P.A.W. Item 14
reel 106

B-28.

THE COMPRESSIBILITY OF HYDROCARBONS.

Report No: 31.

Author: Dr. Kling.

Date: 29/7/43.

Index No: B-28.

Origin: I.G.-Oppau.

Contents: 4 pages text and 1 sheet curves.

Hydrocarbons fall away strongly from the ideal gas laws under the temperature and pressure conditions obtaining during their preparation and actual use.

Thus compressibility considerations are important in questions of measurement, storage and delivery.

The paper contains a general discussion of these problems and has attached a sheet showing compressibility curves for methane, propane, n-butane, n-hexane and ethylene.

- Reel -106

B-32.

INVESTIGATION OF TWO DISTILLATION FUEL OILS AS TO SUITABILITY FOR ENGINE USE.

Report No: 302. **Index No:** B.32.

Author: Witschakowski. **Origin:** I.G. Oppau

Date: 10/12/40. **Contents:** 2 pages text and 1 sheet tables & photograph.

Two fuel oils were tested for use in the Hesselman-Engine. They are:-

1. A fuel oil from the Lurgi Gas Scrubbing Experimental Installation, "Karsten-Centrum" Pit, Beuthen (I.G. No.591).

2. A fuel oil from coal hydrogenation - Lu.498 (I.G. No.592).

The work was complementary to that carried out earlier with fuel-oil "S" (I.G. No.561).

The conclusions reached were that oil No.591 would be suitable for use in the Hesselman engine if it were improved with respect to deposit formation and freedom from mechanical impurities.

Sample 592 was so viscous as to make it unsuitable for use as an engine fuel.

reel 106

B.39.

INVESTIGATION IN THE SOMUA-HESSELMAN ENGINE OF A BROWN-COAL-TAR-FUEL OIL OBTAINED FROM THE COAL IMPROVEMENT AND TAR DISTILLATION CO.

Ref. No. B.39.
Origin: I.G. Oppau.
Date. 27.9.41.

Short Report No. 311.
Author: Dipl.Ing.Witschakowski.
Contents: 6 text pages
3 figure sheets.

SUMMARY

Because of this engine test in the Somua-Hesselman engine the fuel oil in its present condition is unsuitable. A possible use is visualised if the constituents of the fuel oil boiling above 380°C. (at least) are removed as these vapourize badly, cause residue-formation, and hence engine trouble.

Inspection data: Ref. No. D.635

1. Flash point	–	75°C.
2. Specific gravity at 20°C.		0.974
3. Viscosity		about 5.5°Engler
4. Creasote content	–	25%
5. Water content	–	0.2%
6. Distillation Test	–	240°C to 11% vol
		300°C 41% "
		380°C 70% "
7. Conradson test.	–	0.69%
8. Asphalt (insol. in benzene)		0.72%

Inspection data on the crankcase oil before and after the duration test showed an increase in specific gravity at 20°C. (0.870 to 0.887), a considerable fall in flash point (228°C. to 165°C.), and a large decrease in viscosity (268.7 cs at 38°C. to 148 .1 cs).

Graphs are presented of the relationship between speed (r.p.m.) and exhaust gas temperature, specific fuel consumption, and power; and also for specific fuel consumption against mean effective pressure.

Photographs are given of pistons, crank shaft, bearings, cylinder head and cylinder bore after the duration test.

reel 1061

B.40.

THE MEASUREMENT OF CETANE NUMBERS ABOVE 100

Ref. No. B.40.
Origin: I.G.Oppau
Date: 5.11.41.

Short Report No.312
Author: L.Köhler.

Contents: 3 text pages 2 figure sheets.

SUMMARY.

A new reference fuel was introduced and designated R. This was of ether base and could therefore be easily reproduced.

The cetane number of reference fuel R was estimated by extrapolating curves of blending cetane numbers, since the curves of cetane number against concentration were far too curved to extrapolate with any certainty. The values so obtained by blending in various bases gave values between 240 and 300. On account of this variation the cetane number of R was arbitrarily fixed at 200 which was roughly the average blending cetane number.

Cetane numbers above 100 were defined as 100 plus the equivalent blend percentage by volume of R in cetane.

rue 106

B.42.

INVESTIGATION IN THE SOMUA-HESSELMAN ENGINE OF A BROWN-COAL-TAR-FUEL OIL OBTAINED FROM THE HEFRAG-BROWN COAL AND TAR DISTILLATION WORKS HESSEN-FRANKFORT. CO.

Ref. No. B.42.
Origin: I.G. Oppau.
Date: 26.1.42.

Short Report No. 315
Author: Dpl. Ing. Witschakowski.
Contents: 5 text pages
3 figure sheets.

SUMMARY

It was expected in the test on this fuel oil that no tendency to engine trouble would arise in consequence of its better distillation properties. The high Conradson test of 1.21% was, however, considered to be serious. It is recommended that the test on this fuel oil is repeated when it has been cut to about 300°C. It is intended at the same time to increase the compression ratio to 8 : 1 or 10 : 1 in order to prevent the high boiling constituents burning with residue-formation or passing into the crank case oil.

Inspection data for Fuel (Ref. No. D.636)

1. Flash point - 64°C.
2. Specific gravity at 15°C. - 0.946
3. Viscosity at 20°C. - 2.05°Engler
4. Creosote content - 24% vol.
5. Distillation Test.

	I.B.P.	138°/148°C.
Vol. % to	160°C.	0.5
	200°C.	11.0
	240°C.	45.0
	280°C.	69
	320°C.	87.5
	346°C.	96.5

6. Lower Calorific value = 8500 Kcals.
7. Conradson test = 1.21%
8. Asphalt (insoluble in benzene) = 0.77%.

Inspection data on the crank case oil before and after the duration test showed a fall in viscosity (271 to 130.8 cs) and a considerable decrease in flash point (228°C. to 160°C).

As in short report No. 311, graphs and photographs are presented. It is concluded that this fuel oil is unsuitable because of its high Conradson test, which leads to severe carbon-formation in the engine.

reel 106

INVESTIGATION OF TWO FUEL OILS D635 AND D636 IN THE SOMUA HESSELMAN ENGINE. (cf Short reports Nos. 311 and 315).

Ref. No. B.47.
Origin: I.G. Oppau
Date: 26.4.42.

Short report No. 320
Author Dipl. Ing.Witschakowski.
Contents: 8 text pages
5 figure sheets.

This report is merely a repetition of the results given in Short Reports Nos. 311 and 315. No new information is presented. (ref. B.39 and B.42.).

reel 106

B-53.

VAPOUR PRESSURE MEASUREMENTS ON ETHERS & HYDROCARBONS AT LOW TEMPERATURES.

Report No:	326.	**Index No:**	B-53.
Author:	Bauer.	**Origin:**	I.G. Oppau.
Date:	27/6/42.	**Contents:**	4 pages text, 2 sheets diagrams.

This work was done in connection with research on new starting fuels, effective at temperatures down to -60°C.

The vapour pressure curves correspond to the modified Clapeyron equation. An exception was acetal.

Vapour pressure curves are given for:-

di-ethyl ether
ethyl-i-propyl ether
methyl-i-butyl ether
methyl-n-butyl ether
ethyl-i-butyl ether
di-n-propyl ether
ethyl-n-butyl ether
acetal
glycol-methyl-ethyl ether
di-allyl ether.
monoglycol-diethyl ether
glycol-di-allyl-ether.
R.200
tetrahydrofurane
2 methyl pentane
n-hexane & di-v-propyl ether.
33.1/3 % each of (methyl n butyl ether, (di-n propyl ether. (monoglycol-diethyl-ether.

sul 10 6

B. 68

CHECKING THE RATE OF FLOW OF THREE GAS METERS BY MEANS OF AN ADJUSTABLE DIAPHRAGM.

Report No: 345.

Index No: B-68.

Author: Witschakowski.

Origin: I.G. Oppau.

Date: 22/9/42.

Contents: 5 pages text and 8 sheets diagrams.

The work was carried out to check the gasmeters* used at the Station for measurement of air ratios during experiments with rich-mixture test engines.

* Rotating-piston type.

reel 106

B.70

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

Short Report No. 347
Author. H.Leib.

Ref. No. B.70.
Origin. I.G. Technical Test Establishment - Oppau.
Date: 2.10.42.

SUMMARY.

Cold room starting tests by the critical compression ratio method on I.G. Test Diesel Engines were carried out at temperatures down to -25°C. It was found that the cetane number was inadequate in predicting starting behaviour and that viscosity and boiling range played a part. An attempt was made to correlate the data with partial success. The work was proceeding.

1

rul 106

B-71.

GLOWING COMPOUNDS FOR THE PROLONGED WARMING OF APPARATUS.

Report No: 348.

Author: Penzig.

Date: 30/9/42.

Index No: B.71

Origin. I.G. Oppau.

Contents: 10 pages text, 1 sheet diagrams.

The keeping warm of various automobile parts sensitive to cold is discussed, especially the accumulators.

The most suitable heating agent is found to be coke breeze briquetted with certain other components. (cf. A69, report 536.)

rel 106

B-72.

INVESTIGATION OF THE RESISTIVITY OF "COTTONID" and "SACK" FUEL CONTAINERS TO WATER & ORGANIC SOLVENTS.

Report No:	352.	Index No:	B-72.
Author:	Grünwald	Origin:	I.G. Oppau.
Date:	4/11/42.	Contents:	7 pages text.

In quick release experiments carried out by the Luftwaffe the whole fuel reserve of the fully-tanked experimental machine are lost. To prevent this, it is required to find a substitute for this fuel, which acts solely as ballast. The properties of this substitute shall be as near those of benzine as possible and it shall not attack the tanks or their appropriate elektron or iron mountings.

It is found that this substitution is impracticable and the use of low quality benzine is recommended.

rul 106

B-85

TEST OF A PROTECTIVE COATING AGAINST ACID FOR USE WITH ACCUMULATOR WARMERS.

Report No:	368.	Index No:	B-85.
Author:	Leib.	Origin:	I.G. Oppau.
Date:	2/7/43.	Contents:	4 pages text.

In winter conditions accumulators are placed in wooden boxes, heated by a wick-lamp.

The test board, with protective coating, was brushed over with accumulator acid and held 40-50mm. over the wick-lamp. A coating, undamaged after a double 10 hour burning period, and at the same time protecting the board against charring, was stipulated.

reel 106

B-91.

AN EXPERIMENTAL ARRANGEMENT FOR TEMPERATURE MEASUREMENT.

Report No:	375.	Index No:	B.91.
Author:	Dr. Schuch.	Origin:	I.G. Oppau.
Date:	13/9/43.	Contents:	6 text pages, 1 sheet diagrams.

The apparatus was set up to measure the temperature of the various component parts of a combustion chamber on the occurrence of glow ignition.

For this purpose a cooled glow-pipe was built into an engine cylinder, so that when the cooling was shut off the temperature necessary for ignition was reached in a few seconds. Red-sensitive photo cells were used for temperature measurement. In conjunction with an amplifier, sensitivity could be adjusted to suit any temperature range desired (temperature of approximately 700°C. upwards were measured).

rel 106

B. 97.

THE SUITABILITY OF VARIOUS CHEMICAL COMPOUNDS FOR CAUSING ENGINE TROUBLE.

Report No: 383. **Index No:** B-97.

Author: Lauer. **Origin:** I.G. Oppau.

Date: 26/10/43. **Contents:** 7 pages text.

Following a request from the Wehrmacht, various chemicals were mixed with fuel or lubricating oil in an attempt to find some substance which would give trouble in an internal combustion engine, especially of the carburettor type. The quantity necessary should not be greater than 0.1% and engine trouble should set in after 1-3 hours running.

None of the substances tried gave the required results.

reel 106

I.23

INVESTIGATIONS WITH DIFFERENT FUEL ADDITIVES WITH THE PURPOSE OF IMPROVING THE ODOUR OF THE EXHAUST GASES

Ref. No. I.23

Origin: I.G. Oppau

Date: 10.2.33

Report No. 251

Author: Dr. Wilke

Contents: 4 Text Pages

SUMMARY

The following nine substances were tried in varying concentrations in the fuel:- diphenyl methane, benzophenone, cyclohexane, cyclohexanol, mixture of dephenyl and diphenyl methane, mixture of diphenyl, diphenyl methane and diphenyl oxide, β-naphthol methylether, and methanol. The most effective was a 0.05% concentration of β-naphthol methylether. For a heavy oil in the Diesel test the improvement in odour of the exhaust gas was still insufficient to render the odour unobjectionable. The substances were also examined for possible improvement of knocking tendency. The addition of 10% diphenyl methane to a benzine of octane number 67 increased the octane number to 71.

J.A.E.M.

rul 106

INVESTIGATION ON DIACETYLENE AS AN ADDITIVE FOR DIESEL ENGINE FUELS (COAL TAR OIL AND GAS OIL).

Ref. No. I.21.
Origin: I.G.Oppau
Date: 29.7.32.

Report No. 246
Author: Dr.Wilke
Contents: 6 text pages.

SUMMARY.

It was shown that diacetylene (C_4H_2) was suitable as an additive for diesel fuels, especially for coal-tar-oil. At full engine-load, the addition of 8% diacetylene to a coal-tar-oil decreased the average maximum pressure from 49 to 44 ats, and increased the ignition delay from 10 to 12 mm. The further addition of 2% amylnitrate to the coal-tar-oil containing 8% diacetylene changed the ignition delay from 16 to 13 mm., and the maximum pressure from 49 to 45 ats. Similar results were obtained on the addition of 3% diacetylene to a Roumanian gas oil.

(The diagrams, to which reference is made in the text, are missing.)

J.A.E.M.

aul106 B.101

INVESTIGATION ON THE IMPROVEMENT OF DIESEL OILS BY INCREASING THEIR IGNITION QUALITY.

(Copy of the joint Lab. Report No.1671 of the Ammonia Lab. and Technical Testing Station, Oppau)

Ref. No. B.101 | Short Report No. 387
Origin: I.G. Oppau. | Authors: Drs. Drexler, Köhler and Lang
Date: 25.1.44 | Contents: 13 Text Pages.

Improvement of the ignition quality of a fuel has been undertaken by one of the three following methods:

METHOD 1. Mixing a badly-ignitable fuel with a very good quality fuel.

METHOD 2. Addition of ignition-accelerators to the fuel.

METHOD 3. Chemical treatment of the fuel.

METHOD 1 has been discussed by Kölbel (Öl und Kohle, 1938: 46. S1042). Such mixed fuels soon give rise to coke-formation.

METHOD 2. The necessary properties for a good accelerator are:

a) Only about 1% of additive should be required to give a cetane number improvement of at least 10 numbers.

b) The additive must form a homogeneous mixture with the diesel or tar oil.

c) The additive must not cause gum formation in the fuel.

d) The additive in the fuel mixture should not attack copper, zinc or iron.

e) The additive must be easily handled.

f) The additive should boil above 100°C.

g) The additive should not lower the flash point of the fuel.

The groups of compounds studied are:- alky nitrates and nitrites, aromatic nitro-compounds, peroxides, diazo compounds and metallic-organo compounds. It is found that the lower the boiling point of the additive the greater is the lowering of the flash point. The increase in cetane number and the lowering of the flash point for various percentages of ethyl nitrate and iso amyl nitrate in gas oil are shown below:

Additive		Increase in Cetane No.	Decrease in Flash Point °C.
% present in gas oil	B.P. °C.		
Ethylnitrate 1	88	14	20
3		18	32
5		27	37
i-Amylnitrate 1	148	6	3
3		17	9
5		25	16

METHOD 3. Ammonium nitrate cannot be used as an additive, as even when finely powdered it will not mix homogeneously with diesel oil. But treatment of the gas oil with nitric acid improves the ignition quality appreciably. Still further improvement is achieved by treating the oil with NO_2. At the saturation value at 20°C. (2.08% NO_2) the cetane number is increased by 18 numbers. Investigation of the degree of saturation at various temperatures showed that the increase in cetane number reached a maximum at 50°C. and thereafter decreased. It is to be noted that all NO_2 treatments caused the precipitation of a pitch-like material which had to be filtered off before the oil was tested in the engine. No mechanism for the influence of NO_2 is postulated. Catalytic cracking of the oil at moderate temperatures (over a titanium catalyst) did not appreciably increase the cetane number, though a NO_2-treated cracked oil was slightly superior to a NO_2-treated uncracked oil.

The gas oil was fractionated into narrow boiling cuts to determine if any special cut showed a considerable increase in cetane number after NO_2-treatment. This was not found to be the case, but it was shown the fractions below 300°C. did not give rise to gum-formation on nitration.

It was found that the NO_2-treated gas oils did not cause corrosion in the test diesel engine, but NO_2-treated oils from coal (of a high phenol content) rapidly gave rise to corrosion.

reel 106

I.20

INVESTIGATION ON DIETHYLPEROXIDE AS AN ADDITIVE FOR GAS OIL AND COAL-TAR-OIL.

Ref. No. I.20.
Origin: I.G.Oppau.
Date: 23.5.32.

Report No. 244.
Author: Dr.Wilke.
Contents: 2 text pages
6 figure sheets.

SUMMARY.

Diethylperoxide as an additive for diesel engine fuels is applicable in gas oil, but not in coal-tar-oil. The influence in gas oil is however small; for a 1% additive concentration the maximum pressure only falls by about 3 ats. No further effect is produced by a 1.5% additive concentration. No change was noticed in the performance of the engine. Diethylperoxide has an unfavourable influence in the coal-tar-oil, namely the maximum pressure is increased. For a 1% additive concentration, the maximum pressure rises, the knocking of the engine was greater and the test had to be concluded.

Comparison is made with diacetylene which is known to be an effective additive.

J.A.E.M.

TESTS WITH JENTZSCH'S TESTER FOR IGNITION QUALITY.

Ref. No. I.34	Report No. 277
Origin: I.G. Oppau	Author: Dr. Gaupp
Date: 30.1.35	Contents: 10 Text Pages 5 Figure Sheets

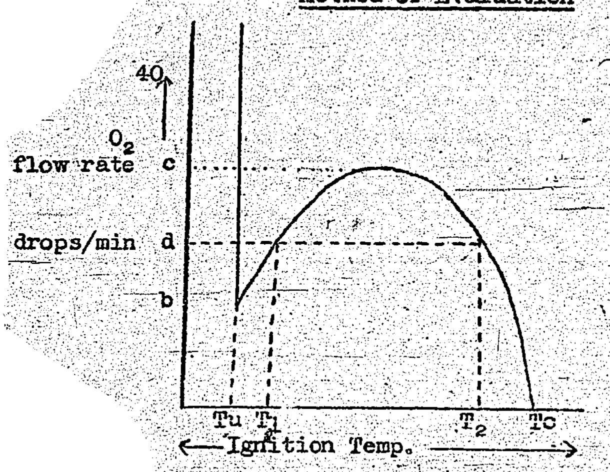
THE TESTER.

The tester consists essentially of an oven with an ignition-crucible and an apparatus for supplying oxygen. In the electrically-heated oven is situated the ignition-crucible, a cylindrical block of V_2A-steel of 48 mm. diameter and 50 mm. high. This crucible contains four equal size cylindrical borings of 15.5 mm. diameter and 40 mm. deep, of which three are connected with a central oxygen supply and serve as ignition-chambers, whilst the fourth is used for temperature measurement. The apparatus for supplying oxygen consists of a fine-adjustment valve, a bubble-counter (of which the principal part is a nozzle calibrated so that 50 oxygen bubbles correspond to 5 cc.), and a calcium chloride drying tower.

SUMMARY.

The object of the investigation was to establish an evaluation for the knock quality of a fuel insofar as it was possible with the aid of Jentzsch's ignition-quality tester. The ignition quality of n-heptane/iso-octane mixtures and of commercial fuels was determined, and thence the knock quality calculated. It was seen that the octane numbers so calculated differed fairly considerably from those determined in the engine. The Jentzsch ignition-quality tester does not give a sufficiently accurate method for evaluating fuels.

Method of Evaluation



The figure opposite is the ignition curve for n-heptane, and is characteristic of gasolines. It is seen that for abundant oxygen flow rates continuous ignition occurs above a certain minimum temperature (Tu°). At lower flow rates ignition occurs at Tu° down to a flow rate b drops/min. Above Tu° and for flow rates between b and c, ignition takes place at a certain temperature above which ignition does not occur. For example at d drops/min n-heptane ignites over the range Tu° to T_1°, and not again until T_2°. This region (T_1° to T_2°) in which ignition fails to appear is called the Ignition gap.

The characteristics of the ignition curve are:-

1. The lower ignition temperature, Tu (self-ignition temperature).
2. The lowest drop/rate, b, at which ignition still occurs for the lower ignition temperature.
3. The upper ignition temperature, To, with zero oxygen flow rate is the air-ignition temperature.

The Ignition Index (ZK) is calculated from the empirical relationship

$$ZK = \frac{To - Tu}{b + 1}$$

(E.g., ZK for n-heptane ≑ 9)

For comparison of one fuel with another the Corrected Ignition Indez (ZKB) is used nowadays. This index involves the "ignition delay", i.e., the time between fuel-injection and the beginning of combustion. As a boundary value of this time interval, 3 seconds has been taken. Whence the Corrected Ignition Index is calculated from the formula:-

$$ZKB = ZK - 0.1\ (sec - 3)$$

(E.g. ZKB for n-heptane = 10.4, and ZKB for iso-octane = 0.5)

By determining ZKB for mixtures of iso-octane and n-heptane, it was hoped to obtain a correlation between ZKB and Octane Number.

EXPERIMENTAL RESULTS.

The first series of experiments were carried out in an earlier model of Jentzsch's tester in which the ignition block was not made of V_2A steel. The results obtained for pure substances (cyclohexane, iso-octane, n-heptane) differed considerably from those reported by Zerbe (Angew. Chemie. 1932, 45, 593). Comparison of octane numbers of fuels determined by the Ignition Index and in the engine showed considerable divergences.

Ref. No. I.34 (Contd.)

The second series of experiments carried out on pure reagents in the present-day tester again produced anomalous results. Large differences in octane number were again found for a given fuel (e.g., O.N. by engine method = 65.5; O.N. from ZKB = 33). Reproducibility of results in the tester was very poor (e.g., two determinations gave the O.N. of fuel as 81 and 49.5). No possible correlation of Octane Numbers determined by the two methods could be achieved. Furthermore, the Octane Number (calculated from ZKB) of a good fuel was frequently found to be less than that of an inferior fuel.

J.A.E.M.

reel 1.0.6

I.50

FURTHER EXPERIMENTS WITH A MOTOR VEHICLE DIESEL ENGINE TYPE DAIMLER-BENZ OM. 67, CONVERTED TO RUN ON METHANOL.

Ref. No. I.50

Origin: I.G. Oppau

Date: 23.6.36

Report No. 302a

Author: Penzig

Contents: 7 Text Pages, 10 Figure Sheets photographs and curves. 1 carbon copy of a typed letter.

SUMMARY

The experiments collected in Report No. 302 were continued. Further experimental data were required on the insertior of spark plugs in place of the injection nozzles without alterations to the cylinder head. An endeavour was made to improve the engine performance in the lower r.p.m. range. In addition, the starting installation for this engine needed development.

K.G.G.K.

reel 106

I.50A

THE CONVERSION OF A DIESEL MOTOR VEHICLE ENGINE, TYPE DAIMLER-BENZ OM.67, TO RUN ON METHANOL.

Ref. No. I.50A
Origin: I.G. Oppau
Date: 9.3.36

Report No. 302
Author: Penzig
Contents: 18 Text sheets
3 sheets photographs
1 table
25 diagrams

SUMMARY

The possibility of running a diesel motor vehicle engine on methanol is discussed and it is established that primarily the use of a carburettor comes into question. In this particular case it was possible to incorporate a spark plug in place of the injector. In new cylinder heads a special opening for the spark plug should be provided. This would provide for the possibility of running the engine with injection and spark ignition. In addition, with new engines, provision should be made for the simplified fitting of spark ignition equipment.

The highest compression ratio tried was 10.4 : 1; at compression ratios about 13 : 1 the usual means of ignition were insufficient, since the voltage necessary for sparking is either not produced, or, if produced, breaks down the insulation. Inlet manifolds were developed for two and also three carburettors. With the two-carburettor arrangement, which could be comparatively easily installed, 150 H.P. was finally reached using 1800 K.cals/ H.P. hr (η_{th} = 34.5%).

Although the mean working pressures were considerably higher than with the diesel engine (95 H.P.), no troubles or failures were observed. Further, it was established that the relationship between the spark advance giving the best performance and the r.p.m. was practically the same as with benzol. The usual regulating equipment could thus be employed; also standard Solex jets could be used; it was merely necessary to multiply the figures given in the installation data by 1.4 - 1.5 corresponding to the doubled area of the jets.

The carburettors available were, however, insufficient in size to deal with the large quantities of fuel necessarily employed.

K.G.G.K.

reel 106

THE BEHAVIOUR OF THE HEAVIEST OIL AS FUEL FOR THE DIESEL ENGINE.

Ref. No. I.59

Origin: I.G. Oppau

Date: 28.10.36

Report No. 313

Author: Samwold

Contents: 5 Text Pages, 3 Tables
5 Figure Sheets

SUMMARY

Tests were made on a Deutz engine at 300 r.p.m. using as fuel an oil of 1.095 specific gravity at 100°C. The use of this fuel was possible although carbon formation on the nozzles and valves prevented continuous running. It had to be heated to 150-160°C. to avoid trouble in the injection system.

J.G.W.

rue 1.06 I.60

EXPERIMENTS WITH PROTECTIVES AGAINST COLD CORROSION CAUSED BY TETRA-ETHYL LEAD.

Report No. 315. Index No. I-60.

Author: Penzig. Origin: Oppau.

Date: 2/11/36 Contents: 7 pages text.

To prevent the formation of metallic lead when leaded benzine is burnt, ethylene bromide or chloride is added with the lead tetraethyl. In this way, the residual products are mainly volatile. However, hydrobromic and hydrochloric acids are formed which are harmless while the engine is running, but cause rusting of the outlet valves and cylinder surfaces when the engine is out of action (cold corrosion).

SUMMARY.

Up to now triethanolamine has been used to neutralise the hydrobromic and hydrochloric acids formed. Unfortunately, this amine is soluble only in castor-oil.

The valves of an engine working on leaded benzine were sprayed with the new anti-corrosives, dissolved in benzine and the engine run for some hours. The valves were then treated with thin mineral oil as protection against damp and left in theopen. After five months storage no corrosion was seen.

Amines tested: Diethylethanolamine (No.1410/U)
Dibutylpropanolamine (No.1411/U)
Ethylhexyldiethanolamine (No.1412/U.

Fuel used: Stanavo Aviation Spirit - Oct. No.87

reel 106

I.62

THE CONVERSION OF A DAIMLER-BENZ DIESEL ENGINE, TYPE OM.59 TO RUN ON METHANOL WHEN FITTED WITH A CARBURETTOR.

Ref. No. I.62 | Report No. 317

Origin: I.G. Oppau | Author: Aldinger

Date: 16.11.36. | Contents: 11 Text Pages, 12 Figure Sheets, 1 Photograph

SUMMARY

For the engine conversion, experiments were made at a 10.8 : 1 compression ratio with three inlet manifolds of 28, 32 and 36 mm. internal diameter. The 36 mm. inlet manifold with 24 mm. venturi and 140 main jet gave the most favourable heat consumption of 1780 k.cal/H.P. hour at 1500 r.p.m.

The calorific value of the methanol was 4650 k.cals/kg. Experiments were then made with the throttle wide open at various r.p.m., first with a 24 mm. venturi and a 140 jet, and then with a 25 mm. venturi and a 150 jet. The working pressure and the specific consumption were much better below 1500 r.p.m. with a 24 mm. venturi than with a 25 mm. venturi owing to bad atomisation in the lower r.p.m. range.

The maximum performance of the engine at 2000 r.p.m. was:-

with 24 mm. venturi, 140 jet - 61 H.P. (p_{me} = 7.5 kg./cm^2)
with 25 " " 150 " - 65 H.P. (p_{me} = 8.0 kg/cm^2)

Part load curves were then obtained using a 24 mm. venturi and a 140 jet at 5 different speeds.

For comparison, further experiments were made using benzol. With a 24 mm. venturi the following series of experiments were made:-

1. With different jets and open throttle.

2. With a 95 main jet and open throttle at various speeds.

3. Various outputs at constant r.p.m.

At full load the influence of the bad atomisation of methanol below 1250 r.p.m. became gradually more noticeable. The best heat consumption was 10% better with methanol than with benzol.

Ref. No. I.62 (Contd.)

The specific heat consumption with methanol in the upper r.p.m. range from 1250-2000 r.p.m. and down to quarter load was materially better than with benzol.

Finally, the best spark advance for methanol and benzol was ascertained. The curves show a shift of 2 - 3°, so that ordinary regulating equipment could be used.

The Solex 35 J.F. down-draught carburettor used was capable of dealing with the change in throughput of fuel required when methanol was used.

K.G.G.K.

reel 106

I.71

EXPERIMENTS WITH NITRATED POTT EXTRACT AS FUEL FOR THE COAL DUST DIESEL ENGINE

Ref. No. I.71
Origin: I.G. Oppau
Date: 8.3.37

Report No. 327
Author: Aldinger
Contents: 28 Text Pages, 3 Tables
29 Figure Sheets

SUMMARY

Tests were made in a horizontal single-cylinder Deutz engine converted to coal dust operation, using pure Pott extract, nitrated Pott extract, lignite and gas oil.

The construction of two dust valves is described, both having the disadvantage of sensitivity of cut off to the sharpness of a blade, and, in consequence, long running being impossible.

A run with pure Pott extract was possible only with the greatest difficulty on account of its low softening point and its high self-ignition temperature. Treatment with nitric acid or nitrous gases increased the softening point and lowered the self-ignition temperature. With increasing nitration the ignition characteristics in the engine improve and finally surpass those for ash-containing lignite. The consumptions were also better with nitrated Pott extract. Best results were obtained from Pott extracts treated with nitric acid, which not only improved in ignition and combustion quality with stronger nitration but with the carrying out of the treatment at 120-150°C.; above 150°C. the improvement lessened. Neutralisation of samples with ammonia had no important effect.

Comparison with gas oil showed poorer consumptions for nitrated Pott extracts over most of the load range but gas oil was equalled at full load.

Indicator diagrams showed that the ignition delay with nitrated Pott extract increased with decreasing dust supply. Indicated horse powers and consumptions were also obtained from indicator diagrams.

The highest obtained indicated mean effective pressure was about 100-105 p.s.i.

J.G.W.

reel 106

I.72

TESTS ON A HESSELMAN ENGINE. EXAMINATION OF DIFFERENT FUELS AND INJECTION NOZZLES.

Ref. No. I.72
Origin: I.G. Oppau
Date: 10.3.37

Report No. 328
Author: Witschakowski.
Contents: 11 Text Pages, 12 Figure Sheets

SUMMARY

The best performances at lowest consumptions were obtained with gas oils and coal tar oils. Light fuels (Stanavo, Leuna benzine and B.V. benzole) were not as good, and further, they could not be burnt completely without residue. With gas oil, however, there was a tendency to knock at increased load.

Five different nozzles were tried, details and performance of which are given.

J.G.W.

reel 106

INVESTIGATION ON THE USE AND KNOCK BEHAVIOUR OF DIFFERENT FUELS IN THE HESSELMAN ENGINE WITH SUCTION STROKE AND COMPRESSION STROKE INJECTION AS WELL AS WITH CARBURETTOR OPERATION

Ref. No. I.73 Report No. 331
Origin: I.G. Oppau Author: Witschakowski
Date: 25.6.37 Contents: 26 Text Pages

SUMMARY

The effects of the following variables were explored: beginning and end of injection, injection period, commencement of ignition, compression and cooling water temperature.

Further tests were made on fuels of different octane and cetane numbers, including alcohols, benzole blends and fuels containing lead. The effect of boiling range was also explored.

Comparisons were made between injection and carburettor operation in regard to performance, consumption and knock behaviour.

Finally, tests were made with suction stroke injection.

The conclusion was drawn that the Hesselman engine could be run under roughly the same conditions with both low and high boiling fuels. The compression ratio was limited by the knock rating, the octane number being used in the case of light fuels, and the cetane number in inverse relationship, in the case of heavy fuels.

Carburettor operation gave better performance than compression stroke injection, the cause being that a better mixture was obtained through the induced swirl. Against this, injection operation enabled fuels of lower octane number to be used.

Better performance with light fuels was obtained with suction stroke injection, but oil dilution was increased. Heavier fuels such as gas oil and coal oil gave best results with compression stroke injection.

NOTE.- The 26 figure sheets that should be attached to this report are missing.

J.G.W

reel 106

THE THERMAL DECOMPOSITION OF LEAD TETRA ETHYL IN LEADED SPIRIT.

Report No. 333. **Index No:** I.75

Author: Schnacke. **Origin:** I.G. Oppau.

Date: 17/8/42. **Contents:** 4 pages Text.

The lead deposition occurring when leaded spirit is used in the internal combustion engine was investigated using a heated quartz tube.

The latter was placed in an electric oven and provided with thermocouples. At one end of the tube was a dropping funnel, at the other a condenser and receiver. Two quartz rods were included in the tube and served to decrease the internal diameter. If required a metal rod could be placed between the quartz rods to investigate the effect of metals on decomposition of the lead tetraethyl.

Little decomposition was found below 400°C.

TESTS ON COAL DUST DIESEL ENGINES (2nd. Report.)

Ref. No. I.76
Origin: I.G.Oppau.
Date: 7.7.37.

Report No. 334
Author Aldinger.
Contents: 7 text pages.

SUMMARY.

Tests were carried out over a range of speeds to determine the limits imposed by various types of fuel.

NOTE.

The copy of the report is only a draft and does not include the figures.

J.G.W.

reel 106

TESTS ON A DIESEL ENGINE WITH VISCOUS AND SOLID FUELS

Ref. No. I.78	Report No. 336
Origin: I.G. Oppau	Author: Dr. Witschakowski
Date: 11.9.37	Contents: 13 Text Pages 5 Figure Sheets

SUMMARY

Tests, in the testing station and on the road, were carried out with viscous TZ.900 fuel (S.I.T. in air = 600°C.), with solid paraffin wax (S.I.T. in air 550°C.) and with gas oil which had been made into a paste by the addition of wax, in comparison with a normal gas oil (S.I.T. in air 500°C.).

The tests at the testing station were carried out on a standard multiple-chamber engine and on a direct injection diesel engine in which the compression ratio was adjustable during operation.

In the first series of tests TZ.900 and paraffin wax were preheated by means of the engine coolant or the exhaust gases, so that the viscosity was lowered, thus making the fuels suitable for injection into the diesel engine. Paraffin wax gave the same power performance as gas oil, whilst for TZ.900 a somewhat inferior performance was measured. This defect can very probably be overcome by suitable improvement of the pre-chamber insertion.

Further tests were carried out on TZ.900 and the wax-thickened gas oil without preheating. The paste-like gas oil did not cause any difficulties, whereas TZ.900 did not atomize to the extent required for ignition in the diesel engine.

Road tests were carried out on a 2-ton truck equipped with a 4-cylinder Daimler-Benz pre-chamber engine. The fuels were preheated by the exhaust gases. In the road test, paraffin wax did not prove to be successful, since the property of the paraffin wax to solidify at about 50°C. lead to operational troubles owing to blockages of pipes and pump.

The road tests on the standard gas oil and TZ.900 were made at three different speeds, 30, 45 and 60 km/hr. It was seen that at 45 and 60 km/hr. the consumption of TZ.900 was about 10% less than when using normal gas oil, but at 30 km/hr. the consumption of TZ.900 was 17% higher than the gas oil consumption. It was concluded that the road performance of such fuels would be satisfactory if preheating were provided.

J.A.E.M.

rul 106

THE BEHAVIOUR OF WATER DISSOLVED IN OTTO FUELS AT LOW TEMPERATURE.

Report No: 341. Index No. I 81A.

Author: Dr. Seidel. Origin: I.G. Oppau.

Date: 31/8/42. Contents: 7 pages text. 2 sheets diagrams.

Occasionally in the running of Otto motors at low temperatures a diminution in the rate of fuel delivery is noticed. This phenomenon is caused by the water content of the fuel. The formation of ice inside the cold fuel line decreases the cross-section through which the fuel may flow. The addition of 1% ethyl alcohol is found to be a useful remedy.

The development of stoppage was followed by means of measurable data e.g. velocity of flow and the behaviour of various fuels was compared.

Fuels compared:

	No.
B4 (Leuna)	IG81
Brabag Benzine	IG9a
ET 110	2460
CV2b	2527
Rumanian Benzine	average sample
Comparison Benzine	IG9
Benzine-benzole mixture	IG90

TESTS ON A COAL DUST DIESEL ENGINE (3rd REPORT).

Ref. No. I.83 Report No. 348

Origin: I.G. Oppau/ Author: Aldinger

Date: 28. 2. 38 Contents: 14 Text Pages

SUMMARY

It was shown that with strong nitration the combustion was improved compared with previous samples. The best consumptions showed about 15% improvement.

With anthracite and poor quality hard coals (forge coals) nitration did not improve the ignition quality and it was impossible to run them in the engine. Nitration of lignite residue gave good ignition and combustion properties, and consumption equal to the best figure for nitrated Pott extract.

Additions of ammonium nitrate, calcium chlorate and trinitrotoluol to peat dust did not show any appreciable acceleration of the combustion.

The following efficiencies were obtained at different speeds:-

Fuel	225 r.p.m.	275 r.p.m.	325 r.p.m.
Gas Oil	29.5%	30.0%	29.0%
N.P.E.	22.0%	21.0%	18.5%
Lignite	25.5%	22.5%	19.5%

Brake mean effective pressures at constant fuel and lubricating oil consumptions increased with speed in the cases of gas oil and peat dust, remained roughly constant with lignite, and decreased slightly with nitrated Pott extract. Micro-fine dust showed the greatest decrease.

The lubricating oil consumption had for these tests to be increased above normal to cope with the poorer combustion of the dusts at higher speeds.

NOTE.- The ten figure sheets which should be attached are missing.

J.G.W.

reel 106

EXPERIMENTS WITH TIME-SWING APPARATUS FOR CATHODE RAY TUBES.

Report No. 361.

Index No: I.86

Author: Dr. Schuch.

Source: Oppau.

Date: 20/10/38.

Contents: 17 pages text.
13 diagrams.

Time-Swing apparatus for the production of stationary pressure diagrams (obtained with internal combustion engines) on the Cathode-ray tube screen is described.

The sideways deflection of the Cathode-ray is exactly synchronised with the revolution of the coupled engine, no matter what changes in r.p.m. take place. In conjunction with a pressure indicator the stationary diagrams are thus formed.

Photographs are given to show the usefulness of the apparatus. Disturbing effects influencing the expected course of the crank-angle, time and piston-thrust, time curves are discussed.

Finally more photographs of stationary pressure - crank angle and pressure-piston stroke curves are included.

reel 106

RADIATION MEASUREMENTS IN THE HESSELMAN ENGINE BY MEANS OF PHOTOCELLS AND CATHODE RAY OSCILLOGRAPH.

Ref. No. I.91

Origin: I.G. Oppau

Date: 30.12.38

Report No. 366

Author: Drs. Schuch and Witschakowski

Contents: 6 Text Pages
9 Figure Sheets

SUMMARY

The radiation process in the combustion chamber of a Hesselman engine was investigated by means of photocells in conjunction with an I.G. cathode ray oscillograph. At the same time the indicator diagram was also measured with a piezo-quartz indicator. It was observed that the onset of radiation, in most cases, took place later than the first measurable increase in pressure.

A difference with regard to the beginning of radiation at different positions of the observation window in the combustion chamber could not be established. Further, advance in the beginning of ignition from 10° to 35° before top-dead-centre or an increase in compression ratio from 6.5 : 1 to 10.2 : 1 did not give a decidedly earlier onset to radiation.

From the diagrams it was evident that not only the indicator diagram, but also the radiation process differed markedly from cycle to cycle. This held for the onset of radiation as well as for the maximum value.

Finally, an investigation was made to calculate the flame velocity. From this it was seen that in the Hesselman engine the flame is scattered considerably by the artificially-induced rotational movement of the air.

EXPERIMENTAL

(a) Engine: Hesselman. Stroke = 150 mm.
Bore = 95 mm.
Swept volume = 1063 cc.

Engine is fitted with normal Hesselman injection nozzle, Bosch ingection pump (7 mm. plunger). Throughout these experiments the beginning of injection remained unaltered at 90° before top-dead-centre. Although variation in the beginning of ignition was investigated, in general, ignition began 24° before top-dead-centre. Various compression ratios were employed. Engine performance was determined by means of a swinging dynamometer. Fuel used was aviation fuel of 87 Octane Number. The cylinder head of No.2 cylinder was provided with an observation window of Maxos glass for the radiation measurements and a piezo-quartz transmitter for the pressure-cycle. These two were interchangeable, thus affording two positions in the combustion chamber where the radiation and pressure could be measured.

Flame propagation investigation was only possible for methods which were completely free from inertia, e.g., by radiation measurements with a photocell.

(b) Photocell. The relationship between the frequency and light current for evacuated and gas-filled photocells is given. It is seen that for the evacuated cell there is no loss in efficiency, whereas with a gas-filled cell at an operating voltage of 90 volts and 10,000 HZ there is a 15% decrease in sensitivity.

As the flame temperature is about 2000°C. the principal radiation lies in the red and infra-red. Hence a red-sensitive photocell was used in this work. A blue-sensitive cell was also employed for purposes of comparison. The two cells were so constructed that there was no overlap of spectral-range. The potential difference, controlled by the intensity of light falling on the photocell, was relayed through an amplifier to the Braun tube of an I.G. cathode ray oscillograph which was photographed. Hence the radiation/time relationship was obtained. At the same time the occurrence of top-dead-centre and 1/50 sec. time intervals were marked on the film.

EXPERIMENTAL RESULTS

(1) With a red-sensitive photocell; no filter.

The radiation process and pressure cycle was investigated at different ignition starting angles and different compression ratios. It was seen that the onset of radiation took place later than the first measurable increase in pressure. Changes in ignition and compression had little influence on the onset of radiation. The onset of radiation was very irregular and hence precise measurements were impossible.

(2) With red- and blue-sensitive photocells; no filter.

Although the total radiation intensity was the same, it was seen that the contribution of blue rays to the total radiation was very small. Radiation measurements were made in two positions, but due to the nature of the two positions, no difference in the measurements could be established.

(3) With red-sensitive photocell and differently-coloured glass filters.

The usual differences in the radiation process were not observable, probably because the weakening of the radiation caused by the glass filters in front of the photocell was little different.

(4) With red-sensitive photocell and a grey glass filter.

Both observation windows were used. Moreover, as many working cycles as possible were photographed in order to establish the uniformity of radiation and pressure cycles. It was seen that not only the pressure cycle, but also the radiation process (and therefore the flame propagation) showed very great differences. Radiation again took place later than the pressure increase.

The same observation has been made by Bisang ("Deutsche Kraftfahnforschung", Vol. 4, p.42). He postulates three types of conditions for the occurrences of radiation in connection with the pressure increase, in advance, together and in retard. In addition, Dixon ("Berichte dtsch. chem. Ges. 1905, 38, 2419) has established that flame propagation does not synchronise with the attainment of the maximum temperature.

Further work should be carried out in which under normal compression ratios, the pressure wave should be propagated at a very much greater velocity than the flame front. The possibility should be investigated of determining the flame velocity in the combustion chamber from the radiation and pressure diagrams.

On the basis of the values given in Fig.1, we have:- C.R. = 6.5; speed = 1200 r.p.m.; ignition advance = 25° before top-dead-centre with the corresponding onset of radiation 15.6° after top-dead-centre. Hence, time for flame to travel from the sparking plug to the observation window ≑ 0.0056 secs. Taking the minimum path between plug and window as 65 mm. a flame velocity of 11.6 m/sec. was obtained.

Ref. No. I.91 (Contd.)

Considering the flame movement in the Hesselman engine a greater value for the path between plug and observation point is permissible. This would mean that in this case the flame velocity would be still greater. This value for the flame velocity approximates to that measured by Bisang on an Otto engine using retarded ignition. From other radiation diagrams obtained with an Otto engine values of the flame velocity were 40 - 60 m/sec.

It was also possible to estimate the "pressure lag". With ignition advance 10° before top-dead-centre, the first measurable increase in pressure occurred at top-dead-centre at a speed of 1200 r.p.m., the pressure lag was then 0.0014 secs.

J.A.E.M.

reel 106

I.88

PRESSURE DIAGRAMS IN THE DIESEL ENGINE WITH GAS OIL AND TWO HYDROGENATED PRODUCTS.

Influence of Compression Ratio and Injection Timing.

Ref. No. I.88
Origin: I.G. Oppau
Date: 10.11.38

Report No. 363
Author: Kühler
Contents: 14 Text Pages and 12 Figure sheets

SUMMARY.

Ignition delay, rate of pressure rise, maximum pressure and exhaust temperature were measured at different compression ratios and several injection advances. The tests were made with gas oil, a bituminous coal diesel oil from the hydrogenation plant at Ludwigshafen and a lignite middle oil from the hydrogenation plant at Leuna.

The first series of tests was carried out at a constant compression ratio and varied injection advance, the second with varied compression and fixed injection advance and the third with the compression and injection adjusted so that ignition occurred at top dead centre. The relations found are given in diagrams. Ignition delay and the point of injection are the most important variables affecting the combustion, but apparently the origin of the fuel, whether from aromatic coal or from the more paraffinic lignite, is noticed even after hydrogenation, especially in the steepness of the pressure increase during combustion.

J.G.W.

reel 106

KNOCKING BEHAVIOUR OF COAL TAR OIL WITH DIACETYLENE ADDITIVE AFTER STORAGE

Ref. No. I.24
Origin: I.G.Oppau
Date: 27.1.33.

Report No. 252
Author: Dr.Singer.
Contents: 1 text page
2 figure sheets.

SUMMARY.

A mixture of coal tar oil and 5% diacetylene after 3 weeks storage was found to have the same knocking tendency as the pure oil. A mixture of coal tar oil and 3% diacetylene was stored in a stoppered flask for 5 weeks and then tested. It was found that the anti-knock tendency of the additive was still apparent, but was weaker than that obtained with the freshly prepared mixture. (see Report No. 246, our ref. I.21.).

J.A.E.M.