IRG-OECD Transition Diagram at very low velocities.

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1. Introduction.

In the IRG-OECD group the IRG-transition diagram is explored extensively, see for instance [1]. However, in the low velocity region A) the distinction between the transitions of the different regimes as present in the transition diagram as well as B) the lubricants liquid to solid state behaviour are unclear.

2. Experimental.

2.1. Test rig.

In this study a ball-on-disc configuration was used, see Fig. 1.

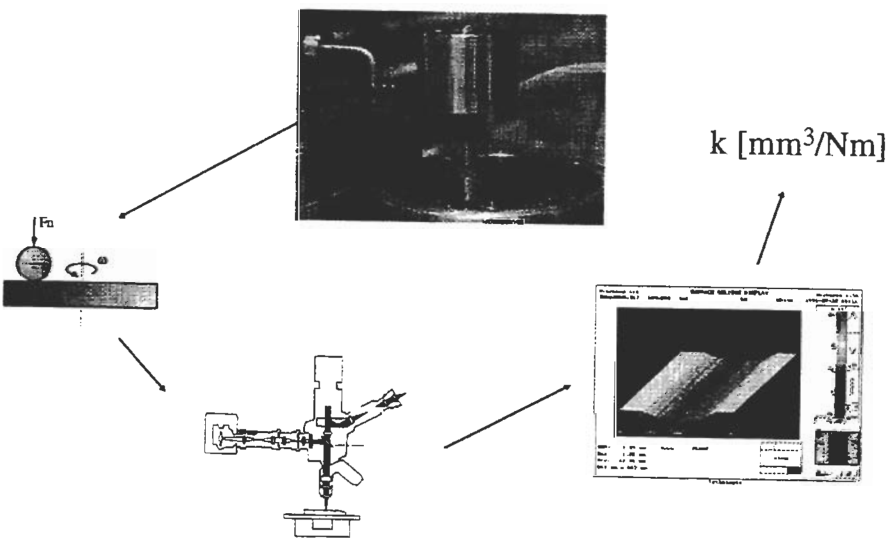

Fig. 1: Testrig

2.2. Specimens and lubricants.

The balls are made of AISI-52100, 6 mm in diameter, a CLA surface roughness of 6.1 nm and a hardness of 63 HRc. The disks are made of AISI-52100, ϕ 30 x 5 mm, a CLA surface roughness of 1.6 nm and a hardness of 63 HRc. Parafinic oils were used as lubricants with viscosities of 9, 32 and 150 mm^2/s at 40 ^{0}C respectively.

2.3. Procedure.

Prior to each test the test specimen are cleaned in an ultrasonic bath, rinsed in hexane or acetone and dried in hot air. After the load is applied the velocity is adjusted. Leakage time of the entrapped oil [2]:

$$t_l = \exp\{2.5\cdot10^{-3}\cdot(\alpha\cdot\hat{p})^3\}$$

$$\text{minimum } \alpha\cdot\hat{p} = 7.1 \quad t_l = 0.89 \text{ sec.}$$

$$\text{maximum } \alpha\cdot\hat{p} = 20.9 \quad t_l = 22.8 \text{ sec.}$$

The test duration was approx. 25 or 60 min. depending on the velocity which was used, ranging from 0.1 to 1 mm/s. The tests were performed at 23 ^{0}C and 50% humidity.

After the tests the wear tracks of the discs were examined using an optical inteference microscope, see Fig. 1.

3. Results and Discussion.

In Fig. 2 and 3 some friction - time characteristics are given for Vitrea 9 and 32 at 10 N normal load ($\bar{p}$ = 0.94 GPa), rotational speed of disk 1 rpm, trackradius of 1, 2, 5 and 10 mm respectively.

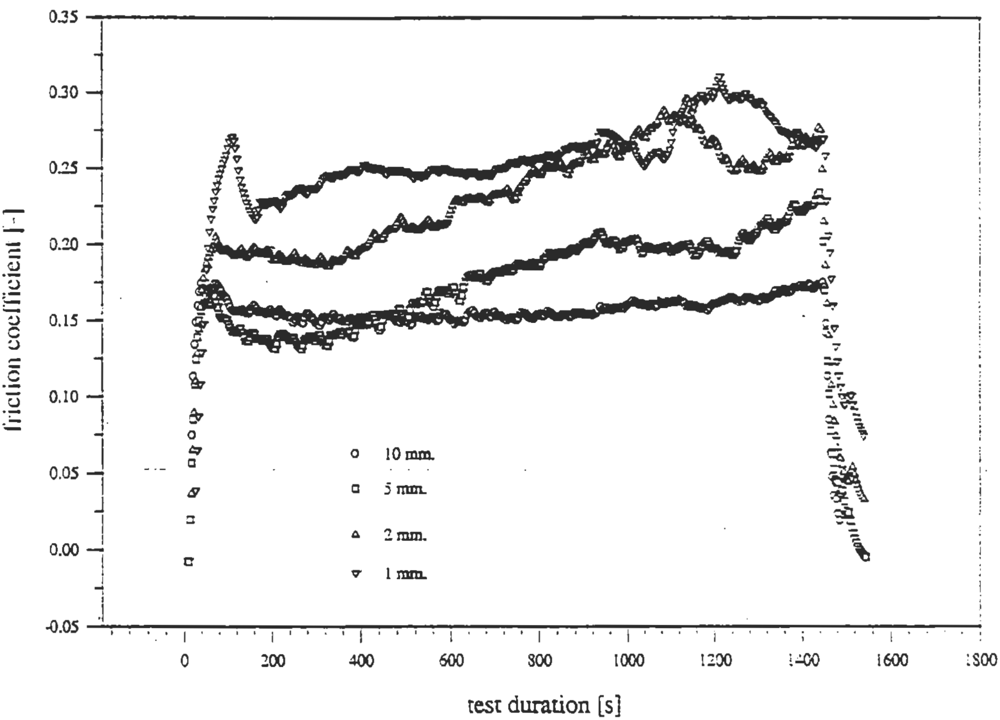

Fig. 2: Vitrea 9, 10 N, at 0.1 (1 mm), 0.2 (2 mm), 0.5 (5 mm) and 1 (10 mm) mm/s. $\alpha\cdot p$ = 16.2, t_l = 10.6 sec.

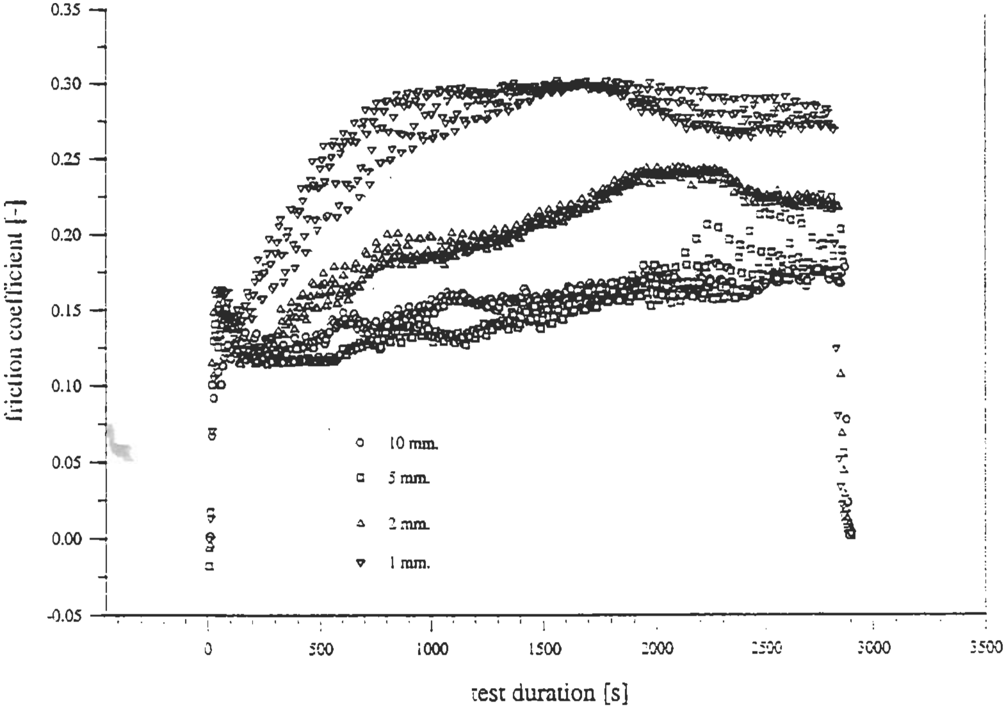

Fig. 3: Vitrea 32, 10 N, at 0.1 (1 mm), 0.2 (2 mm), 0.5 (5 mm) and 1 (10 mm) mm/s. $\alpha \cdot p = 17.4$, $t_l = 13.2$ sec.

These figures show different friction-time characteristics as observed with the traditional IRG-transition diagram.

In Fig. 4 and 5 the results of cold welding are given for Vitrea 9 and 32. For Vitrea 150 no cold welding was observed.

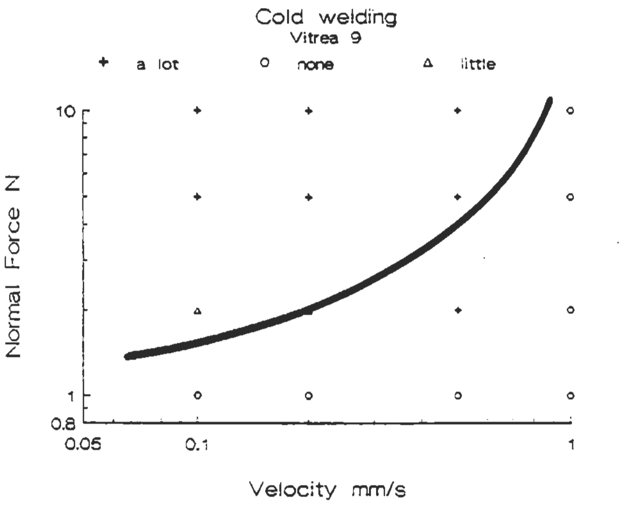

Fig. 4: Transition diagram for Vitrea 9 for low velocities.

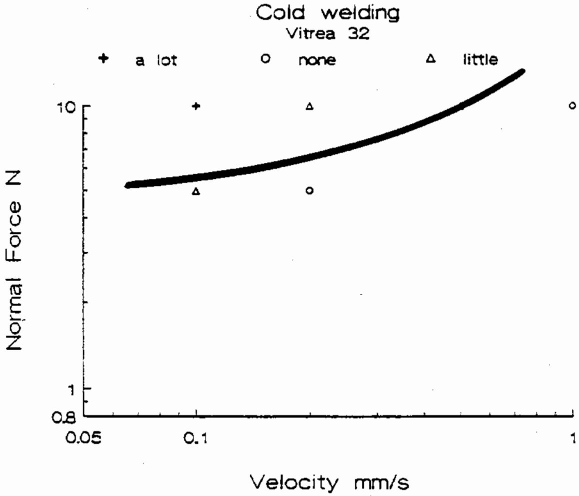

Fig. 5: Transition diagram for Vitrea 32 for low velocities.

From these figures it is clear that the transition between region I and region II shifts to higher values of normal force with increasing velocity, which is different to that the traditional IRG transiton diagram.

4. Conclusions.

The following conclusion are drawn.

- On the basis of friction-time characteristics, as used as a technique for the IRG-OECD transition diagram, it is difficult to make a distinction between region I and region II.
- The cold welding load increases with velocity and viscosity. Therefore it seems that hydrodynamics play a role. In the experiments planned for the near future high surface roughness values will be used to avoid hydrodynamics as much as possible.

5. References.

[1] Begelinger, A. and Gee, A.W.J. de, 1982, "Failure of thin film lubrication - A detailed study of the lubricant film breakdown mechanism", Wear, Vol. 77, pp 57 - 63.

[2] Hirano, F., Kuwano, N. and Ohno, N., 1992, "Fundamental study of static scaling characteristics of solidified oils at high pressure", Proceedings of Fluid sealing, B.S. Nau editor, Kluwer academic publishers, Dordrecht, The Netherlands, pp. 109 - 120.