ENCLOSURE (B) 13

ON THE PHYSICAL PROPERTIES OF PASTES

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by

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LIST OF TABLES AND ILLUSTRATIONS

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SUMMARY

To assist in the design and operation of Bergius coal hydrogenation plants, the viscosity, heat conductivity, heat propagating ratio, density, specific heat, and electrical conductivity of coal pastes and hydrogenated oil product were determined.

I. DETAILED DESCRIPTION

A. Description of Samples

Fushun-Oyama coal was crushed to 120 mesh and thoroughly mixed in a tube mill with heavy oil from hydrogenation of Oyama coal. The properties of the coal and the resulting paste are shown below.

Composition of Fushun-Oyama Coal

Water (wt %)	5.5
Volatile matter	41.4
Carbon	46.4
Ash	7.0

Composition of the Paste

Water (wt %)	3.3
Coal	41.8
Heavy oil	54.9

B. Description of Test Procedures and Results

1. Viscosities at atmospheric and 200 atmospheres of pressure were measured in a falling ball viscosimeter, made of 18-8 Cr-Ni steel, 24.90mm inner diameter, and one meter in length (refer to Figure 1(B)13). A steel ball (7.93mm in diameter) was released by means of handle "B", and the rate of fall was measured by an electrical indicator at "D". Viscosities of the paste and the heavy oil determined by this apparatus are shown in Figures 2(B)13 and 3(B)13.

The relation between the viscosity of the paste and its coal content is shown in Figure 4(B)13. In this case, a MacMichel's viscosimeter was used.

The device shown in Figure 5(B)13, was inserted within the apparatus shown in Figure 1(B)13, and viscosities at 200 atmospheres of pressure and high temperatures were measured.

In Figure 5(B)13, "B" is a cylinder 20mm in diameter and 88mm in depth, and "C" is a capillary (1.5mm in diameter and 100mm in length). An electromagnet is set outside of the tube and the iron cylinder "A", closing the opening to the capillary, can be lifted for a definite time. The viscosity was calculated from the quantity of the liquid that flowed through the capillary per unit time.

By this method, the viscosity of the paste, free from larger particles of solid matter which might plug the viscosimeter, was measured (refer to Table I(B)13).

2. Heat Conductivity. Heat conductivity was measured in the apparatus shown in Figure 6(B)13.

The temperature at the points "A" "B" and "C" were measured with copper-constanton thermocouples (0.1mm in diameter) which were attached by means of tin foil circles, 20mm in diameter. The thickness of the sample was measured with a micrometer. The results are shown in Table II(B)13.

3. Heat Propagating Ratio. The apparatus used for measuring the heat propagating ratio is shown in Figure 7(B)13. The paste was put in "A" and maintained at a constant temperature. Ice water was put in "C" (separated from "A" by copper plate "B"), and vigorously stirred.

Immediately the temperature of the paste at a distance of 1.75cm from the copper plate was measured.

The heat propagating ratio, α, was calculated using the following equation:

$$\theta = \frac{2}{\sqrt{\pi}} \int_0^{\frac{x}{\sqrt{4\alpha t}}} e^{-\gamma^2} d\gamma$$

where "θ" is the temperature of a point at a distance "X" within a solid which is infinite in the direction perpendicular to a plane held at a temperature of 0°C.

The temperature variance and the heat propagating ratio (α) in the case X = 1.75cm are shown in Table III(B)13.

The heat propagating ratio of the paste was found to be 0.000979 cm^2/sec at 15°C.

4. Density. The densities of the paste, produced oil, and Fushun-Oyama coal are shown in Table IV(B)13.

5. Specific Heat. The results of specific heat determination in an ice calorimeter are shown in Table V(B)13.

6. Electrical Conductivity. Two copper plates (3.4 x 5.7cm) were set parallel in the medium, and the electrical conductivity of paste was determined (refer to Figure 8(B)13).

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Table I(B)13
VISCOSITY OF THE PASTE IN THE REACTION CHAMBER

Temp. (°C)	Viscosity (Poise)	
	At Atm. Press.	At 200 Atm.
40	680	
50	155	
60	50	
80	9.1	
200	0.18	
300	0.043	0.075
350		0.043
400		0.028
450		0.018

Table II(B)13
HEAT CONDUCTIVITY AT 15°C

Sample	Paste	Paste 10% water	Paste 20% water	Heavy Oil	Produced Oil
Heat conductivity (Kcal./m hr.°C)	0.142	0.163	0.186	0.124	0.114

(See page 122 for Table III(B)13.)

Table IV(B)13
DENSITY

Samples	Paste	Produced Oil			Coal
		225	225-250	250-280	
Density d_4^{20}	1.15	0.8955	0.9373	0.9442	1.25

Table V(B)13
SPECIFIC HEAT

Sample	Paste	Produced Oil			Coal
		-225°C	225-250	250-280	
Sp. heat(cal/gm)	0.348	0.491	0.489	0.471	0.299

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Table III(B)13
HEAT PROPAGATING RATIO OF PASTE

Time past (sec)	Temp. at x = 17.5mm The initial temp. (21.7°C) is assumed	α which is calculated from equation (1) (cm^2/sec)
0	1.000	
60	1.000	
120		
160	0.997	0.00107
240	0.991	0.00092
300	0.977	0.00097
360	0.964	0.00097
420	0.948	0.00096
480	0.936	0.00093
540	0.913	0.00097
600	0.897	0.00096
660	0.880	0.00096
720	0.866	0.00095
780	0.847	0.00096
840	0.832	0.00095
900	0.816	0.00097
960	0.802	0.00096
1020	0.787	0.00097
1080	0.773	0.00098
1140	0.763	0.00096
1200	0.749	0.00097
1260	0.735	0.00098
1320	0.724	0.00098
1380	0.714	0.00097
1440	0.703	0.00097
1500	0.695	0.00097
1560	0.684	0.00097
1620	0.673	0.00098
1680	0.665	0.00098
1740	0.658	0.00098
1800	0.650	0.00098
1860	0.639	0.00099
1920	0.633	0.00098
1980	0.626	0.00097
2040	0.618	0.00098
2100	0.610	0.00098
2160	0.604	0.00098
2220	0.597	0.00099
2280	0.591	0.00098
2340	0.585	0.00099
2400	0.500	0.00098
2460	0.573	0.00098
2520	0.567	0.00099
2580	0.562	0.00099
2640	0.558	0.00098
2700	0.552	0.00099
2760	0.547	0.00099
2820	0.542	0.00098
2880	0.538	0.00098
2940	0.534	0.00098
3000	0.529	0.00098
3300	0.508	0.00098
3600	0.489	0.00098
3900	0.472	0.00099
4200	0.456	0.00099
4500	0.441	0.00099
4800	0.429	0.00100
5100	0.417	0.00100
5400	0.407	0.00099
5700	0.396	0.00100
6000	0.384	0.00102
		mean 0.000979

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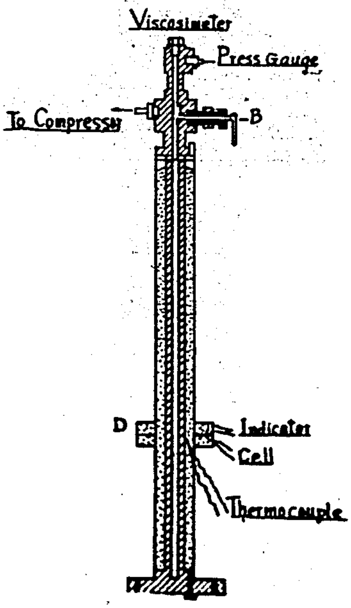


Figure 1(B)13
VISCOSIMETER

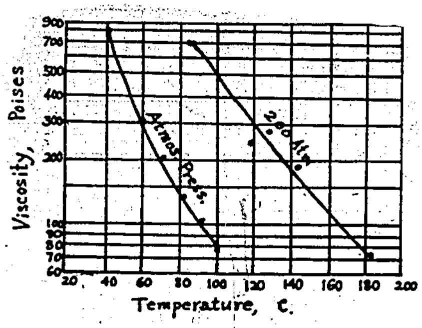


Figure 2(B)13
VISCOSITY OF PASTE

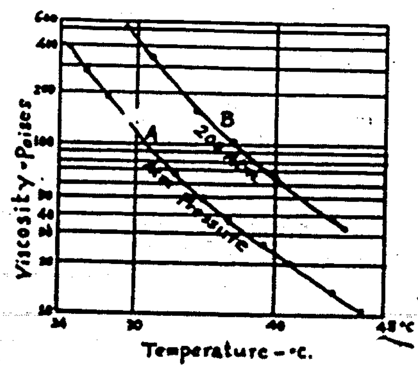


Figure 3(B)13
VISCOSITY OF LIQUEFIED HEAVY OIL

ENCLOSURE (B)13

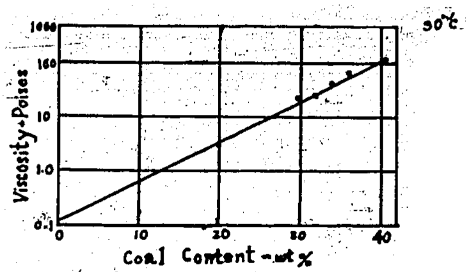


Figure 4(B)13
EFFECT OF COAL CONTENT ON PASTE VISCOSITY

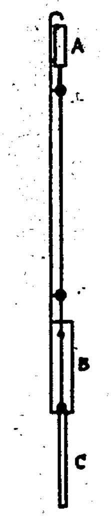
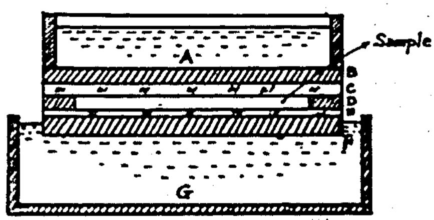


Figure 5(B)13
VISCOSIMETER FOR PASTE AND HEAVY OIL



A,G Thermostats
B,F Copper Plate 200×200×10 mm
C Glass Plate 200×200×10 ·
E Glass Plate 200×200×3 ·
D Ebonite Frame 200×200×10 ·

Figure 6(B)13
APPARATUS FOR MEASURING HEAT CONDUCTIVITY

ENCLOSURE (B)13

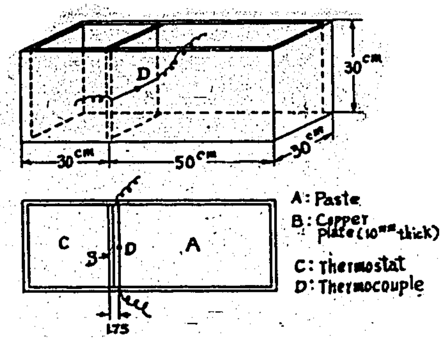


Figure 7(B)13
APPARATUS FOR MEASURING HEAT PROPAGATING RATIO

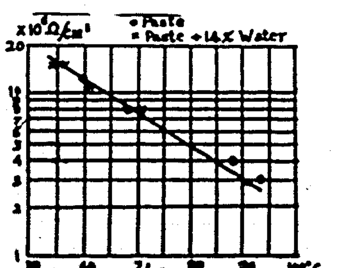


Figure 8(B)13
ELECTRICAL CONDUCTIVITY OF PASTE