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REPORT

on

THE TESTING OF LUBRICANTS IN THE BMW 132 SINGLE CYLINDER ENGINE.

by

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THE TESTING OF LUBRICANTS IN THE B.M.W. 132-SINGLE CYLINDER ENGINE.

General: The modifications carried out to the B.M.W.132, the additional apparatus as well as the test conditions for lubricant testing are described in this report.

Contents:

I. Introduction.

The I.G. Farbenindustrie technical test station, in collaboration with other such laboratories, is carrying out the engine testing of aero-engine lubricants in the B.M.W.132 aero-engine. Owing to some shortcomings in the method, certain modifications have been made.

These modifications, and the apparatus as it is at present, as well as the test procedure, are described in this report.

II. Modifications to the standard engine.

a) The engine.

The engine consists of an old, type A, radial crankcase with a new, N-type cylinder with full scale cooling baffles (Fig.1.). To keep the hold-up of residual oil after oil changes to a minimum, and to restrict the lubrication to places where it is needed, the following modifications have been carried out.

The hollow in the crankshaft which was used for airscrew adjustment has been cut off from the lubricating system by an insert (Fig. 3 and sheet 7). The design of this insert allows the lubricating oil to flow through a small steel tube to the oil spray ring situated in the main bearing. The drilling for this small tube was made at the same time as the alterations to the crankshaft. Also the lubrication holes in the master connecting rod for the eight secondary connecting rods were sealed. The other eight cylinder flange openings are closed with inserts of which Nos. 4 and 9 carry the engine mountings and Nos. 3, 5, 6 and 8 have hot plates of 700 watts each (Fig. 4 and sheet 8).

b) The valve mechanism.

In the front part of the crankcase, the borings for the push-rods were plugged and sealed. The corners of the four strengthening ribs of the case (Fig.5) were removed to obviate trapping any oil residues. The external valve, governing the hydraulic variation of the airscrew pitch, was taken off and the connections were blanked off. The tube leading to it was removed and the connection at the distributor in the front half of the crankcase was sealed by a screwed plug. (Fig.6). The valves are pressure lubricated, the amount being limited by jets installed before the rocker bolts. Excess oil flows back into the crankcase.

c) Engine parts.

To decrease the dead space, the oil passages in the magneto driving shafts were sealed (Fig.7). The starter shaft was extended and its bearing box was packed and made air-tight. The blower coupling has been removed, a blank was inserted on the bearing cover as well as a cover plate being fitted at the end of the crankshaft (sheet 10). The spray nozzles for the lubrication of the blower drive were sealed (Fig.10). In the blower section, the connections for the 9 supercharge pipes were fitted with plugs and closed with a cover and screw cap. The carburettor connection for the main engine is sealed with a cover (sheet 11).

d) Auxiliary apparatus.

1. Lubrication.

To keep the quantity of oil needed for a test run to a minimum, the main engine oil cooler has been removed and an oil sump (Fig.11, 12, and sheet 12) installed. In place of the oil cooler a container of ca. 8 litres capacity was fitted. The pump draws oil from the bottom of this container (Fig.13 and sheet 13) and pumps it, after passing through the engine, to the top, through a foam separator. Another container, which can be weighed, allows for continuous replenishment and measurement of the oil used during the test. The circulation system reservoir is fitted with a gauge glass and overflow to keep the amount in circulation constant, a water jacket for cooling and an immersion heater to keep the oil at a given temperature. Additional heating is provided in the flanges on the cylinder openings 3, 5, 6 and 8 as mentioned previously in IIa.

2. Induction air.

The intake air, which is kept at a constant temperature, reaches the engine partly via a water cooler and partly from a heat exchanger placed round the exhaust silencer. Both branches can be utilized by means of an adjustable cut off valve and the desired temperature is thus obtained. The water cooler is only used when the outside air temperature is too high. An alternative is provided whereby fresh air is drawn in and kept at a temperature higher than any summer temperature by electric heating: the air is also cleaned by a wet filter.

3. Fuel.

The engine runs with fuel injection, the injection being by a Bosch single cylinder pump, type 1/110 V 635 and a nozzle DN 60 N 40 M6 with a static injection pressure of 60 atm. The pump is driven by an auxiliary horizontal drive shaft and is located on a bracket fixed to the engine mounting (sheet 15). To prevent vapour lock in the suction line, the fuel is fed by a supply pump at 0.8 - 1.0 atm., the latter, a Graetzin ZE 135, being driven from the lower end of the left, vertical, auxiliary drive shaft.

4. Ignition.

The ignition is by 6-volt battery and double coil - Bosch TC 6 x 2. The breaker, a Bosch VU I C with manual adjustment, is driven by the right, vertical secondary shaft (sheets 16 and 17) and has an adjustable range of 30° crank angle. A high tension glow bulb can be connected in parallel with each of the two spark plugs and by illuminating a mark on the fly wheel enables the ignition timing and the spark plugs to be checked. The spark plugs used were either Bosch DW 200 GI or W 225/T6.

5. Cooling air.

A centrifugal blower provides the cylinder, which has the usual full scale cooling baffles, with cooling air via a channel of trapezoidal cross section. A branch of the pressure line can be regulated in such a manner as to allow additional ventilation of the room. The hot air flows into the room. A device is proposed, with which, as in a wind tunnel, this air can be recirculated by the blower.

An adjustable amount of unheated air on the suction side permits control of the cooling air temperature. The fan is regulated on the suction side by a hand or motor driven throttle valve.

III. Measuring instruments.

a) Oil consumption measurement.

The main oil container, described in IId 1, holds a constant amount of oil, the oil consumed being replenished from a container standing on a sliding weight balance. To take care of variations, the supply is slightly greater than the consumption, the level being kept constant in the main container by an overflow with a collecting vessel. At the half-hourly checks, the collecting vessel is emptied into the container on the balance, so that the actual consumption can be measured in grms./hr.

b) Fuel and speed measurement.

The fuel and speed measurement is carried out by random tests using a SEPPELER type fuel measuring device in conjunction with a rev. counter and a stop watch. There is a gravity feed to the measuring vessel from another container of 20 litres capacity.

c) Power measurement.

The power is measured by a water-brake with an inclined weight rapid balance and the above mentioned revolution counter.

d) Temperature measurement.

After extensive tests at different locations, the best place for the measurement of the standard temperature - at which the tests are to be run - was found to be the top of the cylinder head. The installation of the iron-constanton thermocouple is shown in the diagram on sheet 17. It is possible to keep this temperature within -0.5°C of the constant value by hand regulation of the fan. Checked also are the temperatures of the exhaust spark plug seating, the cylinder head underneath the exhaust bend, and the exhaust gas temperature. Oil and intake air temperatures are measured by resistance thermometers and kept constant.

e) Blowby determination.

The amount of blowby at the rings is determined as pressure by a liquid manometer and recorded by a pen controlled by floats; a recording dial gauge may be used as an alternative. It is imperative to make the crankcase and bearings - especially the air-screw bearing - air-tight, to enable a sensitive pressure recording to be made. Fig.14 shows the DVL (Report UM 546) method of packing with felt and a cover ring. The different parts of the crankcase are interconnected by large diameter pipes which serve as collecting leads for the blowby (Fig.15). In the front of the photograph a hose connection can be seen for the oil flowing back from the valve chamber.

IV. Test procedure.

After a run has been completed, the oil, still hot, is drained from the cock and a sample is taken for testing. After the cylinder has been dismantled, a flushing cylinder and piston are fitted. The cylinder consists of a liner, the top of which is closed with an oil baffle and a screwed, perforated steel cover. The piston is a normal piston with run-in rings, the crown having a hole in the middle of ca.50 mm. diameter to obviate any pumping action. Flushing oil is now put into the engine via the oil container; if the engine is very dirty the oil is mixed with 80% benzol, and the engine motored for one hour at 1000 r.p.m. by the electric motor. The oil temperature rises to about 80°C. After the flushing is completed, the oil is drained and the new oil to be tested is added. During that time the rating of the test piston is assessed and it is then placed for 2-3 hours in concentrated nitric acid. The oil carbon is thus softened and can afterwards be removed with a fibre brush. This procedure was investigated and examined from all angles as to whether it had any harmful effect on the piston. No corrosion or any other harmful effects were found to take place. Small grooves and any remaining dirty spots can be cleaned carefully with a scraper. The piston is then measured at 20°C., new rings are fitted and it is put back with the cylinder, which has also been measured. 0.65 mm. is the maximum clearance allowed between the average of the measured values of the cylinder and piston on the thrust and gudgeon pin axes. This clearance is usually reached after 150 hours running, when the cylinder and piston are replaced.

After the engine is re-assembled, the 8-10 litres of oil in the container are heated to 80°C. by an immersion heater. The ignition is switched on, until, with the auxiliary engine heating the oil in and outlet show a temperature of 80°C; then the fuel is allowed to flow and the run started. Running under full load is reached according to the following plan:-

10 minutes	1500 r.p.m.	engine idling,	ignition advance	30°
5 "	1900 "	19 H.P.	" "	34°
5 "	1900 "	38 "	" "	34°
5 "	1900 "	57 "	" "	34°

In the next 10 minutes temperature and consumption are regulated and brought to the required values, if necessary the engine power is corrected.

The following measurements are taken:-

Every quarter of an hour: all temperatures, consumption power.

" half-hour: oil consumption.

A power drop of 2-3% and a simultaneous strong blowby are the indication for ring sticking. The engine is switched off at that moment.

For oil tests based on the time to ring sticking, the following constants are observed:-

R.P.M.	1900
Ignition	34° B.T.D.C.
Power	57 H.P.
Injection starts	30° A.T.D.C.
Fuel consumption	2200 Kal/HP/Hr.
Oil	3.5 - 9 g/HP/hr.
Oil temperature	20 (40)°C.
Cylinder head temperature	250°C.

V. Summary.

The modifications described, the present condition of the apparatus and the actual testing operations permit steady working conditions for the test engine. Tests are being carried on to shed some more light on the spread of oil carbon formation and ring sticking times.

We shall report on these when the investigation has been completed.

(SIGNED) LAUER.

Encl: 6 sheets photographs
11 " diagrams.