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EFFECT OF THE CETANE NUMBER OF DIESEL FUELS ON THE STARTING BEHAVIOUR

In rating the starting behaviour of Diesel fuels, it is customary to use the cetane number as an indication.

In the course of fuel investigations, the Technical Test Station was also concerned with the problem of starting Diesel engines, especially at low temperatures. Among other things, the following investigations were made into the dependence of starting behaviour on the cetane number.

The tests were made in the cold chamber at temperatures down to -25° on two I.G. Test Diesels. Altogether, 12 samples of Diesel fuels for Armed Forces and Commercial use with cetane numbers between 23-80, were investigated.

The test was carried out in the following manner:-

The test Diesel was motored over by an electric motor at 100 rpm. This low engine speed was chosen because it is customary for starting in practice. An automatically disengaging coupling prevents the electric motor from braking the Diesel during the start. The tests were made in such a way, that the critical compression ratio, that is the compression ratio at which the engine actually started, was determined for each fuel. To avoid undesirable heating of the engine, or the accumulation of unburnt gas oil in the combustion chamber, a starting time of 20 secs. within which ignition must occur, was laid down. After the test the engine was left idle until it had cooled off. The appended sketch shows the results of these tests:-

(Figure)

With falling temperature the critical compression ratio rises. This is quite natural, since lower compression temperatures are reached in the combustion chamber. The individual gas oils are distinguished by the height of their compression curves (1-4)

If vertical sections are made through these curves, that is, if the critical compression ratios at various temperatures are super-imposed on an abscissa, say that of the cetane number, the result is as shown in Fig 1307. The values at + 10°, 0°, -10°, and -20° are entered here, and joined by lines. The similarity of the four lines is remarkable, but there does not appear to be a dependence on the cetane number. The picture is equally misleading on plotting limiting temperatures for equal critical compression ratios. (Fig.1308)

A glance at the boiling curves of the 12 fuels shows that they all behave differently. (Fig.1310). To return to the first figure (1307) along the lower edge are given the 10% point, 50% point and Initial Boiling Point of each gas oil.

In the region of the lower cetane numbers, one is struck by the low critical compression ratio of fuel number 3. The reason is the low initial boiling point of 36° compared with 144° and 63° for the neighbouring fuels. Comparing points 1 and 2, one finds that, in spite of the rise in the cetane number, there is no improvement in starting behaviour, since the boiling range of fuel 2 is about 30° higher.

Professor Marder has attempted to find a relationship between the cetane number as measured in the engine and specific gravity (ATZ 1937, determination of the ignition quality of Diesel fuels). He found that this is only possible if the 50% point is also taken into account. He established the formula Cetane No. = ~~specific gravity by hydrometer~~ Corrected Cetane No. - (300 - 50% ~~point~~ M.B.P.).f.

He proceeds on the assumption that with gas oils of the same 50% point e.g. 300, there is sufficiently accurate agreement between the cetane number and the Specific gravity, while for other oils the above conversion is necessary.

Since it is evident that in our tests only fuels with the same boiling range behave in accordance with the cetane number when starting, the need for a similar conversion was indicated.

We have therefore adopted Marder's procedure in our studies experimentally.

If this calculation is made with our fuels, and the critical compression ratio is superimposed on the corrected abscissa, then for 0° we have the curve shown in Fig. 1311. For purposes of comparison, the values of Fig. 1 are superimposed on the cetane number as determined in the engine. The cetane numbers are so displaced that the dependence of starting behaviour on on the cetane number becomes clearer. This is especially clearly seen in the case of fuel 10 (Baden gas oil), which at first is completely out of the picture, but has a satisfactory value when the displacement has been made. The next figure (1312) shows the curves for the other temperatures, +10, 0°, -10°, -15° and -20°C superimposed on those of the calculated cetane number, CaZ 300. It will be seen that up to -10° the deviation is slight, but that at -15° and especially at -20° it becomes greater. Also the gradient of the curve increases as the temperature falls; i.e. for a Diesel fuel with a low CaZ 300, the starting behaviour depends more on the temperature than it does in the case of a fuel with a good CaZ 300.

The variations at -15° and -20° show that Marden's correction is clearly insufficient. In Fig.1312 are also shown the viscosity coefficients at -20° and the cloud or crystallisation point, for the individual Diesel fuels. Comparing the viscosities of adjacent points e.g. 7,9 and 3, we see that as viscosity falls the critical compression ratio becomes smaller, so that gas oil ignites more easily if the viscosity is less. As the external temperature rises the influence of viscosity declines, as becomes especially clear on comparing fuels 3 and 11.

These three data alone do not appear to determine the starting behaviour. The example of gas oil 1 shows this, for despite good calculated cetane number and low viscosity its starting properties are poor. Measurements near the clouding or crystallisation point, say with fuel 10 at -10°, show that there is a sharp decline in ease of starting.

The tests show in the first place that the cetane number measured in the engine, whether by the ignition lag method or by the HWA method, is no criterion of the starting behaviour of the fuel at any rate at external temperatures below 0°. A cetane number calculated from the boiling range gives a better rating. Probably starting behaviour is influenced not so much by the 50% point as by the Initial Boiling Point or perhaps the 10% point. At low temperatures the viscosity also has an effect.

Our tests are not yet over. It is to be hoped that when more evidence becomes available it will be possible to obtain a useful characteristic for the starting behaviour of Diesel fuels by simultaneous consideration of cetane number, boiling range, and viscosity.