ENCLOSURE (B) 8

PRACTICAL ENGINE TESTS FOR SUBSTITUTE DIESEL FUELS

Creosote Oil
Wood Gas
Soy-bean Oil and Pine-root Oil

by

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ENCLOSURE (B)8

LIST OF TABLES AND ILLUSTRATIONS

ENCLOSURE (B)8

C R E O S O T E O I L

SUMMARY

Creosote oil was examined to determine whether it was suitable for No.51-10 diesel engine (used in high-speed boat) and for 75 hp hot bulb engine (for small tramp use).

The following conclusions were obtained:

1. For Diesel Engine No.51-10. Combustion was irregular owing to poor ignition, and the maximum pressure in the cylinder was very high (about 70 kg/cm^2). These results show that the use of creosote oil is unsatisfactory.

2. For 75 hp Hot Bulb Engine. When no alteration was made on the engine, the operation of the engine was impossible unless the scavenging air adjusting valve was opened a little, and the hot bulb was heated by a blow lamp every 5 to 10 minutes to keep the bulb at high temperature.

When the engine design was altered as shown in Figure 1(B)8, (Hot metal was made of Si-Cr steel) both partial and full load operations were possible holding the bulb at ordinary temperature. Though the maximum pressure in the cylinder was 2 to 3 kg/cm^2 higher than the pressure when heavy oil No.1 was used, operating results were the same as those of heavy oil No.1, and this shows that in this case creosote oil can be used practically; more over, if the hot bulb was sufficiently heated by a blow lamp before starting the engine could be easily started.

I. INTRODUCTION

A. History of Project

As a result of American victories on Saipan and in the Philippines, the supply of heavy oil from the South Sea Islands was cut off, making the shortage of heavy oil imminent. Therefore, the substitution of creosote oil for heavy oil was considered by the Naval Department of Material, and orders were issued to the Yokosuka Naval Arsenal in January, 1945, to test certain diesel engines and hot bulb engines using creosote oil. Diesel engine No. 51-10 and 45 hp hot bulb engine were tested with creosote oil obtained from the First Fuel Depot. Tests with diesel engine No. 51-10 were abandoned after two or three trials in March, 1945, for the reason stated in the summary. Tests were made with the 75 hp hot bulb engine from April to June, 1945. The experiments were discontinued, when it was found that creosote oil could be practically used if the hot bulb was equipped with "hot metal". "Hot metal" was made or ordinary steel plate in the first test. Metal made of Si-Cr steel was used for the second test and it was found that the latter was better than the former because of its heat resisting properties.

ENCLOSURE (B)8

B. Key Reasearch Personnel Working on Project

Eng. Lt. T. YASUMA
Eng. Lt. M. TOMITA

II. DETAILED DESCRIPTION

A. Description of Apparatus

1. Engines. See Table I(B)8.

2. Testing Apparatus. The apparatus is shown in Figure 2(B)8 and Figure 3(B)8.

B. Test Procedure

1. For Diesel Engine No.51-10.

a. The engine was started by light oil.

b. Operation was continued for 5 to 10 minutes at 4/10 of full load, until a smooth driving state was reached.

c. Light oil was changed to creosote oil previously heated to 50-60°C. No changes were made in the diesel engine.

2. For 75 hp Hot Bulb Engine.

a. No changes were made in either parts or settings of the hot bulb engine at first, and research was carried out on the starting and running characteristics.

b. Secondly, in order to improve the ignition of creosote oil, "hot metal" was equipped in the hot bulb as shown in Figure 1(B)8, and investigations were made on effect of hot metal and its durability in starting and in operating characteristics.

Hot metal was made of ordinary steel or Si-Cr steel, and creosote oil was preheated to 50-60°C.

C. Experimental Results

1. For Diesel Engine No.51-10. Soon after the fuel was changed, the engine revolutions decreased and the maximum pressure in the cylinder increased to about 70 kg/cm^2, combustion becoming irregular and operation very difficult. No data are available from this experiment.

2. For 75 hp Hot Bulb Engine.

a. No design alterations made:

(1) Ease of starting: Though it was more difficult than with heavy oil No.1, the engine could be started using starting air (air pressure being 6 to 8 kg/cm^2) if the hot bulb was previously heated to a red color by a blow lamp.

(2) Running characteristics: Satisfactory engine running was not possible unless the scavenging air adjusting valve was opened slightly and the hot bulb was heated by a blow lamp every 5 to 10 minutes and was kept at a high temperature. No data are available from this experiment.

b. Using hot bulb equipped with "hot metal":

(1) Ease of starting: Same as in (a) (1) above.

(2) Running characteristics: It was possible to drive engine at any load while maintaining the surface temperature of the hot bulb at 300°C. The temperature was measured with a thermocouple, and results showed the same temperature as in the case of using heavy oil No.1. Table III(B)8 shows the operating results at full load.

(3) Durability of hot metal: Hot metal made of steel plate was partially melted after full load operation for 5 hours.

Hot metal made of Si-Cr steel was in good condition after 20 hours of full load driving.

III. CONCLUSIONS

A. According to the several experiments with diesel engines, it was concluded that the low cetane creosote oil obtained from the First Naval Fuel Depot was not suitable for diesel engine fuel.

(Note: The above is not too conclusive as only one kind of creosote oil was used.)

B. It was concluded that creosote oil was satisfactory for hot bulb fuel providing, "hot metal" made of Si-Cr steel was equipped in the hot bulb when a bad quality creosote oil was used.

Table I(B)8
DETAILS OF TEST ENGINES (SINGLE-ACTING, SOLID INJECTION)

	Cycles	bhp	rpm	Bore	Stroke	No. of Cyl.
Diesel engine No.51-10	4	300	1500	140mm	200mm	10
75 hp hot bulb engine	2	75	335	12mm	13 1/2mm	2

ENCLOSURE (B)8

Table II(B)8
CHARACTERISTICS OF TEST FUELS

Oil	Reaction	Sp. Gr.	Flash Pt. (°C)	Viscosity Red. Sec.			Ash	H_2O	S	Solid. Pt.	Calorific Value	Cetane
				30°C	40°C	80°C						
Soya-bean	Neutral	0.914	161	271	137	68		0.6	0.028	-19°C	9442 Cal/gm	37-38
Pine-root	Acid	0.998	46	82	51	36	0.028	2.3		-20°C	9152 Cal/gm	

Table III(B)8
EXPERIMENTAL RESULT USING CREOSOTE OIL AT FULL LOAD

rpm	bhp	Regulating Condition		Fuel Consumption		Max. Pressure in Cylinder (kg/cm^2)	Temperature (°C)		Color of Hot Bulb
		Scavenging Air Adjusting Valve	Fuel Handle	lit/hr	gm/bhp hr		Exhaust Gas	Fuel	
335	75	6/10	4.8/10	22.2	319	24	264	53	Black

Table IV(B)8
CHARACTERISTICS OF TEST FUELS

	Reaction	Sp. Gr.	Flash Pt.	Viscosity Red. Sec.			Solid. Pt.	Ash	H_2O	S	Calorific Value
				30°C	50°C	80°C					
Creosote oil	Neutral	1.08	74.5°C	88	46	34	-19°C	0.103%	9.8%	0.625%	9305 cal/gm
Heavy oil No.1	Acid	0.942	93.5°C	110	59	40	<-20°C	0.005%		0.146%	10600 cal/gm

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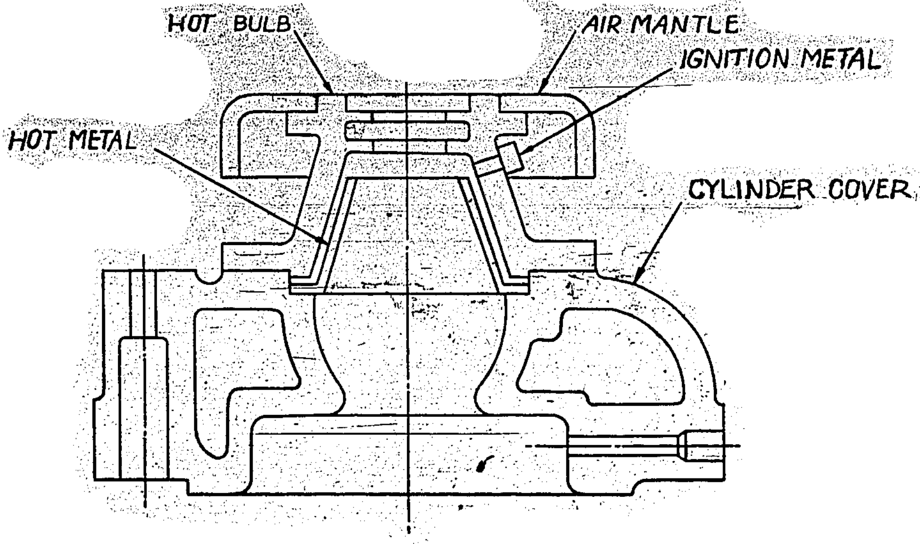

Figure 1(B)8
REDESIGNED HOT BULB

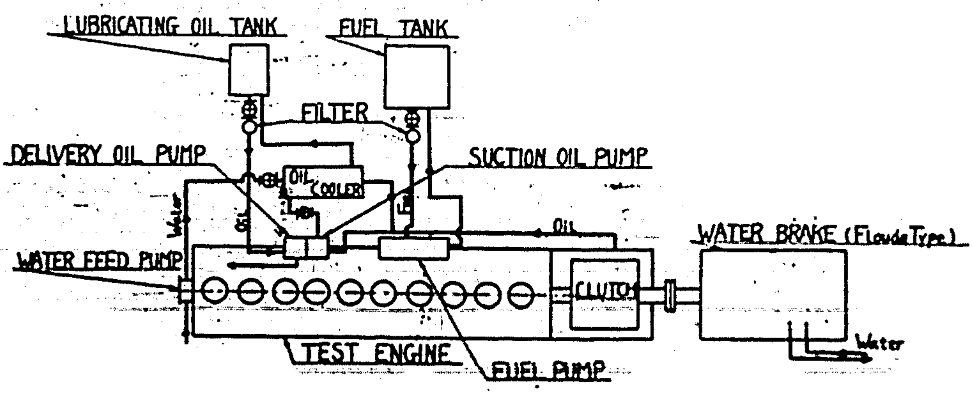

Figure 2 (B)8
TESTING APPARATUS
FOR DIESEL ENGINE NO. 31-10

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SOY-BEAN OIL AND PINE-ROOT OIL

SUMMARY

Practical operations of diesel engine No.51-10 were made with soy-bean oil alone, pine-root oil alone and mixture of both (mixing ratio of 5 : 5). The following results were obtained:

1. Soy-bean oil had better properties than heavy oil No.1. Therefore, diesel engine No.51-10 could be operated easily at full load with soy-bean oil.

2. By operating diesel engine No. 51-10 with pine-root oil alone or mixed oil (soy-bean oil : pine root oil = 5 : 5), similar operating conditions were obtained to those when heavy oil No.1. was used. However, starting was impossible unless the fuel pump plunger and needle valve were cleaned at the end of the preceding run. This fact was caused by the formation of resinous matters in the pine-root oil. Therefore, practical operations were unsatisfactory using pine-root oil or mixed oil

I. INTRODUCTION

A. History of Project

After practical tests of creosote oil, the above tests were made in June, 1945.

These fuels were prepared in the First Fuel Depot. Only a small amount of soy-bean was tested, but running characteristics with soy-bean oil were very good. Therefore, investigations were carried out only for a short period. As pine-root oil and mixed oil gummed up the fuel injection system, it was considered unsatisfactory. As a result, only two or three experiments were made.

B. Key Research Personnel Working on Project

Eng. Lt. M. TOMITA

II. DETAILED DESCRIPTION

A. Description of Apparatus

1. Testing Apparatus. This is shown in Figure 2(B)8.

2. Fuels. See Table IV(B)8

B. Test Procedure

1. No design alteration was made on the main engine No.51-10.

2. Starting was accomplished by use of light oil.

3. Light oil was changed to testing fuel after starting.

ENCLOSURE (B)8

4. Investigations were made at each power.

5. Soy-bean oil and mixed oil heated to 50-60°C were employed.

C. Experimental Results

1. Soy-bean Oil. Properties of soy-bean oil were better than those of heavy oil No.1. Therefore, diesel engine No.51-10 could be operated easily at any load with soy-bean oil. The experimental results at full load are shown in Table V(B)8.

2. Pine-root Oil and Mixed Oil. Diesel engine No.51-10 could be operated with the same operating conditions as for heavy oil No.1; however, starting was impossible unless the needle valve and fuel pump plunger were cleaned immediately after the end of the previous operation. This was caused by the formation of resin in the needle valve and fuel pump plunger. No data were taken.

III. CONCLUSIONS

A. Engine running characteristics using soy-bean oil were very good, and it was concluded that this oil was a good substitute for diesel engine fuel.

B. It was determined that pine-root oil or mixed oil could not be used as a substitute fuel, unless they were thoroughly refined removing the resinous matters which gum up the fuel injection system.

Table V(B)8
XPERIMENTAL RESULT USING SOYA-BEAN OIL AT FULL LOAD

rpm	bhp	Regulating Condition		Fuel Consumption		Max. Pressure in Cylinder kg/cm²	Temperature (°C)	
		Timing Handle	Full Handle	lit/hr	gm/bhp/hr		Exhaust Gas. Temp.	Fuel Temp.
1500	300	4/10	48/60	80.4	245	54	515	45

ENCLOSURE (B)8

WOOD GAS

SUMMARY

The substitution of wood gas for liquid fuel in a 75 hp hot bulb engine was examined, and the following results were obtained.

1. When a mixture of wood gas and heavy oil No.1 (for ignition use) was employed, consumption of heavy oil No.1 was 20-35% of the heavy oil consumption when heavy oil No.1 was employed alone and operations were comparatively smooth.

2. "Hot metal" was installed in the hot bulb shown in Figure 1(B)8 (same as the case of creosote oil) with the following results:

   a. When the load was 2/10-4/10 of the full load, both wood gas and heavy oil No.1 had to be employed.

   b. When the load was 6/10-8/10 of the full load, operation was possible using wood gas only.

3. For starting, liquid fuel was necessary.

4. Characteristics of the gas producer were not examined in detail, but improvements in some parts were considered necessary.

I. INTRODUCTION

A. History of Project

Since the end of 1944, many hot bulb engines could not be driven since the shortage of liquid fuel was imminent.

Therefore, the Naval Department of Material issued orders in October, 1944, to the Yokosuka Naval Arsenal to test hot bulb engines using wood gas. Experiments were made from March to August, 1945, and possibilities for practical use of wood gas in the hot bulb engine were discovered.

B. Key Research Personnel Working on Project

Eng. Lt. S. WATANABE.

II. DETAILED DESCRIPTION

A. Description of Apparatus

The apparatus is shown in Figure 3(B)8 and Figure 4(B)8.

B. Test Procedure

1. When both wood gas and heavy oil No.1 (ignition fuel) were

employed:

(a) Burning cloths were thrown into the gas producer from the firing hole to ingnite wood in the furnace.

(b) Satisfactory gas was produced by blowing for a period of 10 to 15 minutes with a hand blower.

(c) The engine was started with heavy oil No.1, fully opening the airvalve in the gas and air mixing apparatus.

(d) In order to control load, the air valve and gas valve were opened slowly and then the fuel handle (for liquid fuel use) was regulated slowly.

(e) Characteristics of the gas producer and operating characteristics of each load were investigated.

(f) Another engine with a 3mm top clearance in the cylinder was examined. (No changes were made in the engine).

2. When wood gas without liquid fuel was used alone adjusting the top clearance in the cylinder to 3mm:

"a", "b", "c", and "d" were the same as B,1
"e" after operating in 1,d state for 10 minutes, liquid fuel was completely shut off.

"f" characteristics of the gas producer and engine operating characteristics at each load using wood gas only were investigated.

C. Experimental Results

1. The experimental results for when both wood gas and heavy oil No. 1 were employed are shown in Table VI(B)8.

Comparatively smooth operation was obtainable for any load and comparable to the operation obtained when heavy oil No. 1 was used alone.

Consumption of heavy oil No. 1 was about 35% at 4/10 of the full load and about 18% at full load, as compared with consumption of heavy oil No. 1 when heavy oil No. 1 was used only. Consumption of wood: 1.35 kg per boiler horsepower hour at full load. Horse power was greatly influenced by the degree of opening of the air valve.

2. Using wood gas alone. Experimental results are shown in Table VII(B)8.

8/10 of full load operation was possible with wood gas alone, but 2/10-4/10 of full load operation was difficult when hot bulb temperature was low.

Comparatively smooth operation was possible at 6/10-8/10 of full load. Consumption of wood was 1.4 kg per boiler horsepower hour at 8/10 of full load.

ENCLOSURE (B)8

III. CONCLUSIONS

Wood gas could be substituted with satisfactory results in a hot bulb engine but its practical application was considered difficult for the following reasons:

A. Practice and skill are necessary to control the ratio of gas and air mixture.

B. Exact setting and timing of the fuel injection system before operating is necessary.

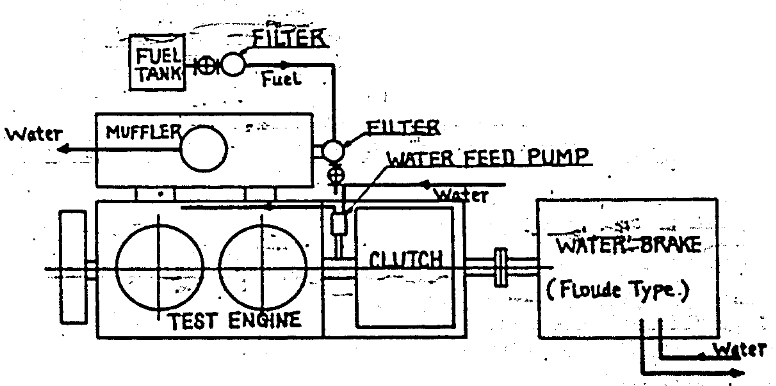

Figure 3(B)8
TESTING APPARATUS FOR
75 H.P. HOT BULB ENGINE

ENCLOSURE (B)6

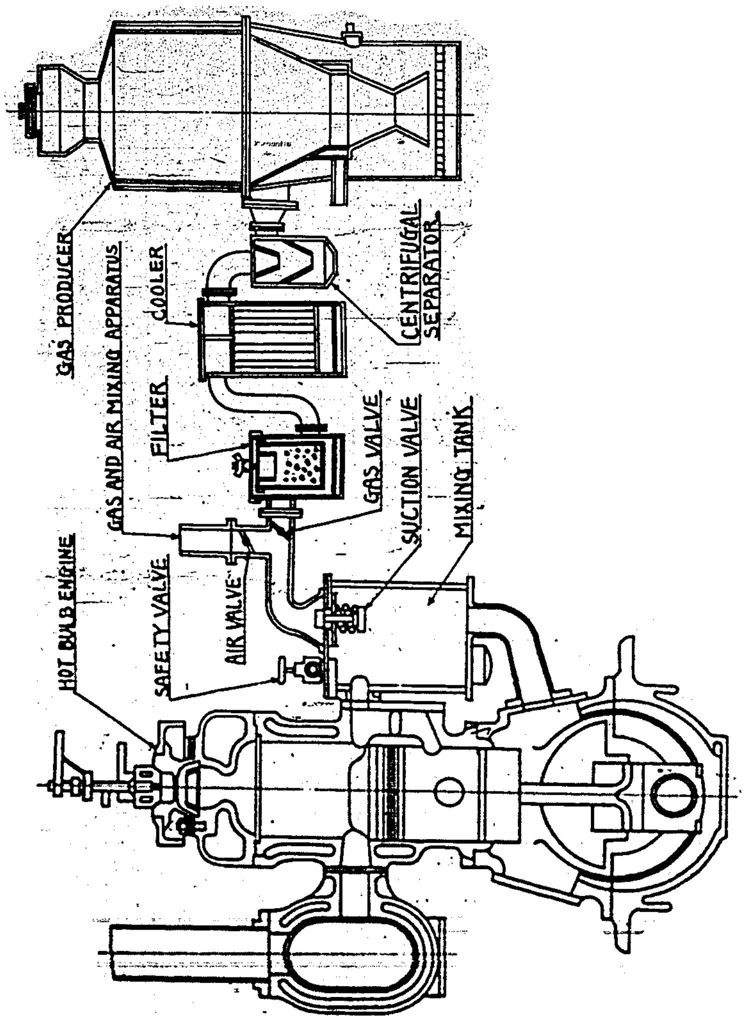

Figure 4(B)8
PRODUCING APPARATUS FOR 75 H.P. HOT BULB ENGINE

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Table VI(B)8
EXPERIMENTAL RESULTS USING WOOD GAS AND HEAVY OIL No. 1

Power Tested	rpm	bhp	Condition			Fuel Consumption				Pressure		Gas Temperature	
			Gas Valve	Air Valve	Fuel Handle	Liquid Fuel		Wood		Max. Pressure in Cylinder kg/cm^2	Gas Pressure (at inlet of engine) $mm.H_2O$	Outlet of Gas Producer ^oC	At inlet of Engine ^oC
						lit/hr	gm/bhp hr	kg/hr	kg/bhp hr				
4/10 of full load	247	30	3	2.5	1.0	3.7	111	-		20	240	-	35
6/10 of full load	283	45	5	2.0	1.0	4.0	80	-	-	22	260	-	32
8/10 of full load	311	60	10	1.5	0.5	3.8	57	-	-	25	290	-	38
10/10 of full load	333	75	10	1.2	0.5	3.8	46	108	1.35	25	320	388	42

Note: Color of hot bulb--black.

Table VII(B)8
EXPERIMENTAL RESULTS USING WOOD GAS AT FULL LOAD

rpm	bhp	Regulating Condition		Wood Consumption		Pressure		Gas Temperature		Colour of hot bulb
		Gas Valve	Air Valve	kg/hr	kg/bhp hr	Max. Pressure in Cylinder kg/cm	Gas Pressure (at inlet of engine) $mm.H_2O$	Outlet of Gas Producer C	At inlet of Engine ^oC	
335	60	10	10	112	1.4	24	320	385	42	black