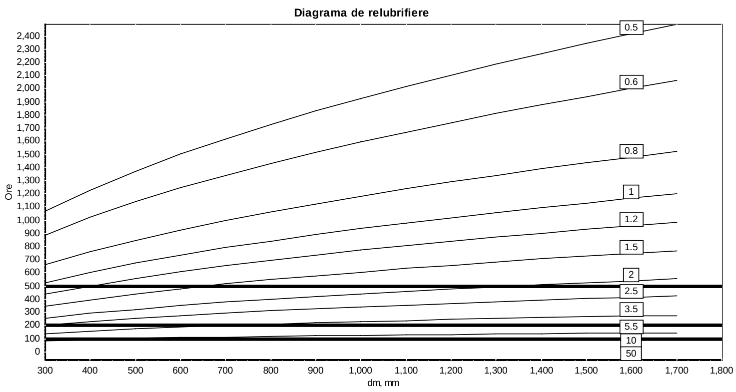

Fig. 10 - Sirca re-lubricating interval chart for p=1540MPa

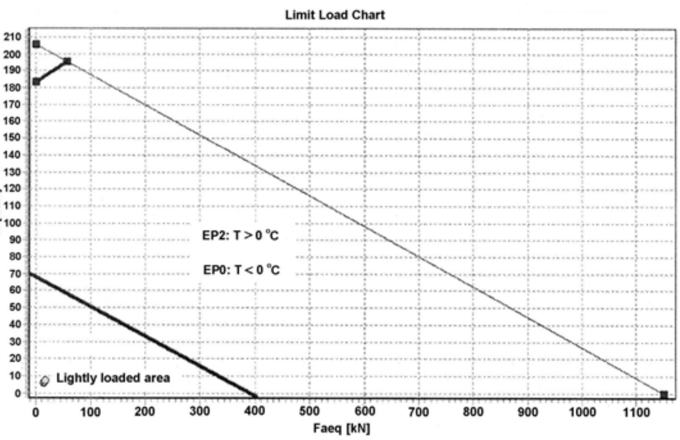

Fig. 11 - Example of the EP0 and EP2 grades to be chosen according to the limit load chart

Table 1 - Some examples of greases, according to the literature

ISO VG	SHELL	Castrol	Mobil	Total	FAG
1500		MOLUB-ALLOY 936 SF HEAVY	SHC 1500	MULTIS XHV2	
1000	OMALA 1000	TRIBOL 3020/1000*	SHC 1000 Special		Load 1000
680	OMALA 680; Alvania Grease CG	MOLUB-ALLOY 3036/680-1*	XHP 681 Mine	CERAN GEP	
480	OMALA 460	CASTROL TRIBOL 4020	XHP 461, 462 SHC 460, 460 WT	CERAN HV CERAN HVA	Temp 120
320	OMALA 320		XHP 320, 321, 322 Mine	MULTIS COMPLEX HV 2	Load 400
220	OMALA 220		XHP 005	MULTIS COMPLEX SHD 220	Load 220
150	OMALA 150	CASTROL LONGTIME Pd2	XHP 100 Mine Mobilux EP 0, 1, 2, 3	CERAN WR 1 ; CERAN MM; CERAN FG	VIB 3 TEMP 110

The area of course many other lubricants and some of these are presented after a internet searching. More detail can be found using [12] internet link.

Received May 03th 2010

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RULMENTI DE DIMENSIUNI MARI – LUBRIFICATIE SI INTRETINERE

Lucrarea prezinta o metoda de trasare a curberlor de lubrificatie si relubrifiere a rulmentilor de mari dimensiuni tinand cont de dimensiunile de gabarit, geometria interna a rulmentului si de conditiile de lucru - sarcina, temperatura si viteza de rotatie. Hartile de lubrificaie prezentate au fost dezvoltate de Sirca SA si Rima Spa si prezinta o dezvoltare a hartilor de lubrifiere clasice prezentate in literatura de specialitate.