FD2866,461t92

B.I.O.S. No. A104

I. G. Oppau Report No. 489

22.1.42. - Singer.

OCTANE NUMBER DETERMINATION BY THE OPPAU METHOD

Synopsis - Aviation fuels can be tested in the I. G. test engine according to the Oppau method by fitting additional equipment. This is described together with the test procedure. For the interpretation of the figures obtained, see the following report No. 490.

Contents

This report contains data for octane number determination according to the Oppau Method. Report No. 470 describes the development of this method. This permits the rating of current leaded aviation fuels of paraffinic or aromatic structure in a similar way to the DVL supercharge method. Under the conditions described below the method is not suited to testing unleaded fuels, or fuels with particularly high benzene additions or alcohol blends. The testing of these fuels will be dealt with in a later report.

The evaluation of the results obtained on the test engine is described in the following report No. 490. Report No. 491 compares the results of the Oppau Method with those of the DVL supercharge method. Report No. 492 contains the results of comparative tests with the Oppau Method.

I. Description of the Method.

The oppau method indicates the octane number of aviation fuel in terms of excess air ratio. The result is not one single figure for a gasoline, as in the traditional octane number determination but as many values as there are tests carried out at various air ratios. The oppau method is therefore a multi-point method for the evaluation of fuels. The results obtained are usually presented as a graph; naturally they can also be expressed by numerical values, for which the octane number is particularly suited since it is well known from the usual knock rating system and it offers the advantage that the fuel rating is largely independent of the engine data. This is a good point, because experience shows that these quantities are always subject to certain variations.

The different values for a given fuel are obtained by varying the excess air ratio. The maximum knock intensity corresponds generally to an excess air ratio of 1.05, which lies between the carburettor settings for optimum output and lowest consumption (Fig. 1). The lowest octane number corresponds to the maximum knock intensity. With a carburettor set at rich or lean higher octane numbers are always obtained than at the setting for maximum knock intensity.

Fig. 1. Effect of carburettor setting on knock intensity and output.

Whilst the fuel sample is tested at different excess air ratios between 0.7 and 1.2, the equivalent knock reference blend is determined as usual at the carburettor setting corresponding to maximum knock. The results obtained are called "Oppau octane numbers". In the case of routine tests it is convenient not to bracket each fuel sample between two reference blends, but to calibrate the octane number dial of the test engine to the new operating conditions of the Oppau method. Thus the knock value of the sample can be read off directly on the octane number dial, whilst the corresponding mixture strength is computed from fuel and air consumptions. For the rest the test procedure is the same in the Oppau Method as in the usual octane number determination.

As aviation fuels have high anti-knock values to start with, and these are further increased by weakening or richening the mixture, the measuring range of the standard I. G. test engine is not wide enough for the Oppau Method. It is therefore extended by boosting the induction pressure. Normally the compression ratio is varied and converted to octane number. The induction pressure can also be introduced as a variable and converted to octane number; in practice however variation of compression ratio offers the following advantages: the mixture temperature remains practically unchanged at any excess air ratio, the mixture strength can be immediately adjusted and in most practical cases read off on the clock, and when using the bouncing pin apparatus similar compression pressures prevail, which is not the case with variable induction pressure.

II. Description of the test equipment

Layout

The standard test engine must be fitted with additional equipment (Fig. 2), including:

1. Pressure reducing valve
2. Surge tank
3. Air meter
4. Safety valve
5. Air manometer with pipe and flange
6. Necessary pipes and stop valves with thermometer

7. Pressure carburettor
8. Knock meter equipment
9. Octane number dial

Parts 1 to 6 are mounted on a common base plate, fixed on the front side of the test engine. The pressure carburettor replaces the conventional one and is connected to the mixture pre-heater. The pressure reducing valve is connected in the air pressure line and is fitted with a manometer on the inlet side.

Working principle

In the test equipment (Fig. 3) the air flows through the pressure reducing valve into the surge tank, the manometer indicating the mains pressure. By turning a handwheel the pressure reducing valve is set at the desired pressure which can be read on a mercury manometer with an adjustable scale. From the surge tank, fitted with safety valve, the air flows through the meter to the carburettor intake pipe by way of a hose connection. A second air line branches off from the tank before the air meter and is connected to the three fuel bowls of the carburettor. This second air line serves as a pressure balance for the carburettor and to adjust the fuel air mixture. The air quantity is not measured by the meter.

Fig. 4 and 5 show the pressurised three-float carburettor. From the fuel bowl b the fuel flows past stopvalve a and needle valve n into the float chamber, whence it reaches the inlet pipe through the three-way cock h and the fuel jet d. The pressure equalising line produces the same pressure in the fuel vessel (and at the start also in the float chamber) as in the carburettor inlet pipe.

Fig. 2. I.G. test engine with Oppau equipment

Fig. 3. Diagram of Oppau epuipment

Engine data: Bore 65mm. Stroke 100mm. Capacity 332ccm.
Compression ratio 4:1 - 15:1, 600r.p.m.
Coolant temperature 100°C
Mixture temperature 125°C
Inlet pressure 1,000mm.Hg.

Fig. 4. Pressure carburettor

Fig. 5. Diagram of pressure carburettor

a. stop cock
b. fuel bowl
c. stop cock
d. fuel jet
e. adjusting screw
k. measuring bulb
n. float valve
s. float chamber
h. three way cock
v. change over cock

Stop-cock a is by-passed by a special fuel line containing a 20ccm, measuring bulb k. When the stop-cock is open, the fuel vessel and measuring bulb are connected by v pipes; when the stop-cock is closed, only the fuel contained in the test line can flow into the float chamber. The equalising air on the fuel bowl can be switched off by cock c, and the bowl can therefore be replenished whilst the engine is fed by the fuel in the measuring line. When the pressure is completely equalised, the carburettor gives an extremely rich mixture.

The air pressure in the float chamber can be reduced by a special adjustment screw e, thus producing a leaner mixture. The head of this screw is graduated for quick reference. The induction pipe of the carburettor can be connected to the atmosphere by a special valve v.

III. Test Conditions

In tests by the Oppau method the following test conditions must be maintained:

1. Engine speed 600r.p.m.
2. Cooling water of 100°C boiling point.
3. Mixture temperature 125°C.
4. Ignition timing 22°B.T.C.
5. Sparking plugs Bosch DM175.
6. Induction pressure 1000mm. Hg absolute.
7. Excess air ratio for the test sample varied between 0.7 and 1.2 for the reference blend set at maximum knock.
8. Knock intensity: This is set by the compression ratio and it must be similar to that used in the motor method octane number determination. It should therefore correspond to the following reference knock intensity:
   = 6.40 for OON 100
   Particular care must be given to allowing sufficient running-in on the OON 100 reference blend.
9. Bouncing pin apparatus with leaf spring and 0.4mm. (CFR) diaphragm. Set pointer at about 50 divisions (centre dial).
10. Knock meter: A moving coil instrument with a good natural damping is used. The thermo transformer of the conventional equipment is discarded. Fig. 6. shows the diagram of the knock measuring equipment.
11. Octane Dial: This must be recalibrated according to the new operating conditions. The new calibration of compression ratio against Oppau octane number is shown in Fig. 7.
12. For the rest the operating instructions of the I.G. test engine are applicable.

Fig. 6. Knock measuring equipment

Fig. 7. Compression ratio and octane number

IV. Test procedure.

Preparation.

The stop valve on the inlet pipe of the carburettor is opened and the engine run according to working instructions, using gasoline from bowl No. 2. The sample is put in bowl No. 1 (previously cleaned of fuel residues) and OON 100 reference blend in bowl No. 3. Owing to the over-rich carburettor adjustment, the threeway valve is not set exactly at 2 but a few mm. beyond it. This reduces the fuel passage, producing a normal mixture strength.

The approximately correct position of the valve is determined by listening to the knock intensity. The test engine should be run in with moderate knocking until the prescribed temperature is approximately reached, which should take about 30 minutes.

In the meantime the scale of the mercury manometer is adjusted until the two equal branches of the mercury column indicate the prevailing air pressure, as taken from a barometer. The pressure air line is then opened and the valve on the induction pipe is closed. Now the engine runs on boost pressure. If necessary the pressure in the surge tank is set to the desired value by the reducing valve. The mixture pre-heating must be adjusted. The three-way valve is switched to position 3 (reference blend O.N. 100) and the test commences with a check of the octane dial.

The above mentioned reference blend of O.N.100 is composed of reference leaded gasoline and leaded reference fuel Z, in the volumetric proportion of 18:82; in both cases the TEL content is 1cc. per litre. This ratio is obtained from Fig. 8. in the usual way, i.e. first by varying the compression ratio and then by means of the carburettor adjustment, the engine is adjusted* for the OON 100 reference blend until the pointer of the knock meter shows 50. The compression dial must then indicate 6.40. The adjustable octane dial is then adjusted to ON 100 and the mean pointer deflection noted. The knock intensity in all following octane number determinations must then be adjusted to this pointer deflection.

Fig. 8. Reference blend and octane number.

Performance of the test.

After checking the octane dial the three-way cock is turned to position 1, and the engine run on the gasoline sample. The test begins as in the usual knock rating determination by finding the minimum octane number of the sample. At first the compression ratio is adjusted to low knock intensity by turning the hand crank, then the carburettor is adjusted to maximum knock by means of the adjustment screw. Now the knock meter should give the same reading as in the previous check of the octane dial. If this is not the case, the compression ratio is altered again until the desired reading is obtained. Then the octane dial indicates the knock value of the fuel sample.

To measure the mixture strength, the stop cock of the carburettor is closed and the engine runs on the fuel contained in the measuring bulb. When the fuel level crosses the top mark of the bulb the air meter is set in motion and then stopped when the fuel level reaches the bottom mark; the air meter thus gives directly the air consumption for 20cu.cm. of fuel. Subsequently the stop cock is turned on again, and the measuring bulb fills once more with fuel. Octane number and air consumption are noted.

The compression ratio is now increased by about one octane number according to the O.N. dial. The knocking increases and so does the knock meter reading. By turning the adjustment screw in a clockwise direction the mixture strength is slowly varied until the knock meter reading again reaches the desired value. The second O.N. is then read off and the air consumption for 20cu.cm. of fuel noted. Then with the compression ratio unchanged, the adjustment screw is slowly turned anticlockwise until the pointer after first rising, returns to the prescribed value. Once more the air consumption for 20cu.cm. of fuel is

measured and noted, together with the O.N., which has not changed.
The test is thus continued, until 5 to 8 figures are obtained approximately between 0.7 and 1.2 air excess coefficient. The air ratio proper is calculated in the usual way (see Report No. 490). These air excess coefficients are plotted against the corresponding O.N.'s, and at the same time additional points of the rich mixture curve are inserted. Owing to the irregular running of engines in the lean region, particularly beyond $\lambda = 1.2$, fewer values can be obtained here than in the rich region. As a result curves are obtained as in Fig. 9., which are flatter for paraffinic fuels than for aromatics. The points of Fig. 9. were determined in the order shown by the figures. To facilitate the plotting, apart from the first test point, whole octane numbers were always used.

Fig. 9. Oppau method knock limit curves.

The test of a fuel sample lasts about ½ hour and requires approximately 500cu.cm. of fuel. After completing a test the three-way cock is switched back to position 3 and the compression ratio is reset to OON 100. At the same time fuel bowl No. 1 is emptied, after disconnecting the air pressure filled again with the next fuel sample and put once more under pressure. In the meantime the engine is run on No. 100 reference blend. Thus it is possible to check the octane dial without loss of time. The test is continued as described above.

Test accuracy.

In the region of ON 100 the tests can be accurate within ± 0.5 OON and ± 0.02 air excess coefficient. These figures refer to tests on the same test stand.

V. Maintenance.

Similarly to the usual O.N. determination, the rich mixture curve is repeated from time to time with a suitable standard fuel. At regular intervals, but particularly after a long period of inactivity or after an overhaul, the following must be checked:

Octane number dial.

The check of the O.N. dial with a reference blend has already been described. If the resulting pointer reading is 30 or 70 instead of 50 as prescribed, the fuel sample must likewise be adjusted to the altered characteristic.
Should the pointer reading be at either end of the dial, the compression ratio is adjusted to a pointer reading of about 50 and the O.N. dial correspondingly adjusted, the compression dial remaining unchanged. The difference in compression ratio from the standard value 6.4 should not exceed ±0.2. This might happen as a result of gas leakage from piston or valves, insufficient valve clearance, erroneous setting of the compression dial or the bouncing pin device, or incorrect ignition advance. The cause of any excessive difference must be determined and removed.

Periodically the octane dial must be checked not only at a single point, but over its whole range. This applies particularly after engine overhauls.

Bouncing pin apparatus

The higher pressures involved in the Oppau method as compared to normal operation nessessitate a thicker diaphragm and higher loading of the bottom contacts. Otherwise the known rules apply for the adjustment of bouncing pin devices. As some aviation fuels have a high aromatic content, the check test should occasionally be made with benzene which should produce no deflection on the knock meter up to a compression ratio at 9.00. For the same reasons it is adviseable to adjust the bouncing pin device in the upper range of octane numbers.

Air line.

This must occasionally be checked for leakage by brushing it with soapy water. This applies in particular to that section of the line which carries the measured air quantity including the mixture heater. The pipe should also be drained periodically.

Safety valve.

This is adjusted to 0.5atm gauge pressure, which should be checked periodically.

Self-ignition

No self-ignition should occur in the normal test region with excess air coefficients between 0.7 and 1.2. When they occur at the rich carburettor setting experience shows that the test values are not affected.

In general the servicing instructions of the I.G. test engine are applicable.

Test pressures.

Surge tank and air meter are tested at 3atms. and 1atm. the carburettor at 2atm. The result of pressure tests on three observation windows and measuring bulbs is:

observation window:	strength over 40atm.
measuring bulb :	" " 15atm.

/RAB

2nd. May, 1946.