Minutes of the discussion on lubricating oil testing in the B.M.W. 132N single-cylinder engine 14.1.44. at the Travemünde test-station.

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After a short speech of welcome by Fl. Stabsing Kübler, Glaser reports on the progress of the experiments at the D.V.L.

1. Experiments at the D.V.L.

It had already been reported in the circular No.7, and mentioned in the discussion of 16.11.42., that deformation phenomena occurred with various pistons, thus leading to erroneous results for the lubricant test. Another short report is made on the experiments which have already been described in the circular No.7*. It is therefore superfluous to quote these experiments here once more. The conclusion was that the troubles observed so far had two different causes. The deformation phenomena were caused by the cylinder, whereas the too short running times could be linked up with the piston.

In order to throw further light on the causes of these findings, the D.V.L. has in the meantime undertaken a further series of experiments; due to air-raids it was unfortunately impossible to conclude these experiments. The lateral ring-play in new or little-used pistons (15 to 20 hours) was, according to measurements of the D.V.L., only 0.1 mm. throughout for oversized rings, instead of the intended 0.15 mm. The D.V.L. therefore followed its earlier experiments with an experiment in which the lateral ring-play was 0.15 mm., a piston supplied by the I.G. being used. The experiment was broken off after 9 hours, since no definite decrease had occurred in the power. The first ring was, however, about 20% stuck, so that after 9½ hours the usual end to the test would probably have taken place (Experiment 1026).

In earlier experiments with the N.S.U. engine it had been found that the temperature of the piston is appreciably affected by a change in the lateral ring play under otherwise constant conditions (compare the D.V.L. report FB 1679). The experiments at that time showed that at the same piston temperature the running time before ring sticking occurs is nearly proportional to the volume to be filled up by the deposits. Since, when ring-sticking is tested in the B.M.W.132, only the external conditions are kept constant, the temperature of the piston falls when the lateral ring-play is increased. If only the space to be filled were of importance an increase of 50% in the lateral ring-play should only increase the running time from 5 - 7½ hours. The above experiment showed (1026) that the ring-sticking time was considerably longer, so that in fact it can be assumed that the increase in the ring-play has caused a fall in the temperature.

* Two typographical errors have to be corrected in the Tables attached to Circular 7. In experiment No.1020 the ignition timing was 32° B.T.C.(not 52), and in experiment No.1024 the running time was 5.0 hours (not 0.5).

In order to examine this problem still more closely, some further experiments were now carried out in which a piston was used, the temperature of which could be measured according to the required method (compare UM 695). A running time of 5 hours was attained with this piston when the lateral ring-play was 0.10 mm. (Experiment 1016). With 0.15 mm. play a fall in the temperature of the piston by about 12° could be observed. The running time before ring-sticking was 8.3 hours, (Experiment 1027). In a further experiment with a lateral ring-play of 0.175 mm., the temperature of the piston fell by another 11°; the ring-sticking time was 7 hours. This running time could, however, be considered to be correct since the contact springs broke after 5 hours, thus causing the engine to run irregularly for a short period of time. It was intended to repeat this experiment before the present discussion took place. In consequence of bomb damage this matter could not be pursued.

These experiments show that lateral ring-play has a great effect on the running time. The rather large difference between the results of experiments 1026 and 1027 is probably mainly due to the fact that the lateral ring-play can only be kept within limits of ±0.01 mm. When, however, the ring-play is increased from 0.10 to 0.15 mm., and this causes an increase in the running time by about 60% or more, then this error of ±0.01 mm. may easily cause a change in the running time of ±10% or more.

For this reason it would be extremely desirable if the lateral ring-play could be confined in future within still smaller limits. It is evident that these variations are less important for larger lateral ring-play than they are for the small play of 0.10 mm. It should be kept in mind that these are only the preliminary results of the D.V.L. investigations. A final confirmation can only be obtained by further experiments in this direction. As soon as this point has been clarified, the D.V.L. will again report on the progress of experiments.

2. Progress of experiments at the Rechlin test-station.

At the Rechlin test-station too, the reproducibility of the test-runs has lately become very bad. For certain cylinders the formation of a ridge was observed on the upper piston land; this did not, however, have quite the same character as that observed by the D.V.L. No building up could be observed in the top groove, but a projecting nose-shaped formation at the upper land of the piston (see sketch). This deformation of the piston always appeared first when steps had been formed on the running surface of the cylinder at the top centre of the first piston ring. For certain cylinders this happened even after a very short time, whereas others could be run for a long time without any trouble. In this connectionSeroka points out that a considerable deviation from roundness could also very soon be observed in the cylinder. The Rechlin test-station has tried to eliminate unsuitable cylinders by means of hardness tests. It was found that the specified hardness of 270 Brinell was very often either exceeded or not reached. The cylinders of the constructional series A in general had a Brinell hardness of 341, whereas low values down to 221 were often found in N-cylinders. No connection could, however, be observed between the hardness of the cylinder working surface and its suitability for the ring-sticking test. One cylinder, for example, for whose running surface the low value of 221 had been found, was employed in a very large number of experiments which yielded reasonable results.

3. Conditions of operation.

(a) Control temperature and ignition. Kübler points out that the Travemünde test-station has made more than 100 unexceptionable oil test runs in the course of the last year. On the basis of the rich crop of experience gained, Kübler ascribes the observed troubles to the choice of unfavourable experimental conditions. The Travemünde test-station employs a thermo-couple to measure the control temperature; the thermo-couple is situated below the sparking plug and built into the sparking plug sealing washer. The best experiments have been made with this arrangement. The D.V.L., on the other hand, has found that when the control temperature usual up till now is altered (D.V.L. double-thermo-couple as plug in the injection boring) there was no effect on the temperature measured below the exhaust ignition plug. The other stations have so far used the D.V.L. double-thermo-couple for measuring the control temperature, but the former has often been destroyed in dismantling. The D.V.L. points out that the thermo-couple must obviously not be pulled out by the wires after the experiment, but that it must be hammered out from the inside by means of a pin of a soft material. Lange proposes changing the construction of the plug, since the most varied residues are formed in the slit between the boring and the plug in the course of time, these residues affecting the transfer of heat, and therefore probably also the measured temperature. The D.V.L. consider that this does not play a large part; it is important only that the oblique faces of the plug fit very well into the cone cut into the boring. The transfer of heat at this point is then so good that the measuring points provided on the outer face of the plug are affected much more by the heat transferred at this point than by the temperature of the filling piece lying in the boring.

In order to guarantee a good metallic contact in the cone, the thermo-couple ought to be slightly ground in before each test run. The D.V.L. is going to produce a small holder for this purpose, so that the plug may be moved easily. Grinding-in should then present no more difficulties in future.

Wenzel is of the opinion that the thermal behaviour of engines differs very widely; thus the temperature in the ring groove is probably decisive, for the running time differs extremely widely under the same external conditions. In the table below, the most important conditions are summarised for the sake of clarity, according as they are maintained at the several stations, and as they influence the thermal behaviour of the engine.

Test station	Travemünde	Rechlin	I.G.	Shell	D.V.L.
Ignition, °B.T.C.	32	40	34	35	32 (previous 40)
Temp. measured with DVL double element °C.	260-265	263	injection	280	283
Temp. at plug-ring (Exhaust side) °C.	240	-	-	256	259-266
Temp. at cylinder-head °C.	-	-	250	-	-

(The underlined values indicate the position of the control temperature installation.)

As, so far, it has unfortunately not been possible to obtain identical results under uniform experimental conditions, the conditions should always be adjusted in such a way that they correspond to a running time of 8 hours with Rotring D. calibration oil. In order to have but one variable factor, it was decided that in future all test-stations would run their experiments with 32° ignition advance, and then to choose the control-temperature so that 8 hours' running time is obtained with the calibration oil.

(b) Lateral ring-play: On the basis of the experiments hitherto carried out by the D.V.L., they propose to increase the lateral ring-play still further. As, however, the Travemünde test-station has shown by a large number of experiments that good reproducibility can also be obtained with the oversized rings, and as the Rechlin test-station still has doubts about the great influence of the lateral ring-play, it is decided to keep to the oversized rings used up to now.

The D.V.L. points out that in general the lateral ring-play contains a large personal factor when measured by means of a feeler gauge. On the occasion of a tour by Dr. Krienke in November, 1943, it was observed that some of the stated differences in the lateral ring-play of new pistons and new rings are partly due to one station inserting the gauge into the slit relatively loosely, the other using a sliding fit and the third inserting it very tightly. This may account for differences of up to more than 0.03 mm. The feeler gauges themselves, moreover, are often very inaccurate. It is therefore very important that the lateral ring-play is always checked by one and the same person using one set of gauges.

(c) Compression: Some cylinders are a little too short, so that at the bottom dead centre the lower piston ring goes a little beyond the end of the cylinder at the compression ratio of 1:6.4 used so far; this ring then mostly tends to break. For this reason the compression is to be put up to 1:6.5 ±0.05 in future.

4. Deformation phenomena in the piston.

The deformation phenomenon in the piston, on a larger scale, has only been observed by the Rechlin test-station and by the D.V.L. It is certainly due to excessive tilting of the piston. As far as it has been possible to judge from the experiments made so far, this is probably connected with a change in the cylinder. The manufacturers have unfortunately not been able to give any information so far. It can, however, be assumed either that the material of the running surface and therefore also its thermal properties have deteriorated, or that there is a greater expansion in the warm state, due to a change in the method of connecting cylinder and cylinder head (different amount of shrinkage).

Whereas the deformation phenomena observed by the D.V.L. can easily be explained by too great a tilt of the piston, the malformation observed by the Rechlin test-station is probably due to the ridge formed in the running surface of the cylinder at the top dead centre of the first ring (probably also due to the strong tilting of the piston) being hit by the upper land of the piston when the latter runs upwards and thus being knocked out in the shape of a nose.

Since no a priori method has so far been found of separating the suitable cylinders from the unsuitable ones, one has to try to alleviate this difficulty by means of the piston. Some experimental pistons have kindly been placed at the D.V.L.'s disposal by the Electron Company, Camstadt; the running surface of these is less barrelled so that the tilting of the piston can probably be reduced in this way. The D.V.L. is going to start on these experiments very shortly, and hopes to be able to give information on the suitability of one or the other kind in a very short time. The Electron Company has offered to manufacture a larger number (800 to 1,000) of these pistons, if that should become necessary, and to supply them to the state-owned depot (Olex, Rummelsburg). In this case the Air Ministry will place the pistons of the present type stored there at the disposal of the Air Force.

5. End point of experiment.

Experiments carried out by the D.V.L. some time ago showed that the end point of the experiment, i.e., the instant when ring-sticking starts, is still comparatively ill-defined. If a run is made so that for the calibration oil there is a distinct decrease in the power output and a high blow-by, one can in most cases observe after only 6 to 6.3 hours, a very short and therefore indistinct power-drop (lasting about 10 seconds), which is accompanied by an equally small and short pulse of gas-pressure. If such a run is interrupted after this first small power-drop, it is shown that the first ring is already stuck. The D.V.L. has employed this first criterion as indicating the end-point of the experiment. In order to reach a running time of 8 hours once more, the control temperatures were reduced by a corresponding amount (from 265°C. to 261°C. at 40° pre-ignition). As, however, the onset of ring-sticking, determined in this way, could only be observed with careful supervision, and not with certainty, the D.V.L. is now providing the second groove also with four holds of g* = 2.5 mm., distributed evenly along the circumference in such a way that the lower edge of the borings is in line with the lower face of the groove. After this measure had been adopted, the end-point of the experiment emerged extremely clearly. The reproducibility of the ring-sticking runs was not thereby impaired. The D.V.L. has therefore kept to this innovation. It is proposed that this boring of the second groove in the manner described above be generally adopted. It goes without saying that all the piston rings have to remain in the grooves, in order to change the transfer of heat as little as possible.

6. Interruptions of the experimental runs.

The present situation has repeatedly made it necessary to interrupt the experimental runs on account of air-raid alarms. In genera. it was found that when the experiments were continued later on, the results were inaccurate. It is therefore desirable to carry out the experiments without interruption whenever possible.

* in the talk itself the diameter was given by error as 3 mm.

7. Reliability of the experimental results.

As the immediate testing of a lubricant is nowadays quite often required by one or the other authority, Glaser proposes that the Air Ministry leave to the several test-stations the responsibility of deciding whether the oil to be tested can be compared with the calibration oil. It has, for instance, happened at the D.V.L. that a test had at first had to be rejected, since the engine had a running time of only 5½ hours with the calibration oil. This experimental result, however, was reproducible. A comparative experiment with Grünring gave a running time of 9 hours. Thus it was proved that the ratio of the running times of Rotring D and Grünring had remained constant (according to earlier experiments, Grünring gives a running time of from 12.5 to 13 hours, corresponding to a running time on Rotring of 8 hours); any oil might therefore very well have been tested in this engine. As, however, the Air Ministry lays it down, that under any conditions tests may only be carried out under conditions such that the calibration oil gives 8 hours, the cause for the shorter running time had to be sought first; this again meant the carrying out of an appreciable number of experiments, so that tests were held up for a considerable time.

Dietrichs, on the other hand, holds the view that the standard running time of 8 hours must be kept to under all circumstances, as otherwise the Air Ministry will have no reliable basis for the experiments. He asks, however, that Dr. Beyer himself should present his own views, so that a final decision can be taken in this question.

Krienke asks for views on the fundamentally important question as to whether the ring-sticking method in the B.M.W.132 single-cylinder engine should in the immediate future be developed with the aim of arriving at a standardised test-method with fixed test conditions (as in fuel testing), or whether the various test-stations should continue to vary their operating conditions until the calibration oil gives the required running time (i.e., in practice each station in a different way).

Dietrichs regards the latter method as the only one which is expedient and defensible today.

8. Wear measurements.

Krienke points out that a determination of the piston ring wear in terms of weight allows of a comparatively reliable assessment of the lubricating properties of the lubricant under test. He therefore requests that the other stations also take measurements in this way and report their results to the D.V.L. Glaser points out that when the ring wear at hourly intervals is plotted against the running time curves are obtained similar to those plotted at the time by the Travemünde test-station for the quantity of oil-carbon found in the grooves; in measurements of wear also, the points obtained during faulty runs lie outside the curve.

9. Replacement crank shafts.

The Air Ministry has succeeded in getting in stock some more replacement crank shafts. As these have not yet been prepared for the single-cylinder engine, the various stations will have to adjust the balance-weights accordingly. All those that are unable to undertake this work by themselves are requested to return the replacement crank shafts they have received as quickly as possible to the government storage depot (Olex Rummelsburg, Mr. Miedreich). The necessary work on the shafts will then be attended to.

10. Running-in oil.

The experiments with running-in oil instigated by the Air Ministry have not yet made enough progress for any such lubricant to be used for the running-in of pistons and cylinders in the oil test engine. It is to be expected that more will be known on this point within about six months.

11. Ring-sticking experiments in the D.K.W. engine.

The D.V.L. reports that in agreement with the Air Ministry, it originally had the intention of investigating the suitability of the air-cooled D.K.W. engine EL 462 for ring-sticking experiments. On receiving a communication from the Auto-Union that such an engine could be supplied from stock, the D.V.L. made out an order to the Auto-Union. The engine was not delivered, however, in spite of repeated reminders; only in the beginning of January, without any further consultation, a liquid-cooled engine EW 462 arrived at Adlershof. For this reason the D.V.L. has not been in a position to carry out any experiments with the air-cooled engine; the D.V.L. will start the corresponding investigations with the liquid-cooled engine in the very near future.

Dietrichs reports that the Air Ministry is just now having a number of test-stands prepared with the D.K.W. engine EW 462, and that it has the intention of utilising these engines for the supervision of current production and for acceptance tests.

Wenzel points out that the engines are apparently only slightly sensitive to temperature conditions, so that ring-sticking tests can in all probability only be carried out under the conditions formerly laid down. It is very difficult to put a thermal strain on the piston ring region (confirmation of this observation by the D.V.L., comp.FB 1679). For this reason, Intava requests the D.V.L. to carry out experiments with the air-cooled engine EL 462, in particular to find out whether this engine is more easily affected thermally from the outside than is the liquid-cooled engine. Intava is very interested in these experiments, and will carry them out by itself if that is possible, and if the D.V.L. should not be in a position to do so.

Intava has succeeded in securing yet a greater number of such engines from a service-station in East Prussia, where the engines had originally been provided for fire-brigade pumps; for unknown reasons they cannot be used for this purpose.

The difficulty of procuring the coolant is also pointed out. Ethylene glycol can still be obtained from the Reichsstelle Chemie. Experiments by the D.V.L. have shown that dynamo-oil or super-heated steam-cylinder oil may also be used for higher cooling temperatures.

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