WEAR IN HIGH SPEED DIESEL ENGINES OPERATING ON POWER ALCOHOL AS PRINCIPAL FUEL

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SUMMARY

Wear tests were conducted with a single cylinder, direct injection, 5 H.P.-1,500 r.p.m. diesel engine for a period of 1,000 hours using power alcohol as principal fuel. During the first 500 hours of the test, an alcohol-water blend (85—15 by vol.) was inducted with the inlet air and neat alcohol was inducted during the remaining period. Throughout the test H.S.D. oil was injected in the normal way to initiate combustion.

It is concluded from these tests that prolonged operation of a diesel engine with neat alcohol as the principal fuel does not lead to any adverse effect on the rate of wear. Besides, there is a noticeable reduction of engine deposits. While the presence of water is conducive to engine cleanliness it is advisable to restrict its content in the blend on account of its adverse effect on wear.

1. INTRODUCTION

Investigations on the use of power alcohol as fuel for high speed diesel engines have, in the past, been directed towards the combustion process and the general performance of the engine.* The present report relates to an investigation aimed at assessing the effects of prolonged operation with alcohol on engine wear. Tests were conducted for this purpose with a high speed diesel engine for a period of 1,000 hours. Alcohol blended with water was inducted with the inlet air during the first 500 hours of the test and neat alcohol during the remainder of time. Throughout, high speed diesel oil was injected to initiate combustion.

2. TEST SET-UP

A single cylinder, vertical, four-stroke, direct injection diesel engine developing 5 H.P. at 1,500 r.p.m. was used for the tests. The engine was coupled to an

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* H. A. Havemann, M. R. K. Rao, A. Natarajan and T. L. Narasimhan, "The utilization of power alcohol in combination with normal and heavy fuels in high speed diesel engines," *J. Ind. Inst. Sci.*, 1953, 35 (4).

T. L. Narasimhan, M. R. K. Rao and H. A. Havemann, "Alcohol as principal fuel in high speed diesel engines," *J. Ind. Inst. Sci.*, 1956, 38 (4).

electric dynamometer for power measurement. Separate fuel flow meters were used to measure the consumption of diesel oil and of alcohol. Other standard instruments were used to measure exhaust temperature, water temperatures, etc. The injection equipment supplied with the engine was retained for admission of diesel oil and a variable jet carburettor was fitted to the air inlet for admission of alcohol.

A new cylinder head assembly and a new set of piston rings were fitted and the engine was run-in for over 100 hours before tests were commenced.

3. TESTS WITH ALCOHOL-WATER BLEND

3.1. *Preliminary Tests*

Previous work in the Department indicated that, to obtain the same thermal efficiency as in a normal diesel engine it was necessary to overload the engine when alcohol was inducted. Furthermore, it was found that only under overload conditions could the engine accept alcohol in such quantities as to render it the principal fuel. Consequently, the full-load brake thermal efficiency of the diesel engine (used for the test) was chosen as the optimum efficiency to be attained by the engine while operating with alcohol.

The brake thermal efficiency of the engine while running on diesel oil only was therefore first determined. Then, an alcohol-water blend (85—15% by vol.) was inducted in progressively increasing quantities and the load on the engine suitably increased such that the brake thermal efficiency attained the same value as before. This load was found to be about 30% more than the full-load value. At this load the alcohol accepted by the engine was about 71% by weight of the total fuel used.

3.2. *Wear Test*

The engine was started on diesel oil and allowed to warm up for half an hour. With cooling water temperature at 80° C. the load and the induction of the alcohol-water blend were simultaneously increased until they attained the values obtained in the preliminary test (30% overload and the amount of alcohol being 71% by weight of the total fuel).

Under these conditions, the engine was run for 15·5 hours per day. Water and exhaust temperatures, fuel consumption, etc., were recorded at intervals of one hour. With the above daily routine, the engine was run for 500 hours. During this period the lubricating oil was tested periodically for crankcase dilution.

At the end of the test, the engine was dismantled and examined for combustion chamber deposits, piston lacquering and wear of the liner, piston assembly, valves and valve seats and main and big-end bearings.

4. TESTS WITH NEAT ALCOHOL

Preliminary tests were again conducted on lines similar to the above with neat alcohol inducted. These tests indicated that to obtain the same thermal efficiency as in a normal diesel engine the load to be carried by the engine was 30% overload and the corresponding proportion of alcohol was 78% by weight of the total fuel used. With these values of load and alcohol inducted, the wear test was repeated for another 500 hours.

Table 1 presents the details of operating conditions of the tests.

TABLE I

Wear tests with a diesel engine running on alcohol as principal fuel
Details of test conditions

Duration of Test ..	500 hours	500 hours	*500 hours
Speed of engine ..	1500 r.p.m.	1500 r.p.m.	*1500 r.p.m.
Power output from engine (observed)	5·77 H.P. (30% overload)	5·7 H.P. (30% overload)	*4·36 H.P. (Full load)
Fuel injected ..	H.S.D. Oil	H.S.D. Oil	H.S.D. Oil
Fuel inducted ..	Alcohol + Water (85−15% by Vol.)	Neat Alcohol	..
Alcohol inducted—% of total fuel by weight	71	78	..
Brake Thermal Efficiency—%	29·2	28·9	*29·1

* Information taken from a previous wear test.

5. TEST RESULTS

The results from the above tests together with similar results of wear tests on the engine while running on diesel oil only, are presented in Figs. 1 and 2 and Tables II and III.

TABLE II

Wear tests with a diesel engine running on alcohol as principal fuel
Comparative statement of crankcase dilution

Crankcase dilution			
With alcohol-water blend as principal fuel	With neat alcohol as principal fuel	With diesel oil as the only fuel	In petrol engines
1·1%	0·6%	*0·7%	†1–5%

* Information taken from a previous wear test.

† C. W. Georgi, *Motor Oils and Engine Lubrication*, 1951, p. 305, II printing, Reinhold Pub. Corporation, U.S.A.

TABLE III

Wear tests with a diesel engine running on alcohol as principal fuel
Comparative statement of wear of component parts after 500 hours run

		Wear for 500 hours		
		With alcohol-water blend as principal fuel	With neat alcohol as principal fuel	With H.S.D. oil as the only fuel
Piston Rings				
Top compression ring: (Chromium plated)	Gap growth 1″/1000	7	2	*6
	Loss of weight gm.	0·339	0·205	0·25
Second compression ring:	Gap growth 1″/1000	21	16	*6
	Loss of weight gm.	0·415	0·268	0·213
Third compression ring:	Gap growth 1″/1000	16	9	*7
	Loss of weight gm.	0·303	0·208	0·106
Oil ring:	Gap growth 1″/1000	27	17	*8
	Loss of weight gm.	0·344	0·205	0·054
Liner (increase in circumference 1″/1000)				
½ inch from top	.. ..	Nil	Nil	*Nil
1	.. ..	2·0	2·0	*1·5
2	.. ..	1·5	0·5	*1·0
3	.. ..	1·5	0·5	*1·0
4	.. ..	1·5	0·5	*1·0
5	.. ..	1·5	0·5	*0·75
6	.. ..	..	..	*0·75
7	.. ..	..	..	..

* Information taken from a previous wear test.

The results can be summarized as follows:—

5.1. Combustion chamber deposits were negligible with alcohol-water blend. They were slightly higher with neat alcohol and were in the form of fluffy soot. They were highest with neat diesel oil and were in the form of hard coke (*vide* Figs. 1 and 2).

5.2. Lacquering of the piston was negligible with alcohol-water blend, higher with neat alcohol and highest with neat diesel oil (*vide* Fig. 3).

5.3. Crankcase dilution was practically of the same order in all cases (*vide* Table II).

5.4. There was no noticeable difference in the wear of gudgeon-pin and bush, valves and valve seats, and main and big-end bearings with either alcohol-water blend or neat alcohol as compared to diesel oil only.

5.5. The wear of the top piston ring was quite low with neat alcohol, higher with neat diesel oil and highest with alcohol water blend. The wear of the rest of the rings was a minimum with neat diesel oil, higher with alcohol and highest with water-alcohol blend (*vide* Table III).

The liner wear was least with neat alcohol, higher with neat diesel oil and highest with alcohol-water blend (*vide* Table III).

6. Discussion

6.1. *Combustion Chamber Deposits and Lacquering of Piston*

In a normal diesel engine the mixing of air and fuel is inadequate. Further, in the combustion chamber fuel is mostly in the liquid state prior to ignition. The ensuing combustion is akin to "liquid state" burning which is prone to lead to cracking of the fuel and formation of coke-like deposits.

The induction of alcohol as principal fuel into such an engine results in vapourization and thorough mixing of a major part of the fuel prior to ignition. The ensuing combustion is more akin to "vapour state" burning which minimises the possibility of cracking of the fuel and thus reduces the formation of deposits and lacquering of the pistons. Presence of water in alcohol reduces the deposits further.

6.2. *Crankcase Dilution*

The crankcase dilution observed when inducting alcohol with or without water is well within the average values found in petrol engines.

6.3. *Wear*

(1) Despite the higher load on the engine when running on alcohol there is no noticeable increase in wear of the bearings, journals and valves.

(2) The total wear of the liner and rings when running on neat alcohol is comparable to the normal wear in diesel engines. However, the presence of water in the alcohol tends to increase the wear somewhat, though this does not materially affect the performance of the engine.

7. CONCLUSIONS

1. Operating a diesel engine with alcohol as principal fuel does not have any adverse effect on the rate of wear.

2. There is a noticeable reduction of engine deposits.

3. Though the presence of water in alcohol is conducive to engine cleanliness, it is preferable to reduce its content in the blend on account of its adverse effect on wear.

8. FUTURE WORK

1. This investigation needs to be extended to automotive diesel engines in field service so that the disparity of wear (if any) between the laboratory test and the field test can be assessed.

2. The reasons for improved engine cleanliness and increased wear when alcohol is blended with water require investigation.

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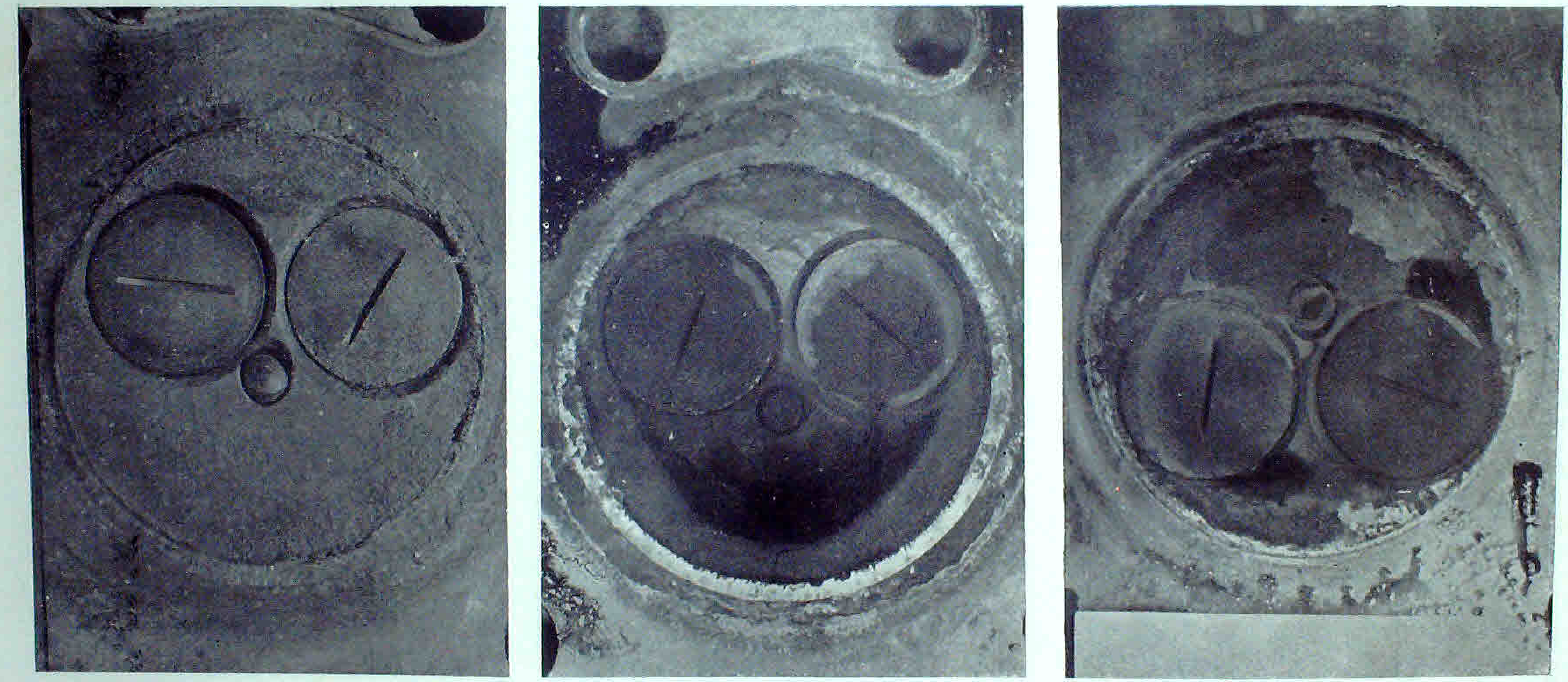

Diesel Oil + Alcohol-water blend. Diesel Oil + Alcohol. Diesel Oil only.

FIG. 1.

Combustion chamber deposits—(Cylinder head) after 500 hours. Wear test with a Diesel Engine running on alcohol as principal fuel.

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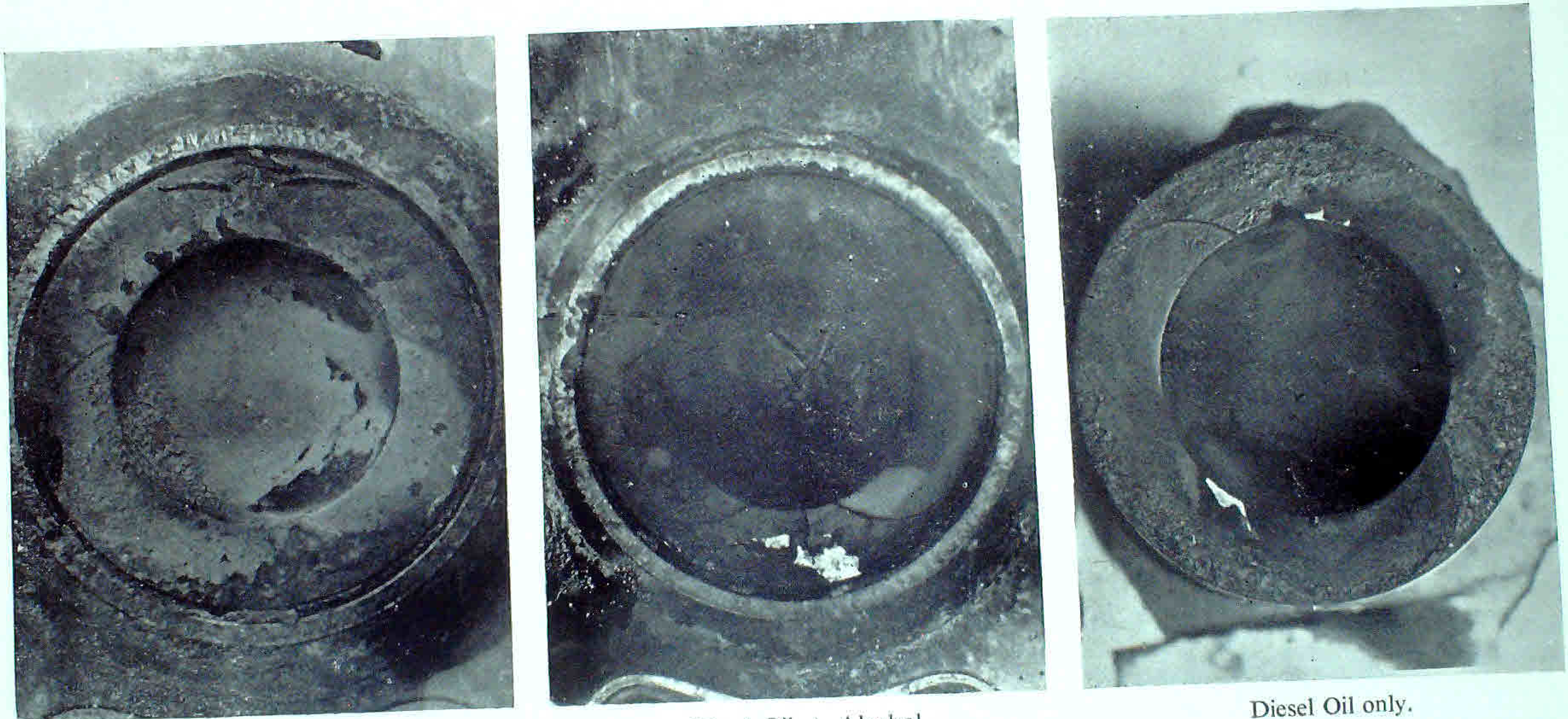

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Fig. 2.

Combustion chamber deposits—(Piston Crown), after 500 hours' run. Wear test with a Diesel Engine running on alcohol as principal fuel.

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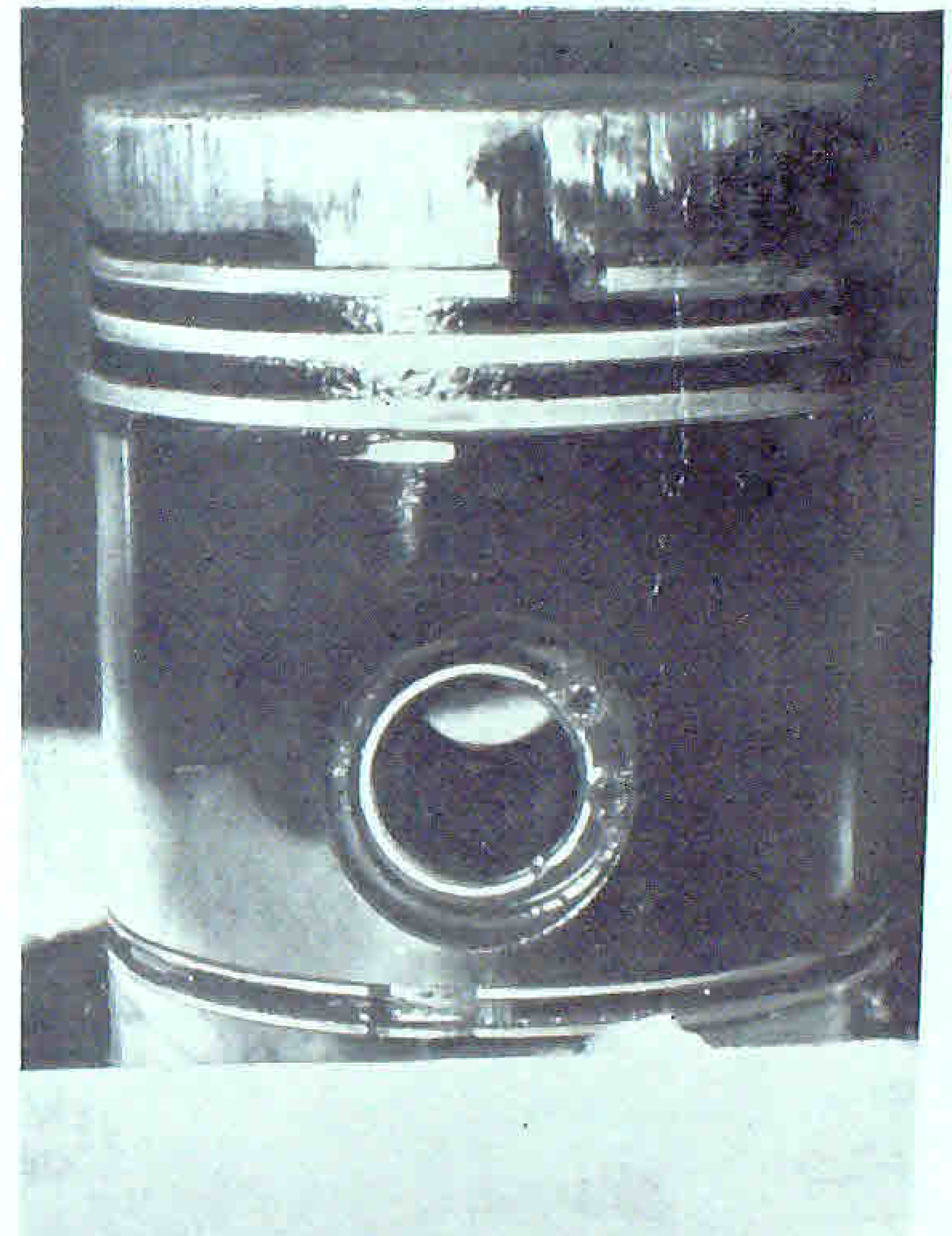
Diesel Oil + Alcohol-water blend.

Diesel Oil + Alcohol.



Diesel Oil only.

FIG. 3.

Piston Lacquering, after 500 hours' run. Wear test with a Diesel Engine running on alcohol as principal fuel.