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Report No. 474 by Technical Test Station Oppau.

Note on testing the knock behaviour of fuels in a small test engine.

Survey. The DVL supercharge method for testing aero-engine fuels in the BMW 132 has the disadvantage that the installation and maintenance costs are high. At least 30 litres of fuel are required for one test. The I.G. test engine, which is solidly constructed, and has a capacity of 1 litre, is without these disadvantages. It therefore seemed that it would be a good thing to convert the I.G. test Diesel, which is found at many fuel testing stations, for use as a small super-charged engine.

As regards construction parts and test conditions, the I.G. test Diesel was very similar to the BMW 132 super-charged engine. The engine data, boost pressure, and mean effective pressure were maintained at the same rate as in the BMW 132 supercharged engine, when plotting knock limit curves.

The knock limit curves recorded with this super-charged engine are similar to those of the BMW 132 single cylinder, they have a maximum and a minimum, and also bring out the steepness of the curves of fuels with an aromatic content. The rating of the fuels is the same as with the BMW 132 super-charged engine.

Object of the tests

The tests are intended to show how far it is possible to obtain knock limit curves in an I.G. test engine by altering some constructional details and by operating it under tests condition as near as possible to those of the BMW 132 single cylinder super-charged engine, which only differ slightly from those of this test engine for aero-engine fuels of high anti-knock value. It was also necessary to find whether the fuels are rated in the same order.

Construction of the Test installation

A normal I.G. test Diesel, such as is found in many forms at the various fuel-testing staions, was used for these investigations.

The I.G. test Diesel was approximated to the BMW 132 supercharged engine by exchanging or installing the following parts:-

1) Gasoline-engine cylinder head, as in drawing KD 27101a.
2) Flat piston, as in drawing KD 6201.
3) Light fuel injection pump, with injection in the suction stroke, type Bosch PZ 1/110 V 635a.
4) Injection nozzle, Type Bosch D/V 2081 U 4
5) Magneto, Type Noris, E 1 F H
6) High duty sparking plug, type Bosch W 280 T 7.

These are the principal parts which are already available for running the I.G. test Diesel as a gasoline engine.

As the engine has an injection device, it is not so dependent on the volatility of the fuels as a carburetter engine. The exchange of the piston with a flat top for the Hesselmann Cup-shaped piston, as in drawing KD 23203a makes it possible to investigate also high boiling safety fuels. Finally, for special investigations it is possible to attach a second injection pump without special difficulty.

The construction of the test installation is shown by the diagram and the photo which follows it.

A swinging dynamo was coupled directly with the I.G. Test Diesel to measure the power. The dynamometer also serves to start the engine, which is started and loaded by means of a button switch.

The boost air was taken from the mains. The boost pressure was adjusted with a finely-controlled throttle. A damper was installed in the boost air pipe to compensate for the pressure fluctuations. The boost air was heated to the required temperature by electrical resistances. The temperature of the boost air was set and controlled with a mercury thermometer. The boost pressure was read off on a mercury manometer. The air volume was not measured for fuel/air ratio calculations, since this was not strictly necessary. The fuel is supplied in the same way as in the I.G. Test Diesel, and is fed to the injection pump from measuring vessels by gravity. The fuel was measured volumetrically, with the aid of a stop watch. As a protection fuel filters were connected before the injection pump.

Nothing was altered in the lubricating arrangements of the I.G. Test Diesel, except for the addition of a lubricating device for the fuel injection pump.

The engine had an easily adjustable through flow liquid cooling arrangement. It is the intention to change to circulatory cooling when the larger condenser planned for gasoline working is completed.

Test Method

There were two possible ways of recording knock limit curves

1) To alter the boost pressure while keeping the compression ratio constant.

2) To vary the compression ratio while keeping the boost pressure constant.

The difference between the two processes lies in the fact that in the first case the compression pressure only is changed, the compression temperature remaining constant, while in the second case both change simultaneously. Although the second process was possible in the I.G. test engine, which has adjustable compression ratio, the first was preferred, on the basis of the BMW 132 super-charged engine *) quite apart from the fact that it was simpler to alter the boost pressure than to adjust the compression ratio,

The engine values, that is, mean effective pressure and boost pressure, were retained, in order to approximate the process to the BMW 132 super-charged engine.

Since the engine has a capacity of only about 1 ltr; little fuel is

*) Originally the engine was intended to work on the ignition lag principle, but the idea was r ejected for the same reason.

consumed in recording a knock rating. It is also possible, by using the reference fuels octane and heptane, to establish correlation with octane number, and to ignore the engine constents.

In recording the knock limit curves the intensity of knocking was fixed at 6-10 knocks, in accordance with regulations.

Test Results

The knock limit curves obtained with an I.G. test Diesel are compiled in plates 1446-1452. The test conditions were:-

Engine speed : n = 1600/min.
Compression ratio = 1:8
Boost air temperature = 80°.

Ignition was not varied and was at 20° before top dead centre. The TPr.S plates Nos. 1446-1452 show the knock limit curves obtained with the reference fuels 1817, 1869, 1868, and 1861 in the I.G. test Diesel.

In TPr.S plates 1447 to 1452 the knock limit curves with other fuel samples are shown, and compared with those of the BMW 132 super-charged engine.

The following conclusions can be drawn

1) The knock limit curves obtained in the I.G. test Diesel follow the same trend as those for the BMW 132 super-charged engine. Their minimum is in the region of the air excess, and their maximum in the fuel excess region, and they also reproduce the greater steepness of aromatic fuels.

2) The order of rating of the fuels is the same as in the BMW 132 single cylinder engine.

As it was to be expected that the effective pressure at the knock limit would show a dependence on the two processes, TPr.S. plate No. 1454 compares the effective pressures obtained with the same fuel samples at the same air ratio by the two processes. It appears that there is a certain proportionality between the two effective pressures. As there is some inaccuracy of measurement in both processes, the relation ship between the two can only be shown as a broad band of test points.

The results show that the investigations, originally only intended as initial tests, are very promising.

The tests should therefore be continued with a view to simplifying the process further, and to bringing about an even closer agreement with the knock limit curves of the BMW 132 super-charged engine, by reproducing the compression ratio and the boost air temperature of the engine.

Sheet 1, 2, 3, 4, 5, 6 and 7

Knock limit curves by the supercharge method
Engine type — compression ratio
Blower air temperature

Test fuel

Sheet 8. Relation between the mean pressures of the BMW 132 and the I.G. Prüfdiesel.