Technical Test Laboratory. Oppau 200.
Report No. 365.

Investigation of suitability of IGENIL as a bearing material

by Halder: 10.1.39.

Summary:

Igenil as a bearing material possesses good sliding properties and shows little wear. It is very brittle and cracks easily. On account of the last property it is unsuitable as a bearing material.

Object of Tests:

It was desired to test the properties of Igenil as a bearing material. Igenil is a filler-free condensation product of aniline and formaldehyde manufactured by the Dyes Division of I.G. Farbenindustrie Ludwigshafen. It is mainly used in the press-forming technique. The following synthetics were compared:

Igenil from I.G. Farbenindustries A.G. Ludwigshafen a. Rhein
Dytron " " " " Troisdorf
Gerolith " the firm of H. Römmler A.G. Spremberg.

Two test installations were built for these tests:

I) a bearing test machine with rotating shaft.
II) a "knee lever" (Kniehebel) machine.

I) Tests on the Rotating Shaft Bearing Test Machine

A. Apparatus

The design of this machine was based on the consideration that endurance testing of the bearings should be done before proceeding to the estimation of friction torque. For this reason it was not attempted to measure the torque. The design of the machine is shown in Plates 1 and 3 and is briefly described as follows: A hardened polished test shaft is mounted in 5 ball bearings. The two test bearings are situated between bearings 2 and 3, and 4 and 5, respectively. Modified ball-bearing housings were adapted for the test bearings so that they could be used for split and solid bearing shells. Pressure circulation lubrication, ring lubrication or grease lubrication can be used as desired.

The loading of the bearings is applied by means of weights and a 3-lever system with a 50:1 ratio. With a shaft diameter of 50 mm. and a bearing length of 50 mm., a maximum specific surface pressure of 110 kg/cm^2 may be applied.

The ball-bearing s are lubricated by a continuous circulation oil system. The bearings are at the same time cooled by this method, an important factor in the testing of synthetic bearings.

The drive is from a 12 H.P., 2000 r.p.m. 3-phase motor, through an automatic gear-box and a double vee-belt pulley drive. With this arrangement the test shaft speed can be varied between 50 and 4000 r.p.m.

B. Tests

For test purposes bearing shells of Igenil and Dytron were manufactured with a bearing play of 0.3 mm., as is necessary for synthetic bearings of these dimensions. Before erection the bearings were weighed and measured. Gas machine oil was chosen as lubricant and a ring lubrication system adopted. Both bearings were tested on the same shaft and under the same loading. After and 8 hour run-in at 200 r.p.m. and 10 kg/sq.cm. load, the load was increased (by 10 kg/sq.cm. every four hours) at the same speed and the oil temperature measured every hour. After reaching the maximum load of 110 kg/sq.cm., the bearings were dismantled and examined. Damaged bearings were replaced and the test repeated at a different speed. In order to eliminate any peculiarities due to the machine, tests were repeated with the bearing shells exchanged: the Igenil bearing shell from bearing No.I was mounted in No.II, and the Dytron mounted in bearing No.I.

In order to find the maximum permissible load for Igenil, bearing shells of this material were finally tested in both housings. In the last test, Test No.7, the bearing play was reduced from 0.3 to 0.1 mm.

C. Test Results.

From the tabulated results in Table I it will be seen that the four Igenil shells from Tests 1 - 4 are rendered unserviceable by the formation of cracks on the pressure side. Of the two Dytron shells which were both run for twice as long as the Igenil shells, only one was unserviceable, after running at 1000 r.p.m. at a high temperature.

At reduced loads, Tests 5 and 6, cracks again appeared in the Igenil shells. This could not be prevented by the use of a smaller bearing play (Test 7).

A conclusion may be drawn as to the coefficient of friction, from the running oil temperatures attained. The oil temperature lay throughout the test at some 5 - 10°C higher with Igenil than with Dytron. The run of these temperatures for the two 8-hours duration is shown in fig.6. The coefficient of friction is thus greater for Igenil than for Dytron, but is still regarded as permissible.

After it was found from these endurance runs that Igenil was not suitable as a bearing material owing to the formation of cracks, the determination of the friction coefficient was not carried out.

II. Tests on the Knee-lever machine.

A. Test Apparatus

In order to test the suitability of bearing materials for high pressures and low sliding velocities under pendulum motion, as met e.g. in automotive road spring shackles, the following machine was built (see also figs. 2 and 3).

The steel bracket c is given a reciprocating motion by a connecting rod a (see fig.2), the motion being linearly constrained by the plunger mechanism d, e. This bracket e is connected to the right and left by rods b to spring loaded sliding pieces f. The shackles under test consist of hardened bolts of 16 mm. diam. fixed at both ends of the transverse rods and mounted in synthetic bearings.

The assembly shown in fig.2 is mounted at one end of a belt-driven shaft carrying a fly-wheel, and an identical assembly mounted at the other end. (See photo. fig.3). Thus there are in all 8 test shackles on the machine, of which each pair is exactly equally loaded, being at opposite ends of the same rod. (1' and 2', 3' and 4', 1" and 2", 3" and 4"). Grease lubrication is used.

The drive consists of a 2 H.P. 3-phase motor, giving speeds between 20 and 400 r.p.m.

B. Test Method

8 Igenil shackle bearing shells were compared with 4 Dytron shells and 4 Gerolith shells. The shells were distributed so that each transverse rod was supported in two different shackle bearing materials. In this way the unavoidable differences between the springs are eliminated and direct comparisons between the materials obtained. Before assembly the weight of the shells and the bolt diameters were measured. After every 8 hours the shackles were freshly lubricated with "Motenol" red. For loading 4 springs with spring constants of 195 kg/cm. were used, precompressed to give a specific bearing load of 100 kg/sq.cm. The drive shaft speed was fixed at 200 r.p.m. The variation of the specific bearing pressure and the circumferential speed are shown on fig.4, for two revolutions. After 100 hours the test was ended, and the shells weighed and shackle-bolt diameters checked.

In order to investigate the behaviour of the bearing materials when starved of lubricant, the shells were immersed in grease at -120°C for 2 hours and assembled without further lubrication. The test is continued until individual shells fail.

C. Test Results

As shown on fig.6, the wear of the Igenil shells was less than that of the Dytron shells. The wear of the relevant shackle-bolts gave the same picture. The comparison with Gerolith was inconclusive. This could be traced to the fact that the filler used in Gerolith is very coarse, and that, in such small bearings, differences can easily appear in the quality of the running surfaces.

In the last test the Igenil shells swelled badly after the 2 hour hot soak in grease, and had to be re-machined. The test with these shells was terminated after 21 hours due to cracking and wear of the Igenil. All the other synthetics were fit for further running at this stage, as they apparently have a greater capacity for taking up the grease.

(Signed) Helder.

Table I

Tabulation of Test Results on Bearing Test Machine

Test No.	Test conditions R.P.M. mins.	Loading kg/cm^2	Duration hrs.	Bearing I (Dismantled conditions)	Bearing II (Dismantled conditions)
1				Dytron shell No.1	Igenil shell No.5
	200	10-110	40	good	good
	100	30-110	36	-	-
	50	60-110	14	good	good
	300	30-110	32	good	cracks on press. side
2				Igenil shell No.6	Dytron shell No.2
	200	30-110	32	cracks on press. side	good
	100	30- 80	20		
3				Igenil shell No.7	Dytron shell No.2
	1000	20	1	on press. side cracks and porous surface	on press. side surface carbon-coated
4				Igenil shell No.8	Dytron shell No.1
8	400	20-110	51	cracks on press. side	good
5				Igenil shell No.9	Igenil shell No.1
	300	30	100	cracks on press. side	cracks on press. side
	300	20	100		
6				Igenil shell No.11	Igenil shell No.1
	300	20	8	cracks on press. side	cracks on whole circumf.
	300	10	8		
7				Igenil shell No.15	Igenil shell No.1
	200	10- 40	24	good	good
	200	40- 70	22	good	good
	200	70-110	28	good	cracks on press. side

Diagram Titles

Fig.1 - Diagram of bearing test machine

Fig.2 - Diagram of Knee-lever machine

Fig.3 - Photograph of bearing test machine

Fig.4 - Photograph of Knee-lever machine

Fig.4 - Curve - Variation of sliding velocity and specific bearing loading during 2 crank revolutions on Knee-lever machine

Fig.6 - Variation of oil temperatures during 2-day test with Igenil and Dryton.
Wear test after 100 hr. run on knee-lever machine.
Wear of synthetic shells.