INFLUENCE OF THE GREASE TYPE ON THE FRICTION AND EFFICIENCY OF THE BALL SCREWS. EXPERIMENTAL DETERMINATIONS

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Abstract: *This work is presenting the experimental results concerning the influence of the thick grease types on the kinematical friction coefficient and efficiency of the ball screws. Ranges of variation are established for these rates, related to this type of motion screws.*

Key words: ball screw, friction, grease, efficiency.

1. INTRODUCTION

The ball screws are most frequently lubricated with liquid lubricants (mineral / synthetic oils). The running conditions, in principal, may require plastic lubricants (thick greases). The grease lubrication can provide a better protection against external agents or avoidance of its leakage from the ball-rolling way contacts.

The lubricant is selected in function of the running conditions and its characteristics. Several factors are considered, such as: load, rpm, running temperature [1]. In this experimental program the following are considered: thick greases of general purpose, STAS 562-80 (Romanian Standard) (U80 Ca 0, U85 Ca 3, U100 Ca 4) used for lubricating the bearings at maximum temperatures of 40 - 60ºC; bearing greases, STAS 1608-84 (RUL 100 Ca 3, RUL 145 Na 3, RUL 165 Na 4), used for lubricating the bearings under normal running conditions; lithium-calcium greases, STAS 8789-83 (UM 65 Li Ca 1, UM 170 Li Ca 2, UM 175 Li Ca 5) used for lubricating the bearings, sliding bearings etc.

2. EXPERIMENTAL STAND

The experimental stands are presented by the literature of specialty into a variety of constructive types that differ from each other especially through the loading manner of the helical coupling.

The loading systems are hydrostatic. They require simultaneously the transmission bearings as well, by applying the load either axially or eccentrically.

The links between the constructive elements of the loading system and the coupling are generating parasite frictions. Because of these and of the frictions into bearings, measuring errors may come up [1][2].

Important on this stand is that the load applied to the helical coupling does not require the bearings. This means that there is no link with freedom degrees to generate parasite frictions between the coupling and the measuring captor.

The stand is coupled to a data measuring system and to rotation speed, directly connected to the data recording system.

The kinematic diagram of the tribometer for motion screws is shown in Fig. 2.

Symbols: Electric motor for driving (1); "V" belt transmission (2); Ball screw for testing (3); bearings (4); loading and measuring device (5); linear scales (6); limit sensors (7).

The electric motor (1) drives the helical transmission consisting of the ball screw (3). This is provided with two nuts located into the loading and measuring device (5). This device has two threaded lids that are pressing the nuts each against other in a controlled manner, loading the helical coupling. The device (5) is provided with two guiding rollers that slide along the scales (6) and do not allow its rotation while moving. On the roller rod of the device (5) the resistive electric encoders are mounted, for measuring the loading thrust and the rotating torque of the box, produced by the frictions in the helical coupling.

Fig. 1. Stand for experimental determinations

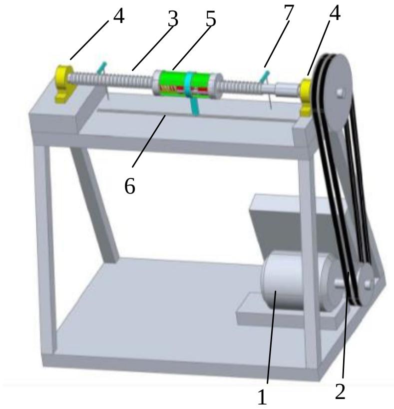

Fig. 2. Kinematic diagram of the Tribometer

The tribometer is driven through an electric circuit. The electric motor for driving is supplied, through a rectifier bridge, in D.C., with a variable voltage. The limit sensors (7) assure the stop and change of the motion direction. They are connected in series with the timing relays. The control of the rotation direction is controlled through two electric contactors.

The circuit is also provided with safety elements for electrical/mechanical overloads. The voltage into the electric board is signaled through pilot lamps.

Into the contacts the reactions R_1 and R_2 occur, through pressing the two nuts each against other, at the thrust F. They are tilted at the friction angle related to the normal line n-n to the helical surface, reversely to the direction of relative motion. The components of the reactions are oriented axially and tangentially.

From the equation of static balance of the loading-measuring device on the axial direction, equality will result between the axial components of the reactions R_1 and R_2. Their direction is contrary and their module is equal to the loading thrust.

The tangential components are producing torsion torques of contrary senses, related to the ball screw axis. Through composing, they are tending to rotate the loading-measuring device. The value of the resulting torque (as algebraic sum of the torques on the two nuts) is recorded through the tensometer encoders mounted on the roller rod of the device (5).

3. PARAMETERS OF THE EXPERIMENTAL TESTING

For the experimental determinations a ball screw of round profile as per the international norm ISO3408-75 has been used, of average diameter d_m = 32 mm, pitch p = 10 mm and thread length l = 500 mm. This ball screw was manufactured by S.C. “TITAN Componente de Precizie” S.A. Bucharest [4].

All elements into contact are made of bearing steel.

The minimum thrust rate is 200 N.

The ball screw rpm complied with usual practice values, n_s = 20 – 80 rpm respectively.

For lubrication the following types of grease have been used [3]:

1. Thick grease of general purpose, STAS 562-80: U100 Ca 4 (calcium soap, dropping point: 100°C, thickness degree: 4)

2. Bearing grease, STAS 1608-84: RUL 145 Na 3 (sodium soap, dropping point: 145°C, thickness degree: 3)

4. EXPERIMENTAL RESULTS

Table 1 shows the results of the experimental trials for the ball screw and grease types presented above. The thrust varied within 200 and 8000 N and the rpm rates being used were 40 and 80.

Table 1 - The results of the experimental trials

Grease	n [rpm]		40			80		
	No.	F [N]	Mt [Nm]	μ_{ak}	η	Mt [Nm]	μ_{ak}	η
U100 Ca 4 STAS 562-80	1	200	0.078	0.0117	0.893	0.097	0.0156	0.869
	2	500	0.151	0.0092	0.936	0.116	0.0081	0.933
	3	1000	0.149	0.0043	0.962	0.115	0.0057	0.955
	4	2000	0.152	0.0037	0.977	0.194	0.0038	0.971
	5	4000	0.301	0.0035	0.978	0.391	0.0037	0.970
	6	8000	0.580	0.0027	0.979	0.551	0.0029	0.971
RUL 145 Na 3 STAS 1608-84	1	200	0.097	0.0150	0.870	0.116	0.0180	0.922
	2	500	0.116	0.0072	0.933	0.155	0.0016	0.966
	3	1000	0.117	0.0036	0.966	0.156	0.0036	0.955
	4	2000	0.155	0.0024	0.977	0.156	0.0025	0.980
	5	4000	0.269	0.0021	0.977	0.309	0.0026	0.977
	6	8000	0.606	0.0024	0.968	0.695	0.0028	0.974

In Fig. 3, 4 and 5 these experimental results are presented graphically.

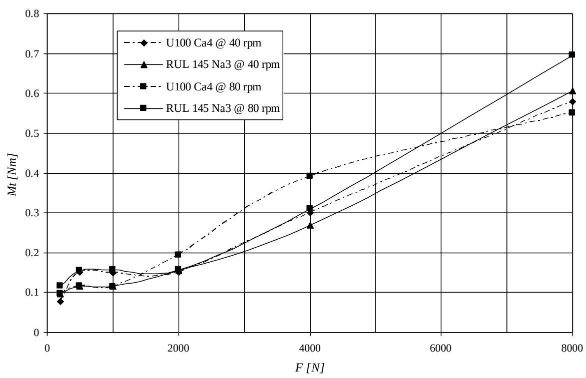

Fig. 3. Variation of the torsion moment

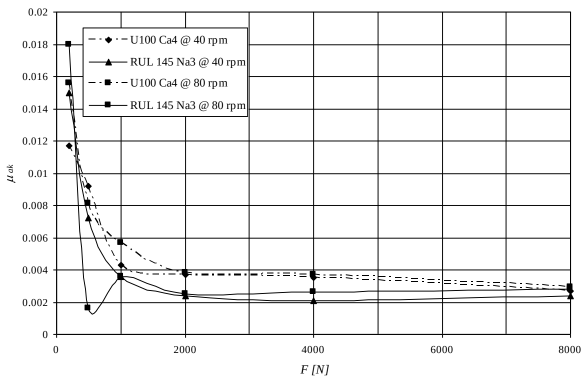

Fig. 4. Variation of the kinematical friction coefficient

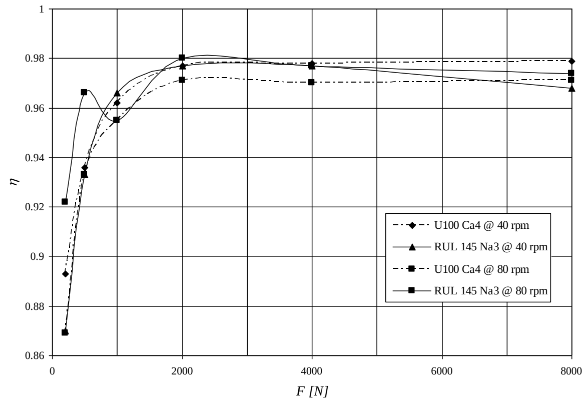

Fig. 5. Variation of the efficiency

4. CONCLUSIONS

After analyzing the numerical results (tab. 1) and graphical evolutions (Fig. 3, 4 and 5) the following conclusions may be drawn:

1) The ball screw rpm has a low influence.

2) The loading force of the coupling generates significant variations at low loading rates, especially in case of the grease RUL 145 Na 3, STAS 1608-84.

3) The efficiency of the ball screws lubricated by grease varies within relatively narrow limits (0.93 – 0.97).

4) The friction torques vary within a larger field (0.07 – 0.58) Nm.

5) The variation values of the kinematical friction coefficient resulted within 0.011 … 0.092, values that are satisfactory during exploitation.

6) Both grease types being tested shown, in general, a good tribological behavior and are recommended for exploitation.

5. REFERENCES

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