

ENCLOSURE (B) 22

STUDIES ON A SIMPLIFIED APPARATUS  
FOR CARBONIZATION OF SHALY COAL

by

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ENCLOSURE (B)22SUMMARY

A simplified apparatus for carbonization of shaly coal was studied with the object of obtaining bunker fuel from its product, tar. After preliminary tests on pilot-plant scale, a plant was designed with a carbonization capacity of about 30 T/day of shaly coal. This plant consisted of four blast-furnace type carbonization retorts, each having about 2m<sup>3</sup> inner volume and equipped with tubular condenser, exhauster and packed columns. In March, 1945, a test plant was operated continuously for 20 days, and about 12 tons of tar were produced (about 2% of shaly coal). From these tests it was determined that the ash content of shaly coal should be less than 65% and the size should be greater than 50mm. Construction of 200 of the 30 T/day plants was started in March, 1945. Forty plants are located at FUKUOKA (Fourth Naval Fuel Depot) and the balance are located at various mines in KYUSEU. About 80 plants were finished by the end of the war.

I. INTRODUCTIONA. History of Project

In December, 1944, orders came to study this project. After fundamental experiments on 1.8 T/day and 7 T/day pilot plants, a treating apparatus of about 30 T/day charge capacity was designed.

The following points were specifically requested for this project:

1. Minimum usage of critical materials.
2. Ease of operation.
3. High capacity.
4. Mass production of apparatus beginning in March, 1945.

B. Key Research Personnel Working on Project

Chem. Eng. Lieut. R. SUSUKI  
Chem. Eng. Sub Lieut. R. KAWASHIMA

II. DETAILED DESCRIPTIONA. Apparatus and Procedures

The general layout of the plant is illustrated in Figure 1(B)22. This plant was designed to minimize cracking by removing quickly, by suction fan, tar which is produced by the carbonization of low calorific-value, high ash-content shaly coal. The raw coal is fed into the charge hopper and travels slowly downwards. The retort is heated by the gas generated from the fixed carbon remaining in the shaly coal after it has passed through the carbonization zone. Thus, in this retort, the sensible heat of the gas is employed directly in raising the temperature of the shaly coal up to 700°-800°C. It flows upward through the retort, counter current to the coal, carrying along volatile matter evolved from the coal during distillation.

The temperatures employed in this retort are:

1. Temperature of hot gas leaving retort, 200°-280°C.

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2. Temperature of carbonization zone, 300°-800°C.
3. Temperature of combustion zone, 800°-1,100°C.

The construction materials required for the complete plant are:

Iron and steel.....	6.8 tons
Fire bricks.....	5,500 ea.
Fire mortar.....	5.0 tons
Cement.....	5.0 tons

This plant can be constructed in about 15 days.

### B. Experimental Results

#### 1. Material and Heat Balance (Based on 20 days average results).

##### a. Material balance (yields per ton of shaly coal).

###### Input

Shaly coal...1.00 tons
Air.....1.88 tons
<b>Total</b> <b>2.88 tons</b>

###### Output

Tar.....	0.022 tons
Ash.....	0.75 tons
Condensed water.....	0.10 tons
Non-condensed gas...1.90 tons	
Loss.....	0.11 tons
<b>Total</b> <b>2.88 tons</b>	

##### b. Heat balance (Basis: 100 kg of shaly coal)

<u>Input</u>	<u>K cal</u>	<u>Percent</u>
Shaly coal (gross cal. value)....	265,000	99.6
Water Vapor in air (gross cal. value)	960	0.4
<b>Total</b>	<b>265,960</b>	<b>100.0</b>

<u>Output</u>	<u>K cal</u>	<u>Percent</u>
Tar (gross cal. value).....	17,000	6.4
Ash (gross cal. value).....	76,500	28.8
Flue gas (gross cal. value).....	149,000	56.0
(Non-condensed gas)		
Tar (sensible heat).....	170	0.04
Ash (sensible heat).....	6,025	2.27
Flue gas (sensible heat).....	1,710	0.64
(Non-condensed gas)		
Steam in Flue gas (sensible heat)...	235	0.09
Condensed Water (sensible heat)...	5,670	2.13
Heat in cooling water.....	2,070	0.78
Heat loss of radiation.....	7,580	2.85
<b>Total</b>	<b>265,960</b>	<b>100.0%</b>

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2. Physical and Chemical Properties of Feed stock and Products.a. Feed Stock (Shaly coal from 4th Naval Fuel Depot, FUKUOKA).Proximate Analysis (%) (as charged)

Moisture.....	1.30
Volatile matter.....	22.03
Fixed carbon.....	15.05
Ash.....	61.62
Total	100.00

Gross Calorific value, 2,650 K cal/kg.

b. Products.

Properties of the tar are discussed in a subsequent report by Chem. Eng. Lt. Cmdr. M. KUMAMOTO.

Proximate Analysis of Ash (%)

Moisture.....	0.59
Volatile Matter.....	2.71
Fixed carbon.....	6.37
Ash.....	90.33
Total	100.00

Gross calorific value, 817 K cal/kg.

Orsat Analysis of Non-Condensed Flue Gas

CO <sub>2</sub> .....	8.1
O <sub>2</sub> .....	7.1
C <sub>2</sub> H <sub>4</sub> .....	0.4
CO.....	0.2
H <sub>2</sub> .....	2.3
CH <sub>4</sub> .....	6.4
N <sub>2</sub> .....	75.5

Gross calorific value 700 K cal/m<sup>3</sup>.  
Condensed water was not analysed.

3. Operating Difficulties.

a. When the particle size distribution of shaly coal varies over a large range (e.g. from powder to 200mm dia.) or ash content of the coal is more than 65%, ash accumulates in the bottom of the retort, and, in this hand-discharged retort, the formation of bad clinkers occurs.

b. Small size coal, less than 55mm in diameter, and especially high content of powder, caused bad distribution of blast in the retort.

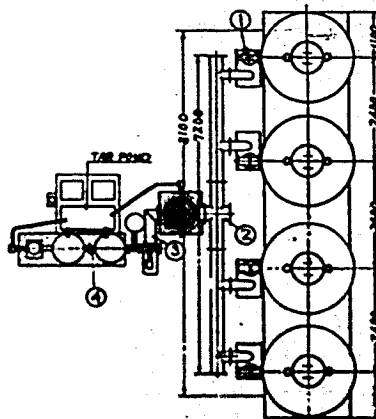
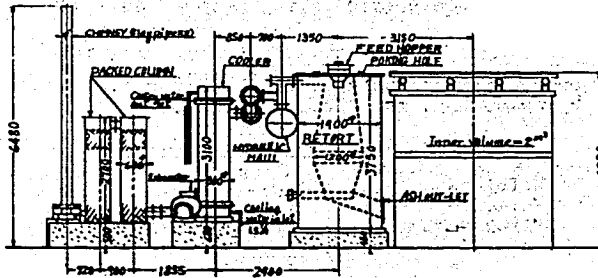
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c. The tar loss from the chimney was about 7-9 gm/m<sup>3</sup> of g (e.g. 75-85 lit/day).

III. CONCLUSIONS

A. In spite of the difficulties mentioned above, mass production of this type plant was begun by the Imperial Navy in March, 1945, in order to quickly produce tar for the fleet.

B. The physical and chemical properties of shaly coals were different at every coal mine, so the design details of this apparatus (especially the retort structure), were left up to the engineers of each coal mine.



Conditions:

Food in discharge	30%
Porosity	average
Content of tar	20-30%
Pressure of each zone	2-3 atmos
Tar	600 lb
Output	6000

Item	Rated Value	Exposure	Center	Max. Air Flow	Gas Flow	Temperature	Pressure
Description	60000 lb/day	20000 lb/day	20000 lb/day	20000 lb/day	20000 lb/day	20000 lb/day	20000 lb/day
% Tar	20-30%	20%	15%	15%	15%	15%	15%

Figure 1(B)22

SIMPLIFIED CARBONIZATION APPARATUS FOR SHALY COAL

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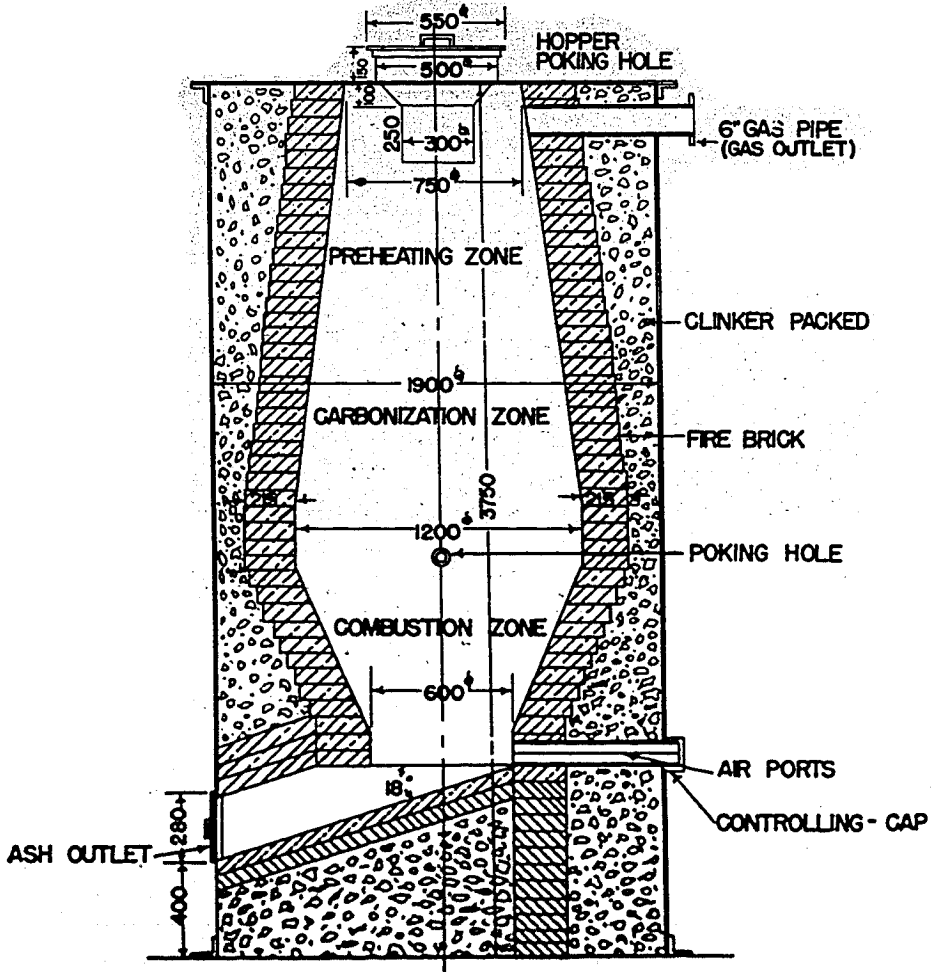


Figure 2(B)??  
CROSS-SECTION OF CARBONIZATION RETORT