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Report of the technical test-station Oppau.

Report No. 448 by Halde

Testing the lubricating capacity of oils in 3 different apparatus.

Synopsis: The six oils (synthetic products, each of which represents a uniform material) were tested in the following 3 apparatus:-

1) **The four ball machine:** This tests under maximum pressures until seizing begins (> 10,000 kg/sq. cm).

2) **The wear testing machine:** This determines the wear at middle to high pressures (from 13 to 1300 kg/sq cm)

3) **The Wieland machine:** This measures the friction coefficient to high pressures (2200 kg/sq cm) and determines the seizing load.-

In some respects the results agree amongst one another; in most cases however contradictions exist. As the test conditions for the various apparatus differ from one another completely the evaluation of the different oils affords very dissimilar results. Further tests will have to show which apparatus approaches practical conditions best.

I Purpose of the experiments.

The purpose of the experiments was to examine the lubricating capacity of 6 oils and to correlate the results which were obtained with the 3 apparatus at our disposal: the four ball machine, the wear testing machine and the Wieland machine.

II. Test Equipment.

The four ball machine, as described in report No. 293, was used as the test engine though the design was improved upon in practice.

The wear, testing machine (cf. report No. 388) was improved in the following way. Instead of the cast iron plates which are often not uniform in their structure, brass pins were used as wear parts and as friction surfaces thin strips of steel were employed in place of ground drums

Testing oils by means of the Wieland machine (similar to the Almen machine) miniature plants made of steel were used; these are loaded by means of plates laid upon each other until seiz ing results. Each plate exerts a surface pressure of 90 kg/$_{sq\ cm}$ upon the bearing. The number of plates reouired to bring about seizing are a measure of the lubricating capactiy of the oil. A friction balance makes it possible to measure the friction moment which results. The tmperature of the oil at the beginning of the experiment is equal to room temperature; it increases by the end of the experiment to about 40° to 80°C in accordance with the duration of the latter and the friction moments which are set up, A more detailed description of the Wieland machine is found in the literature. +

+ Kadmer Fr. Lubricants and machine lubrication. Berlin 1940, S.309.

III. Carrying out the experiment.

The oil tests in the four ball machine were carried our at temperatures between 20 and 160°C, in accordance with the method described in report No. 293.

When tests were made on the wear testing machine, the former were made to last up to 60 hrs.and the wear was measured as a function of the time. This was achieved by measuring the diameter D (see fig. 2) of the wear part after 1,3½,20, 40 and 60 hrs resply. The oil temperature was kept constant at 50 or 100°C during the experiment. The load on the wear part acmounted to 10 kg, the number of backward and forward movements per minute to 100 (cf. report No. 388).

When carrying out the experiments on the Wieland machine the test instructions we e followed.

A complete account will follow shortly on the individual test machines.

Six synthetic products each of which represents a uniform material were tested. H8, H32, H88 and H 140 are hydrocarbon oils of differing viscosities, whilst H 426 represents an ester.

Oil	Viscosity in centistoke		
	20°C	50°C	100°C
H 8	153.6	36.43	8.53
H 16	325.3	68.3	14.23
H 32	775.2	137.7	22.63
H 88	2365	325.0	42.42
H 140	4349	518.3	55.7
H 426	146.8	29.41	6.4

IV Test results

Four ball machine

The results obtained with the four ball machine were influenced by fairly strong scattering. Form fig. 1 ~~it~~ is evident that there is no definite relationship between the behaviour of the oils; this is illustrated by the viscosity for example. Surprising is the fact that the ester H 426 behaves unfavourably under the high surface pressures given here, whilst the wear tests indicate an excellent lubricating effect for this material. In this connection it has to be mentioned, that some preliminary tests were carried out with spheres of different hardness; the ester was lying as high as the best hydrocarbon oils. Further tests are being carried out to explain this phenomenon.

Wear testing machine.

With thewear testing machine the oils were tested at 50° and 100°C (fig. 2 and 3.) in both cases the ester H 426 showed the least wear. The other oils cannot be determined consistently at the two temperatures. Whilst at 100°C the thinnest oil, H 8 gave the greatest wear and the others arranged themselves in order of their viscosity, at 50° this behaviour was not observed. At this temperature after the ester the thinnest hydrocarbon oil H8 showed the smallest wear, then follow H 16, H 140 and H 88. H 32 cuts the last two. It is noticed that the two thickest oils, H 88 and H140 show no increase in the wear after 30 hours running time whilst the other oils show an increase in the wear even after 60 hrs. It is to be assumed that after carrying out the experiments for 100 hrs. and more another order would be set up for the efficiency of the oils, as was the case after 60 hrs. The fact that an increase of the oil temperature from 50 to 100°C does not bring about an increase but a decrease in wear is interesting. Especially remarkable is this phenomenon with very viscous oils. To clarify the dependence of the wear of the different oils on the temperature further experiments are being carried out and the experiments mentioned are completed. It is possible that a temperature can be indicated when minimum wear occurs.

Again the ester takes up an exceptional position. The wear was not only remarkably low but it was also ~~found~~ to be independent of the temperature of the experiment.

Wieland machine.

The tests on the Wieland machine gave strongly differing results as was shown by these instances (fig. 4). This applies less to the friction value than to the number of plates which bring about the seizing of the bearings. In this connection it is noticeable that the main feature of the deviation consists of the values being equal to half of the maximum values. An evaluation of the oils is hardly possible on basis of these results. Similarly the coefficient of friction which is expressed by the slope of the curves, does not give a criterion for judging the oils. One can definitely say however that the two thickest oils give the smallest coefficient of friction. The two oils which are most viscous behave to a certain extent exceptionally. Whilst the rotational forces for all oils increase approximately in a straight line, H 88 and H 140 show a parabolic course, i.e. at the beginning of the experiment like in the case of small surface pressures the rotational forces and thus the coefficients of friction are very small. Then the curves rise very quickly and end up by a relatively premature seizing of the bearing.

To a certain extent this corresponds to the results obtained at 50° in the wear testing machine, a temperature at which probably the testing in the Wieland machine occurs.

H 88 and H 140 show no wear after running period of 20 or 30 hrs at 50°C in the Wieland machine (cf. fig.2) and thus they make an exception as compared to the other oils. It appears that here the specific surface pressure has decreased to such an extent that liquid friction could occur, which gave no wear. At the beginning of the experiment, i.e. at high surface pressures the two oils are remarkable in their behaviour as a result of very steep rise of the wear curve; this phenomenon can be explained by a poor infiltratio n of the oil between the rubbing surfaces.

Final conclusions

On basis of these experiments the following connection was found:

Very thick oil in the wear testing machine at high specific loads brings about a very high wear and in the Wieland machine premature seizing. The reason for this is small mobility of the oil molecules and consequently a too slow refilling of the oil between the rubbing surfaces.

The same thickly flowing oil shows in the wear testing machine a premature and complete stoppage in the wear as a result of the diminished surface pressure brought about by a high wear at the start and in the Wieland machine a remarkably low coefficient of friction at low surface load. The reason for this is the absence of metallic contact and the formation of liquid friction, which for thick oils is possible at higher surface pressures than for thin oils.

In this connection further conlcusions cannot be arrived at. In particular a relationship to the four ball machine is lacking. Under these differing circumstances agreement cannot be expected. For the oil tests the apparatus which best approximates to practical conditions is to be used.

The tests with these six oils are being continued. It is to be investigated to what extent the accuracy of the measurements can be increased by fitting up and improving the apparatus. By examination of further lubricants still further experience will have to be gained.

Plate 1.

Fig. 1.

Testing in the four ball machine

Fig. 2. at 50°C

Testing in the wear testing machine over 60 hrs.

Fig. 3. at 100°C.

Plate 2.

Testing in the Wieland machine.

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