I. G. FARBENINDUSTRIE AKTIENGESELLSCHAFT LUDWIGSHAFEN a. RH.

REPORT

BY

THE TECHNICAL TEST-STAND OPPAU

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THE USE OF THE I.G. TEST-ENGINE FOR LUBRICANT TESTING

(Lecture given at the conference of the Lubricant Panel of the DVL in Berlin, on the 7th August, 1942).

SUMMARY:

The I.G. test-engine for the determination of knock rating can be adopted as an oil testing engine after a few minor modifications have been made, enabling one to recognise and study ring-sticking. Test conditions, procedure, and the actual testing will be described briefly. A series of tests under tentative conditions gave the same classification of four aero-engine oils as the BMW 132 single cylinder engine, the repeatability being satisfactory. The end-point of the test is not always clear, as power decrease and blow-by do not always coincide. Improvement in that direction must be sought. As the tests are promising, they will be continued on two I.G. test-engines.

THE USE OF THE I.G. TEST-ENGINE FOR LUBRICANT TESTING

by

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The technical test-stand of the I.G. Farbenindustrie has recently carried out tests on ringsticking in small engines. The I.G. test-engine for knock rating seemed to be especially suitable.

The general principle of the motor will be well-known. In the following illustration (1) two sectional drawings of the motor are shown. It is a four stroke engine, has a stroke of 100 and a bore of 65 mm.

Parts necessary for the testing of fuel, like variable compression ratio regulator plus scale, bouncing pin indicator etc., have been omitted. The compression ratio is set 1:5.5 throughout all the tests.

The engine works with a light metal piston; the same metals as in the large size engine came into contact with the oil, a condition which is of importance, in view of a possible catalytic reaction on the lubricant.

At the beginning, difficulties with valves were encountered, especially with the exhaust valve, which leaked frequently after a few hours, and so caused a decrease in power. But by using the new "leaded gasoline proof" valves of the I.G. test-engine this difficulty was overcome.

The fact that the I.G. test-engine is driven by belt from a symbronous generator working on multiphase current is very convenient, especially in regard to simple manipulation. In that way the regulation of r.p.m. can be dispensed with as the motor runs steadily with only very slight variations, at constant speed.

Favourable also is the fact that the motor possesses wet cylinder liners. This in turn enables not only a simple and cheap renovation of the piston running surfaces, but something more important, namely, a constant loss of heat, as the wall thickness remains the same throughout. That condition is of great importance for a constant piston temperature.

The method of liquid cooling is also very advantageous. It results in a constancy of the cylinder temperature, which could never be achieved by air cooling. The use of a cooler to condense the evaporated cooling medium enables any desired temperature to be kept with little variation. The cooling liquid is triglycol (B.P.260°). To obtain lower evaporation temperatures, triglycol was mixed in appropriate proportions with diglycol (B.P.195°). In that manner any desired temperature between 195° and 260°C. can be obtained.

The lubricating system was altered for the oil tests.

Normally the engine has a circulating lubrication system, in which the HAJOT pump sucks the oil from the sump and pumps it dropwise into the hollowed crankshaft. Through a boring in the crankshaft the oil is sprayed into the connecting rod bearing. For the first tests on lubricants that arrangement was kept. But soon the same difficulties as with the BMW 132 were encountered. There is no control over the amount of oil that comes out again at the connecting rod bearing, and how much leaks back into the crankcase without taking part in the cylinder lubrication. All measurements of the amount of circulation per hour are of no avail, if there is no control on the way the oil is distributed throughout the engine. We solved the problem simply and radically. Now the oil is not brought to the connecting rod bearing through the inside of the crankshaft, but by means of a nozzle situated on the side of the crankcase in the same plane as the connecting rod. In that manner the connecting rod receives at every revolution a constant amount of oil from the outside, which in turn is sprayed round and so lubricates cylinder and piston. Such an arrangement is only possible if there is no slide bearing. Here again the advantage of the I.G. test-engine is demonstrated, where the crankshaft and its connecting rod run on ball and roller bearings, both of which run satisfactorily with lubrication by spray and oil vapour. That this is possible is shown, for example, by our engine which ran for 200 hours on this lubricating system, without any working difficulties.

Also of interest is the arrangement of the sump. The oil was collected in a receptacle outside the engine, which simplifies the measuring of oil consumption and circulation, and also the installing of an oil heating arrangement. The oil quantity in circulation was very small, only 0.8 of a ltr.

In preparation for the test and the actual testing the following, briefly, can be added. One hour before beginning the test run, the cooling liquid and the motor casing are warmed up electrically. The heating arrangement installed proved too weak, so that it took 45 minutes to reach the required temperature after the test run had begun. As the engine runs from the start with open throttle, the power is higher than normal, because of the low temperature of the cooling liquid at the start. Only after the cooling liquid has reached its determined temperature did the power attain its normal level. This takes usually half to three-quarters of an hour.

During the test the following conditions were kept constant: the temperature of the cooling liquid, r.p.m., the fuel consumption per hour and the oil circulation. (300 ccm/h.). The lubricant was not being heated. The oil inlet temperature is somewhere about 30°C.

The most important factors for the end of the test, namely power and crankcase pressure, are carefully observed and recorded on automatic recording charts. Illustration 2 shows the recorded graph of power and pressure in the crankcase during a test. It can clearly be seen that the power is greatest at the start and - as it has been mentioned before - that normal power is reached only after 30 minutes. The blow-by is also very high at the beginning. It is assumed that the increased power as well as the not yet run-in piston rings are responsible for it. From then onwards the power remains constant, the pressure in the crankcase alters only immaterially until ring-sticking appears, then the pressure increases greatly and at the same time a power decrease of 20% is apparent. Such a clear and convincing indication of the conclusion of the test is undoubtedly ideal. Unfortunately this happens only in two-thirds of the runs, in the others a power decrease of 5% was observed before blow-by. The decrease intensified at the moment of blow-by. Illustration 3 shows an example. One sees the first power decrease after 11 hours and after 1$\frac{3}{4}$ hours the blow-by and another decrease in power is observed. One can assume that ring-sticking had already taken place after the first decrease in power, an assumption which was proved by examining one of these cases. It seems that the carbonised oil deposited on the piston, especially in the region of the rings, seals the piston, so that at first despite ring-sticking no noticeable blow-by increase can be observed. Only gradually do the gases penetrate past the piston into the crankcase. Illustration 4 shows that this process is sometimes very slow and laborious. Here, the first decrease in power after 6$\frac{1}{2}$ hours is followed by a short recovery, then a second decrease is recorded until finally at the third power decrease a strong blow-by is observed.

This occasional blow-by delay impairs a clear-cut picture of the conclusion of the test. The power decrease on its own is not sufficiently clear to be recognised by the operators every time without exception as an external indication of the conclusion of the test. It would be extremely desirable if the extraordinarily great pressure increase inside the crankcase could be accepted as the criterion for ring-sticking. It may be possible to find a solution by an appropriate alteration of the piston shape, but as it a[illegible]ars also that the blow-by delay is connected with the position of [illegible] ring gap of the first ring, further investigations on this point are [illegible]quired to clarify the position.

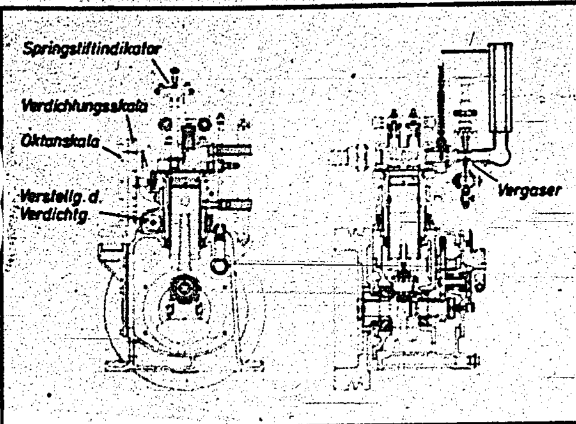
In deciding the suitability of a small engine, the question of repeatability of tests, the relation between results of small engine on the one hand and large engine and practice on the other hand also arises. Illustration 5 shows the results of tests with four oils at different coolant temperatures, wherein for each test two running times are shown, the first power decrease as well as the blow-by being considered.

These curves are based - according to the facts previously explained - on the running time to the power decrease. They show a marked superiority of Rotring over Aeroshell, especially at low temperatures. The synthetic lubricant SS 978 a2 0.04 reaching 10 hours in the BMW, was also slightly better than Rotring. The two tests run in the I.G. test-engine gave the same result (there is only one run) on SS 902 F 25 without additive, but it tallies very well with the 16 hours running time in the BMW.

One can observe that between the I.G. test-engine and the BMW single-cylinder complete agreement exists, because of good relative rating. The graphs on hand also show at least two examples that with increasing temperature of the cooling liquid the running times not only diminish but also come so near together that a difference can scarcely be detected at all.

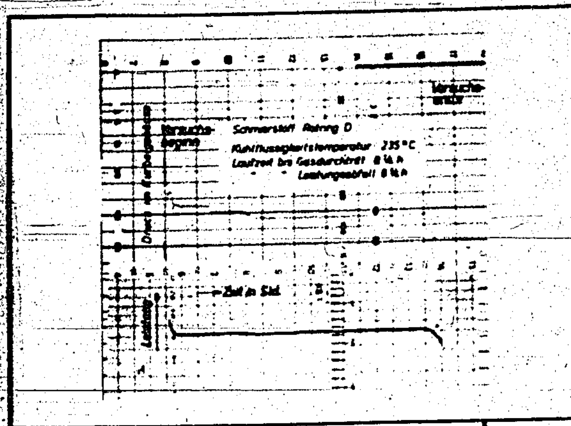
These are the results of the first test series run on this engine. In view of the fact that the test apparatus has still a few shortcomings one can be satisfied with the results. In the meantime we have converted another I.G. test-engine for lubricant testing, and the experience gained on previous tests has been utilised. It is hoped that such results will be achieved, that they will not only supplement but in time replace those of the BMW 132.

Bildblatt 1 zum Vortrag Halder



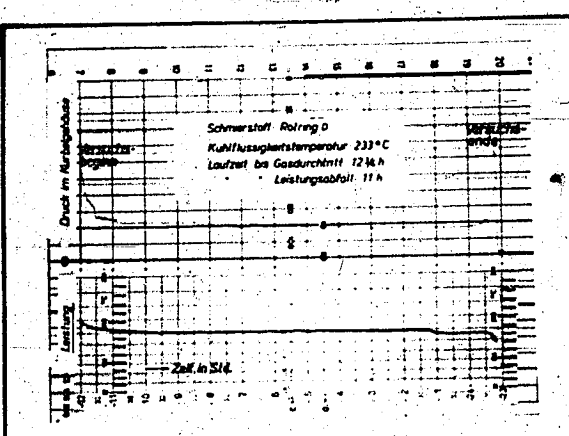
IG Ludwigshafen a. Rh. 1938 | I.G. Prüfmotor | Techn. Prüfstand Oppau 700

Bild 1



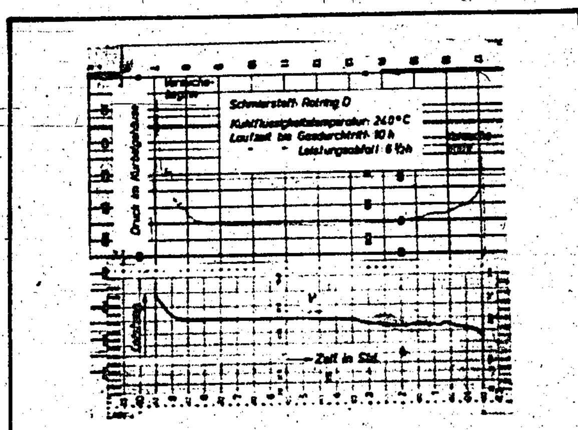
IG Ludwigshafen a. Rh. 1942 | Gasdurchtritt und Leistung in Abhängigkeit von der Laufzeit | Techn. Prüfstand Oppau 1212

Bild 2



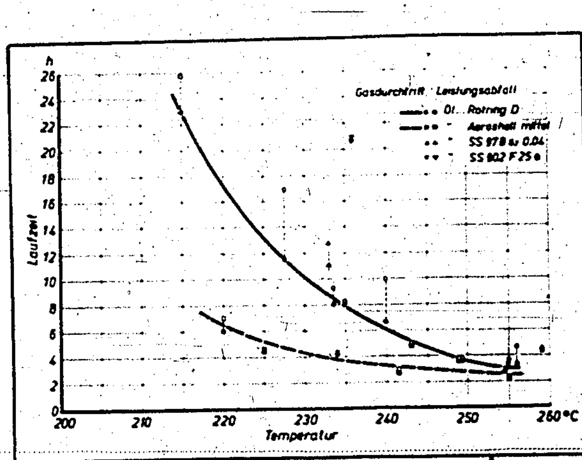
IG Ludwigshafen a. Rh. 1942 | Gasdurchtritt und Leistung in Abhängigkeit von der Laufzeit | Techn. Prüfstand Oppau 1214

Bild 3



IG Ludwigshafen a. Rh. 1942 | Gasdurchtritt und Leistung in Abhängigkeit von der Laufzeit | Techn. Prüfstand Oppau 1213

Bild 4



IG Ludwigshafen a. Rh. 1942 | Laufzeiten verschiedener Öle und Temperatur der Kühlflüssigkeit | Techn. Prüfstand Oppau 1216

Bild 5

Zum Bericht Nr. 504 vom 1.7.42 | TPrS 2322

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