SERBIATRIB`07
10th International Conference on Tribology
and
WORKSHOP`07
Sustainable Development in Industry by Apply Tribology Knowledge

THE INFLUENCE OF LUBRICANTS ON CAM MECHANISM RELIABILITY

Dr. Ing. Radoslav Rakić
NIS-Petrol, Naftagas promet, Narodnog fronta 12, 21000 Novi Sad, Serbia

ABSTRACT

Cams have contacting surfaces that do not conform to each other very well. The full magnitude of the load must then be carried by a very small contact area. The lubrication of the contacting surfaces of cams involve a complex technology.
This paper presents the following:

- *The classification of industrial oils for cams. To establish this classification, two essentials of parameters have been taken into account: the environment (ambient temperature) and the cam operating conditions (load and sliding velocity).*
- *The flowchart of lubricating oil selection procedure for cams as a function of all relevant influencing factors.*
- *The analysis of the symptoms and the causes of failure of machine tool cams.*
- *The curves of cams reliability in function of tribological properties of lubricating oils under presented operating conditions of investigation.*

Key words: 1. lubricant, 2. cam mechanism.

1 INTRODUCTION

In the modern mechanics, cams represent very important tribomechanical systems of the machines and mechanisms. The main role of these tribomechanical elements is to insure smoothness and noiseless service, precision of processing, and so on.
The primary function of the lubricant is to separate contacting surfaces, thus preventing metal to metal contact and premature cam failure. In cam operation, elastohydrodynamic lubrication films and generated which reduce the interaction of the contacting surfaces.

For these tribomechanical elements numerous methods have been developed to calculate the thickness of these films, including those by Dowson and Higginson [1], Hamrock [2] and the others. The differences in the formulas apply primarly to different contact geometry.

2 NONCONFORMAL SURFACES OF CAM

This tribomechanical system, as it is shown in Figure 1, consists of three elements, these being: the element 1 (cam), the element 2 (lever transmission) and the element 3 (lubricant) in which the contact between the two former

elements is realized. The cams have poor conformity between surfaces, very small contact areas and very high unit loading.
can conditionally be devided into the external and internal ones. The main influential factors are: t_a –ambient temperature, p – Hertz pressure, V_g – sliding velocity and v – velocity.

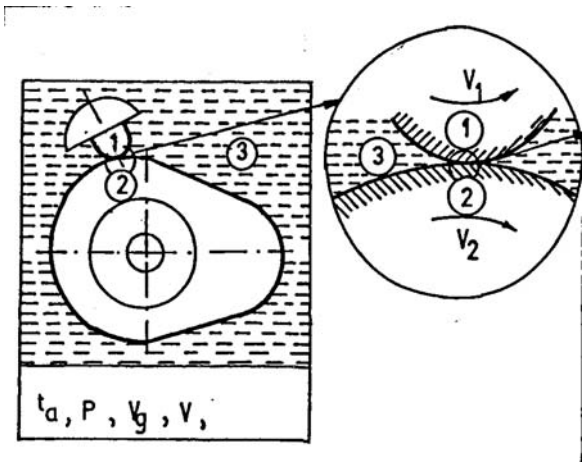

Figure 1.: Schematic illustration of cam, t_a - ambient temperature, p-Hertz pressure, V_g - sliding velocity, v-velocity.

3 LUBRICANTS

The kinds of industrial oils with recommended ISO viscosity classification [3] and based upon the investigations by Rakić [4, 5, 6, 7, 8, 9] are presented in Table1.

Table 1. Classification of industrial oils for machine tool cams

Letter symbol	Category symbol ISO - L
C	CKB32 - CKB68
G	G 32 - G 68
H	HM 32 - HM 68
	HG 32 - HG 68

4 SELECTION PROCEDURE OF LUBRICATING OILS

The description of the lubricants selection procedure is given as the flowchart in Figure 2, in function of all relevant influential factors, i.e.:

- The enviroment (ambient temperature - t_a)

The tribological behaviour of the cams in influenced by a number of factors that are interrelated in complicated ways. These factors

- The cam operating condition (Hertz pressure – p , maximum sliding velocity on the cam surface – V_g and velocity on the operating cam – v).

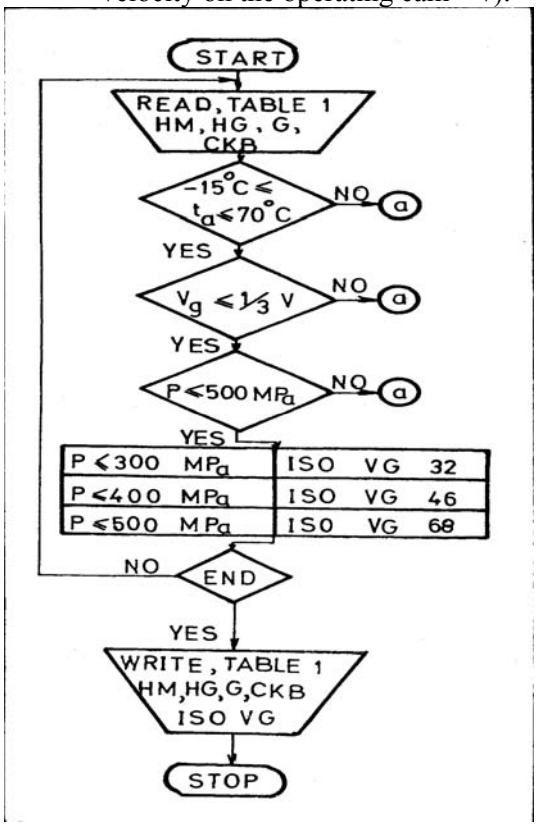

Figure 2: Flowchart of lubricant selection procedure, a-go to the other model of decision making

5 EXPERIMENTAL INVESTIGATION

The experimental investigation of the influence of lubricating oils on cam failures has been carred out on machine tools in three periods of time, each being 10.000 working hours. Working conditions of these cams and other influential factors are shown in Table 2.
The results of the experimental investigation are presented for two viscosity grades and three types of lubricating oils:

- Hydraulic oils, category symbol HM, ISO VG 46 and 68 (first period of time)
- Hydraulic oils, category symbol HG, ISO VG 46 and 68 (second period of time)
- Gear oils, category symbol CKB (C) , ISO VG 46 and 68 (third period of time)

Operating conditions:	
Contact geometry	Line
Contact stress	Low ($P \leq 500 MP_a$)
Type of motion	Rolling / sliding
Frequency of motion	Irregular
Sliding velocity	Low ($V_g \leq 1 m/s$)
Environment:	
Ambient temperature	$-15^0 C \leq t_a \leq 70^0 C$
Medium	Static moisture and contaminants
Structure participients (element 1 and 2)	
Composition	Steel
Hardness	High (> 500 HV)
Surface condition	Smooth
Coating	No coating
Lubricant (element 3) :	
Condition	Lubricated
Type	Lubricating oils

Table 2: Working conditions of cams and other influential factors

For example, Figure 3 shows the proportion in percentage of cam failure in the third period of investigation, which are: 1-excessive clearance (h >hmax), 2-decrease of machining accuracy, 3-untrue running (vibration), 4-corrosion, 5-other symptoms (metal fatigue, contamination). The life time of the cam up to the failure mostly shows a large scatter. With the aid of a probability and statistical methods, it was possible to determine the influence of lubricating oils on the reliability of cams.

The results for three periods of time were plotted in the reliability curves (R) versus time (T) are shown in Figure 4. These curves represent the probability of cams reaching the moment »T« without failure. As it is evident from this Figure, the least reliable are cams in first period of investigation, i.e. for oil ISO-L-HM 46 (the greatest incline of the curves R(T)) and they are the most reliable on III period of investigation, i.e. for oil ISO-L-CKB (C) 68 (the least incline of the curve R(T)).

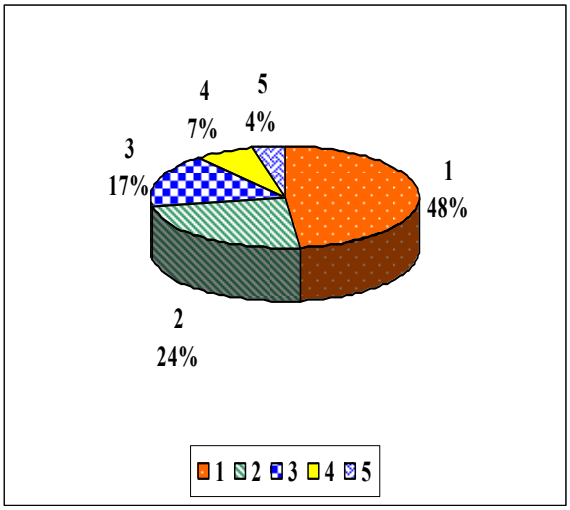

Figure 3.: Symptoms of failure for cams

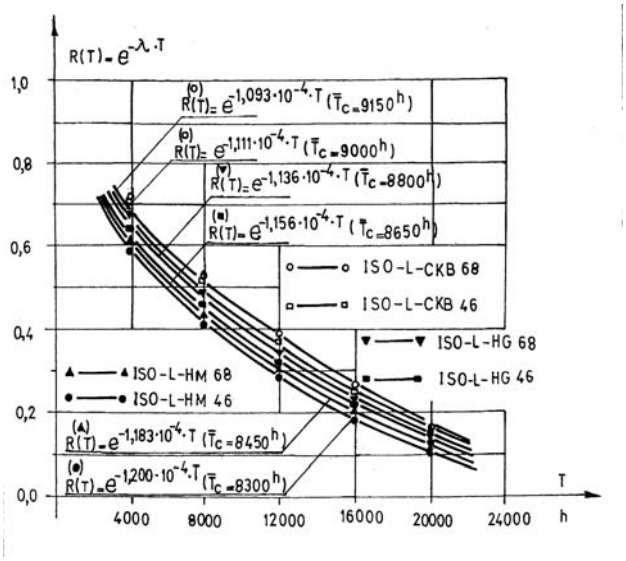

Figure 4.: Reliability curves cams versus time, R(T)- reliability, T- time (h), Tc- average life time (h)

6 CONCLUSION

The results presented above give the following conclusion:

- The reliability of cams was found to be affected by both viscosity grades and type of lubricating oil.
- The hydraulic oil ISO-L-HG gives a longer cam' s life compared with the case of the hydraulic oil ISO-L-HM.
- The gear oil ISO VG 68 gives the longest cam's life among all the lubricating oils studied in the present work, under presented operating conditions of investigation.

REFERENCES

[1] Dowson, D. and Higginson, G. R.: *Elastohydrodynamic Lubrication,* Pergaman Press, Oxford, 1966

[2] Hamrock, B.J. : Elastohydrodynamic Lubrication of Eliptical Contacts, *1st Symposium I ntertribo´81",* April 27 – 29, 1981, the High Tatras, Slovak Republic.

[3] *** , ISO Technical Report 3498, Lubricants, Industrial oils and related products (class L) - Recommendation for the choice of lubricants for machine tools, 1986.

[4] Rakić R. : The Influence of Tribological Processes on the Reliability of Machine Tools, *11th Int. Conference on Production Research ICPR '91, August 19-23,* 1991, Hefei, China.

[5] Rakić R.: Lubricant Selection for Tribomechanical Systems of Machines in The Function of Lubricant Properties, *8th International Colloquium Tribology 2000,* January 14 - 16, 1992, Ostfildern, FR Germany.

[6] Rakić, R.: The Influence of Tribological Properties of Lubricants on the Tribomechanical System Elements in Nonconformal Contact, *6th Int.Congress in Tribology " Eurotrib ´ 93 ", August 30. - September 2, 1993,* Budapest, Hungary

[7] Rakić, R.: Tribo-Economical Effects of Lubricants Application on Tribo-mechanical System, *9th Int. Colloquium Ecological and Economical Aspects of Tribology,* January *11 - 13, 1994,* Ostfildern, FR Germany.

[8] Rakić R.: The Influence of Lubricants on Operation of Machine Tools, 10th Int. Colloquium Tribology, January 9-11, 1996, Ostfildern, FR Germany.

[9] Rakić R.: The Influence of Lubricating Oils on Reliability of Cams. 7 th Int. Symposium Intertribo'99, April 27 - 30, 1999, The High Tatras, Slovak Republic.