ENCLOSURE (B) 20

STUDIES ON COAL

by

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ENCLOSURE (B)20

LIST OF TABLES AND ILLUSTRATIONS

ENCLOSURE (B)20

SUMMARY

This work was carried out to investigate the nature of coal in MANCHUKUO and in North China. About 50 kinds of the North China coal and 40 of the Manchukuo coal were investigated.

Test results showed that the North China coal was suitable for high temperature carbonization, whereas, the Manchukuo coal was better for low-temperature carbonization or liquefaction by hydrogenation.

I. INTRODUCTION

This work was begun in April, 1940. About 90 kinds of coal were investigated. It was desired to study, in detail, the chemical factors affecting caking properties of typical coals, but this project was ordered to stop in May, 1942.

The key research personnel working on the project were Eng. Cmdr. Dr. M. HAGIHARA and Eng. Lt. Cmdr. M. KUMAMOTO.

II. DETAILED DESCRIPTION

A. Description of Test Methods

1. Proximate Analysis. Moisture, volatile matter, ash, and fixed carbon were measured by the standard British method.

2. Ultimate Analysis. After grinding and drying the coal at 105 5°C, the content of carbon and hydrogen were determined by combustion. Nitrogen was determined by Kjeldahls' method, and sulphur by the Eschka method. The gross calorific value was measured by the bomb method.

3. Hydrogenation Test. 300 grams of coal (sized through to 60 mesh) and 15 grams of $ZnCl_2$ were put into an autoclave of 2.5 liters volume. After replacing the air by hydrogen gas, the hydrogen pressure was increased to 100 kg/cm^2 (no oil used). The autoclave was heated gradually and 3 hours were required to raise the temperature to 420 °C. After one hour at this temperature, the pressure was released and the hydrogenated product removed. The moisture and benzene-soluble material in the reactant were measured. The yield of liquid and the reactivity were calculated by the following formulae:

$$A = \% \text{ Yield of liquid} = \frac{\text{total liquid product(wt)}}{\text{ideal coal(wt)}} \times 100$$

(The ideal coal is defined as the volatile matter plus fixed carbon contained in the coal.)

$$B = \% \text{ Reactivity} = \frac{\text{ideal coal} - (\text{residue} - \text{ash})}{\text{ideal coal}} \times 100$$

(The residue is the material remaining after removal of moisture and benzol soluble material from the product.)

4. Carbonization Test. The Gray-King method was used.

5. High-temperature Carbonization Test. The Lessing method was used.

ENCLOSURE (B)20

6. Caking Properties. Caking properties were determined by the usual observation of the residue from the volatile matter test, and also from the high-temperature carbonization test. It was desired to study the chemical factors affecting caking properties, especially oxygen content of typical coals, but this project was abandoned.

III. EXPERIMENTAL RESULTS

Experimental results are summarized in Table I(B)20 and Table II(B)20.

IV. CONCLUSIONS

Apparently the Manchukuo coal has more water and less fixed carbon than the North China coal. Most Manchukuo coal is a form of brown coal, but the North China coal is bituminous.

Practically all of the North China coal is suitable for high-temperature carbonization, as compared with only 16% of the Manchukuo coal.

The average yield of liquid by hydrogenation of Manchukuo coal is 64.1%, and of the North China coal is 41.9%. The Manchukuo coal is better suited for hydrogenation or low-temperature carbonization.

ENCLOSURE (B)20

Table I(B)20
TESTS ON NORTH CHINA COAL

Coal Field		Proximate Analysis (%)					Ultimate Analysis (%)					Cal. Value (gr-cal)	Hydrogenation (%)		Low Temp. Carbonization			High Temp. Carbonization			Caking Property
		Moist.	Vol.M.	Fix.C	Ash	Fuel Ratio	C	H	N	S	O		A	B	Coke wt %	Tar wt %	Gas wt %	Coke wt %	Tar wt %	Gas wt %	
Tatung	No.1	3.6	29.2	64.1	3.1	2.19	85.1	5.6	0.9	0.7	7.9	7,890	61.8	80.2	82.9	5.9	7.4	71.5	9.8	11.1	none caking
	No.2	3.0	29.4	61.2	6.4	2.08	84.1	5.8	1.0	0.6	8.6	7,549	53.5	77.8	83.6	6.2	5.7	69.3	7.9	12.6	none caking
	No.3	4.3	30.6	62.3	2.8	2.03	83.5	5.4	0.9	0.7	9.6	7,860	64.9	82.8	82.6	6.2	4.6	66.9	9.3	16.8	good caking
	No.4	3.6	31.8	57.4	7.2	1.81	84.6	5.3	0.9	0.8	8.5	7,450	59.6	81.4	77.3	4.5	13.7	68.2	7.9	16.9	good caking
[illegible]	No.1	1.9	12.1	73.7	12.3	6.09	90.8	4.5	1.0	0.6	3.1	7,284	0.0	0.0	98.5	0.0	1.3	89.4	0.0	7.7	none caking
	No.2	4.8	33.2	57.3	4.7	1.73	78.1	5.3	1.1	0.2	15.5	7,440	73.3	95.1	79.6	13.1	6.2	65.8	14.9	8.6	none caking
[illegible]		3.6	7.5	81.7	7.2	10.89	92.3	3.2	1.4	0.9	2.1	7,878	0.0	0.0	97.9	0.0	1.6	90.3	0.0	6.4	none caking
Kailuan	No.1	0.9	29.1	44.9	25.1	1.54	84.0	6.9	1.4	1.5	6.2	6,084	62.7	74.8	80.9	8.7	6.6	75.6	9.4	9.6	good caking
	No.2	1.2	30.6	49.3	18.9	1.60	84.2	6.7	1.6	2.2	5.4	6,724	52.0	75.1	79.4	11.4	7.2	71.9	12.1	12.7	good caking
	No.3	1.5	25.8	40.0	32.7	1.55	83.9	6.7	1.5	1.2	6.8	5,306	57.1	73.5	83.7	8.2	4.7	75.0	7.7	11.6	good caking
	No.4	1.2	26.6	40.7	31.5	1.53	82.2	7.4	1.3	1.4	7.7	5,426	60.2	69.4	81.2	8.9	5.5	74.2	8.0	12.0	good caking
	No.5	0.9	30.1	49.8	19.2	1.65	85.4	6.5	1.4	1.9	4.7	6,716	57.8	74.7	80.4	10.4	6.5	77.7	9.9	10.1	good caking
Taiyuan	No.1	1.1	29.5	45.7	20.7	1.32	76.9	6.3	1.5	1.4	14.0	6,156	44.1	47.7	83.6	11.5	4.8	73.5	11.8	9.6	good caking
	No.2	1.3	28.6	52.0	18.1	1.82	79.4	5.6	1.3	1.6	12.2	6,788	34.5	50.3	82.9	10.8	6.3	72.2	11.9	12.2	good caking
	No.3	1.5	28.4	52.0	18.1	1.83	71.2	5.5	1.6	1.3	14.4	6,797	46.3	56.4	83.6	10.9	5.3	73.7	10.2	12.1	good caking
[illegible]	No.1	1.8	28.5	45.4	24.3	1.59	73.5	6.5	1.5	1.0	17.4	6,217	43.8	69.8	81.7	9.8	8.4	73.7	8.4	13.9	good caking
	No.2	1.3	29.8	48.9	20.0	1.64	77.6	5.8	1.5	1.1	13.9	6,713	29.6	77.5	82.4	11.8	5.4	75.6	11.0	12.5	good caking
	No.3	1.9	25.9	39.2	33.0	1.51	82.5	5.9	1.6	1.2	8.8	5,231	26.4	68.9	87.4	8.4	4.0	76.9	6.9	10.6	good caking
	No.4	1.3	25.9	47.6	25.4	1.80	80.3	5.3	1.5	0.9	12.0	6,063	26.0	80.0	84.9	9.9	5.0	75.9	9.8	15.4	good caking
	No.5	1.5	32.1	48.6	18.0	1.56	77.8	6.1	1.4	2.1	12.7	6,700	37.0	72.0	87.6	10.3	1.9	74.4	9.4	11.5	good caking
[illegible]	No.1	1.7	29.1	45.8	23.4	1.57	81.5	5.3	1.6	0.7	10.9	6,086	52.1	61.8	81.9	10.0	6.1	72.2	9.3	13.9	good caking
	No.2	1.7	34.5	47.5	16.3	1.38	82.9	5.5	1.4	2.2	7.9	6,871	48.5	76.8	77.5	12.9	7.0	69.8	13.4	11.8	good caking
	No.3	2.7	27.4	38.0	31.7	1.39	82.5	5.4	1.4	0.9	9.8	5,324	51.5	62.2	83.7	8.7	5.0	68.5	11.3	18.1	good caking
	No.4	2.0	28.2	44.3	25.5	1.57	81.5	5.2	1.4	0.8	11.3	5,820	47.1	62.1	80.8	9.3	5.9	74.6	9.2	11.5	good caking
	No.5	2.0	33.4	48.2	16.4	1.44	83.0	5.5	1.4	2.2	7.9	6,640	47.6	73.7	80.5	11.4	6.1	70.7	8.9	15.7	good caking

Table I(B)20 (cont'd)
TESTS ON NORTH CHINA COAL

Coal Field		Proximate Analysis (%)					Ultimate Analysis (%)					Cal. Value (gm-cal)	Hydrogenation (%)		Low Temp. Carbonisation			High Temp. Carbonisation			Caking Property
		Moist.	Vol.M.	Fix.C.	Ash	Fuel Ratio	C	H	N	S	O		A	B	Coke wt %	Tar wt %	Gas wt %	Coke wt %	Tar wt %	Gas wt %	
	No.1	1.8	34.9	49.2	14.1	1.98	83.9	5.2	1.4	1.8	7.7	6,335	34.5	64.9	87.9	7.1	4.7	77.6	7.2	10.6	good caking
	No.2	1.5	27.2	54.4	16.9	2.00	81.9	5.0	1.5	2.9	8.2	6,966	43.5	76.0	87.5	6.2	6.1	75.5	8.0	14.2	good caking
Liuchi	No.3	1.9	25.0	41.1	32.0	1.64	83.3	5.4	1.5	1.1	8.8	5,351	41.7	60.5	88.5	6.7	3.7	73.5	5.6	11.3	good caking
	No.4	1.4	26.6	48.1	24.5	1.94	84.9	5.3	1.5	1.2	7.2	6,115	59.9	63.6	86.8	5.8	7.1	77.2	8.1	11.0	good caking
	No.5	1.1	27.3	53.1	18.5	1.92	81.8	5.2	1.2	2.1	5.7	6,838	48.4	74.8	84.9	8.0	7.0	75.4	7.6	12.4	good caking
	No.1	1.2	32.5	55.1	11.2	1.69	80.4	5.8	1.4	1.6	10.8	7,701	58.3	75.4	94.0	2.9	3.1	80.9	6.5	11.4	good caking
	No.2	1.2	30.0	56.4	12.4	1.88	82.5	5.5	1.5	1.2	9.3	7,588	45.9	52.3	94.0	2.4	3.6	77.2	5.1	16.8	good caking
Ching Ching	No.3	1.2	26.8	66.2	7.8	2.67	85.8	5.6	1.5	3.5	3.6	7,829	26.6	33.4	88.6	9.1	2.2	85.5	3.2	9.6	good caking
	No.4	1.1	21.0	62.9	15.0	2.99	83.7	6.6	1.5	0.7	7.9	7,244	9.6	22.9	88.9	7.8	3.3	79.4	6.7	12.6	good caking
	No.1	1.3	25.3	61.1	12.3	2.42	85.4	5.2	1.4	1.7	6.3	7,574	56.9	70.1	90.4	2.1	6.9	82.9	3.5	11.7	good caking
	No.2	1.0	23.2	59.0	16.8	2.54	85.4	5.6	1.4	1.4	6.3	7,202	49.0	58.1	90.1	3.4	5.4	82.9	6.6	8.1	good caking
Chang Feng	No.3	1.0	23.5	70.1	5.4	2.98	86.9	5.4	1.4	1.9	4.4	8,187	42.2	58.5	89.4	5.4	4.8	70.9	4.4	22.9	good caking
	No.4	1.3	21.0	69.2	8.5	3.29	88.9	5.4	1.7	0.6	3.4	7,889	28.7	28.1	86.7	6.7	5.6	78.5	7.9	11.6	good caking
	No.1	1.8	22.0	64.5	3.7	3.03	88.4	4.8	1.4	0.6	4.8	7,303	42.7	72.5	88.5	6.8	5.5	81.0	5.8	11.4	good caking
	No.2	1.8	22.5	56.0	19.7	2.49	84.1	5.0	1.5	3.4	6.0	6,725	27.7	32.2	88.7	5.7	5.4	79.9	6.4	11.4	good caking
Fushun	No.3	1.3	20.8	54.7	19.2	2.63	79.5	4.3	1.5	4.6	10.1	6,101	19.0	37.2	86.9	0.5	6.5	79.2	1.5	10.6	none caking
	No.4	1.2	22.1	56.7	17.0	2.65	82.3	5.2	1.6	3.4	7.5	7,072	41.3	44.9	87.0	6.3	6.5	79.4	6.3	12.2	good caking
	No.1	2.7	23.1	54.1	18.1	2.43	71.3	6.3	1.5	1.1	19.9	6,545	55.2	81.2	78.2	15.7	5.3	67.2	10.7	12.5	good caking
	No.2	3.2	33.4	45.1	18.3	1.35	71.0	5.3	1.4	1.3	20.9	6,464	39.2	56.4	80.8	11.9	6.8	66.3	11.7	13.3	good caking
Hun-gao	No.3	3.0	33.7	53.5	9.8	1.59	75.8	5.1	1.5	0.6	17.0	7,244	47.3	77.8	78.9	14.0	6.6	66.9	9.3	15.2	good caking
	No.4	1.8	37.0	49.0	11.2	1.32	72.7	5.5	1.2	4.6	16.1	7,279	44.5	61.6	77.1	15.8	6.5	63.1	15.4	13.5	good caking
	No.5	3.2	33.7	43.7	18.4	1.30	64.3	5.1	1.4	4.8	23.5	6,538	18.9	43.6	73.5	10.2	15.8	67.8	11.7	12.2	good caking
	No.1	1.1	26.8	43.8	8.3	2.34	76.2	5.9	1.6	0.8	15.7	7,778	11.2	18.3	84.8	9.7	5.5	69.7	11.8	1.58	good caking
Shan Guan	No.2	1.3	30.2	60.3	8.3	2.00	78.2	5.9	1.7	4.2	9.9	7,986	16.7	19.9	93.1	3.1	3.8	71.7	11.1	16.9	good caking

ENCLOSURE (B)20

Table II(B)20
TESTS ON MANCHUKUO COAL

Coal Field		Proximate Analysis (%)					Ultimate Analysis (%)					Hydrogenation (%)		Caking Property	Low Temp. Carbonisation (%)		
Coal Field		Moist.	Vol.M.	Fix.C.	Ash	Fuel Ratio	C	H	N	S	O	A	B		Coalite	Tar	Gas
Salinor		19.8	55.7	20.8	3.7	0.37	74.6	7.3	1.3	0.3	18.4	49.4	87.1	none caking	52.3	7.4	16.3
Sincheng		13.6	37.7	44.9	3.8	1.19	75.9	5.4	1.2	0.6	16.8	59.7	91.5	none caking	70.8	11.9	10.5
Padogo	No.1	15.9	35.4	39.8	8.9	1.12	76.1	5.2	1.1	2.3	15.2	64.6	88.2	none caking	70.9	7.0	12.5
	No.2	14.1	35.8	40.0	10.1	1.11	76.2	4.7	1.3	1.7	16.1	68.6	91.6	none caking	67.1	8.0	12.9
Taiping		10.8	36.2	49.4	3.6	1.36	78.3	6.2	0.9	1.4	13.3	81.3	92.5	none caking	71.1	10.9	9.8
Sun Kiawan		11.0	35.3	44.2	9.5	1.25	77.9	4.2	1.2	0.9	15.8	65.5	92.4	none caking	65.3	6.9	10.5
Peipiao	No.1	11.9	39.6	41.9	6.6	1.05	77.4	3.9	1.0	2.9	14.8	69.1	89.8	none caking	69.5	16.2	6.1
	No.2	13.1	38.1	43.2	5.6	1.13	76.8	5.1	0.9	1.4	15.8	64.8	91.6	none caking	72.5	7.8	8.8
	No.3	11.4	40.1	42.4	6.1	1.06	76.3	5.8	0.9	1.4	15.6	65.2	91.9	none caking	65.6	11.3	8.2
	No.3	7.2	36.5	52.4	9.9	1.43	86.0	6.1	1.2	0.2	6.7	64.9	80.4	caking	94.3	14.5	9.2
	No.4	2.1	33.7	44.7	19.5	1.32	82.0	5.7	1.2	0.6	9.5	65.9	81.2	caking	78.6	11.0	6.1
	No.5	2.2	33.8	44.8	19.4	1.33	84.7	5.7	1.2	0.4	4.0	67.3	80.2	caking	75.1	12.4	8.2
	No.6	2.0	35.7	50.3	12.0	1.40	86.8	5.8	1.2	0.3	6.4	65.8	81.3	caking	74.1	12.4	8.5
Heian	No.1	9.3	36.2	46.2	8.3	1.27	74.0	5.5	1.2	0.8	18.3	68.2	93.2	none caking	72.7	6.5	12.0
	No.2	9.4	36.2	45.1	9.3	1.24	77.9	5.8	2.0	1.5	12.9	63.0	87.0	none caking	68.3	10.1	11.6
Talsheng	No.1	11.2	30.7	40.4	17.7	1.31	75.8	5.7	1.0	0.5	17.0	65.1	83.0	none caking	73.4	3.3	6.3
	No.2	10.5	41.5	41.6	6.4	1.00	75.6	5.9	1.5	0.7	17.3	64.1	91.1	none caking	64.3	10.3	9.4
	No.3	11.0	34.3	35.6	17.7	1.00	78.8	6.2	2.4	0.7	12.6	70.8	89.7	none caking	68.9	7.8	8.6
Chiseho	No.1	7.5	28.6	39.1	23.8	1.37	77.3	4.9	1.4	0.6	15.7	67.0	82.1	none caking	74.1	8.9	17.6
	No.2	4.7	31.0	37.5	26.8	1.21	79.3	6.1	1.2	0.7	12.7	78.1	88.3	none caking	92.2	9.1	7.8

ENCLOSURE (B)20

Table II(B)20 (cont'd)
TESTS ON MANCHUKUO COAL

Coal Field		Proximate Analysis (%)					Ultimate Analysis (%)					Hydrogenation (%)		Caking Property	Low Temp. Carbonisation (%)		
		Moist.	Vol.M.	Fix.C.	Ash	Fuel Ratio	C	H	N	S	O	A	B		Coalite	Tar	Gas
(Hide Kasi)	No.1	22.0	48.3	12.5	17.2	0.26	72.1	6.3	1.7	0.2	19.6	58.2	86.1	none caking	60.8	10.3	11.2
	No.2	23.7	47.3	15.3	13.7	0.32	71.0	6.3	1.7	0.3	20.7	50.5	92.0	none caking	60.0	20.5	10.1
	No.3	23.0	45.7	21.3	9.0	0.46	70.0	6.3	0.2	0.3	23.3	48.7	92.6	none caking	61.7	11.2	13.8
Biyong		18.8	42.1	8.9	30.2	0.21	70.0	8.0	1.4	0.4	20.2	71.7	83.4	none caking	62.7	3.2	20.5
Feny Turho	No.1	16.8	49.2	18.4	15.6	0.37	72.0	7.0	1.6	0.2	19.1	67.0	87.8	none caking	57.4	18.5	14.8
	No.2	20.8	42.2	13.1	13.9	0.55	71.5	6.6	1.9	0.3	19.8	59.0	88.7	none caking	58.8	12.2	11.4
	No.3	19.5	44.5	25.9	10.1	0.58	69.3	5.7	1.8	0.2	22.8	66.9	93.6	none caking	58.7	12.8	11.2
Unchun		18.7	32.8	32.2	16.3	0.98	70.3	5.0	1.0	0.3	23.3	53.8	77.3	none caking	65.5	9.3	14.5
Holung	No.1	16.4	30.4	39.2	14.0	1.29	76.1	5.1	1.1	0.7	17.0	72.8	95.4	none caking	69.4	12.1	5.8
	No.2	11.3	28.3	40.4	20.0	1.43	75.7	5.5	1.0	1.6	16.6	61.7	77.7	none caking	79.9	3.2	5.7
Laotoang	No.1	10.5	33.5	43.1	12.9	1.29	79.3	5.1	1.2	0.5	13.9	69.6	88.3	none caking	72.9	1.1	10.3
	No.2	11.5	32.1	39.5	16.8	1.23	78.2	6.2	1.0	0.5	14.1	73.4	91.4	none caking	74.7	14.8	5.5
	No.3	7.3	33.6	42.3	16.8	1.25	79.1	5.0	1.1	0.4	14.4	72.1	84.0	none caking	75.2	8.9	8.5
Mishang	No.1	1.8	20.2	52.8	25.7	2.61	84.0	5.9	1.1	0.6	8.4	54.1	58.2	none caking	85.5	5.0	7.2
	No.2	1.0	21.2	62.0	15.8	2.92	86.8	5.7	1.2	0.7	5.0	64.0	64.6	none caking	86.1	5.5	7.2
	No.3	1.5	19.9	64.2	14.4	3.22	88.3	5.5	1.0	0.7	4.5	68.6	52.5	none caking	87.6	6.1	6.0
	No.4	1.2	20.2	60.3	18.8	2.98	86.3	5.1	1.1	0.7	6.8	61.3	60.0	none caking	85.9	6.1	7.0
Hunung	No.1	2.7	30.6	53.5	13.2	1.75	83.4	5.7	0.9	0.2	9.8	67.1	81.1	none caking	81.5	7.5	7.6
	No.2	2.4	34.8	51.6	11.2	1.48	83.2	5.3	0.9	0.2	10.4	64.8	83.7	none caking	73.7	12.6	8.7
	No.3	2.3	34.1	52.6	11.0	1.54	83.3	5.3	0.8	0.8	10.3	64.4	85.7	none caking	78.4	10.9	9.4
	No.4	1.9	36.3	47.3	14.5	1.30	82.5	6.1	0.7	0.2	10.5	64.0	86.6	none caking	73.7	11.8	7.7