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PREHEATED COAL STUDY USING BLENDS SUBMITTED BY DOMINION FOUNDRIES
AND STEEL LIMITED, HAMILTON ONTARIO

PROJECT NO. 03-5-0/9-17 - INVESTIGATION NO. 17

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Canadian Metallurgical Fuel Research Laboratory

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SUMMARY

This investigation is No. 17 in the continuing series of programs undertaken on behalf of Dominion Foundries and Steel Limited, Hamilton, Ontario (Dofasco), by the Canadian Metallurgical Fuel Research Laboratory.

In this instance however, it was agreed that the work would be included in the *CCRA-sponsored "priority" research projects category, and therefore all information derived from it would be available to CCRA members.

Dofasco provided the necessary samples for the program and indicated the composition of the three blends to be tested.

Each test blend was carbonized without preheating at a bulk density (db) approximating to 45 lb/ft³ and was also carbonized with the charge preheated to 490°F.

As an addendum, each blend was also carbonized without preheating at a bulk density (db) of approximately 50 lb/ft³.

The results showed that in every case preheating markedly increased the stability and hardness when compared with the un-preheated test at bulk density (db) of approximately 45 lb/ft³. However, the results obtained from the un-preheated tests at bulk density of 50 lb/ft³ compared very well with those from the preheated blends.

*CCRA represents Canadian Coke Research Association

PREHEATED COAL STUDY USING BLENDS SUBMITTED BY
DOMINION FOUNDRIES AND STEEL LIMITED, HAMILTON, ONTARIO

Project No. 03-5-0/9-17 - Investigation No. 17

by

A.B. Fung^{*}, W. Gardiner^{**}, T.A. Lloyd^{**} and J.C. Botham^{***}

INTRODUCTION

This program was initiated by discussion between Mr. J.E. Ludberg (Dofasco) and Mr. J.C. Botham (CANMET), in November 1974. It was agreed that this work would be regarded as a research project, and that the results would be available to CCRA members.

The requisite samples required by the program were supplied by Dofasco, as follows:

Coal Blends (from North Plant) - 15 drums
Coke Fines - 1 drum

The coal blend referred to above is composed of 20 percent Itmann, 40 percent Moss No. 1, and 40 percent Kopperston.

Background information concerning the program is contained in the Project Authorization form, which is included in this report as Appendix 1.

Resident Carbonization Engineer, Western Regional Laboratory, Edmonton, Alberta, **Heads, Carbonization Operations, Coal Treatment and Rheological Section respectively and *Manager, Canadian Metallurgical Fuel Research Laboratory, Energy Research Laboratories, Canada Centre for Mineral and Energy Technology, Department of Energy, Mines and Resources, Ottawa, Canada.*

DETAILS OF INVESTIGATION

The material from which the test blends were composed was supplied by Dofasco and comprised:

Dofasco Blend - 15 drums
Coke Fines - 1 drum

The oven tests were conducted on the Koppers 12-inch MW oven located at Clover Bar, Edmonton. This is a gas-fired oven using natural gas. The amount of gas used in each test was metered to provide data regarding the energy required for carbonization.

The preheating was carried out by placing the charge in the charging hopper which was then sealed as well as possible and placed in a gas-fired drying oven for approximately four days, until a temperature of 490^oF was obtained in the centre of the charge. A nitrogen supply was fed into the hopper during preheating to combat possible oxidation.

The original agreed program called for six tests as follows:

Test 1	Dofasco Blend 100 percent	Without Preheating
Test 2	Dofasco Blend 100 percent	Preheated
Test 3	95 percent Dofasco Blend 5 percent coke fines	Without Preheating
Test 4	95 percent Dofasco Blend 5 percent coke fines	Preheated
Test 5	93 percent Dofasco Blend 7 percent coke fines	Without Preheating
Test 6	93 percent Dofasco Blend 7 percent coke fines	Preheated

It was later decided to carry out three additional tests on each of the above three blends. These tests were not preheated but the bulk density was increased (by reducing the moisture) in comparison to the original tests on these blends (Tests 1, 3 and 5 above).

DISCUSSION OF RESULTS

The three blends tested were as follows:

- (a) 100 percent Dofasco Blend
- (b) 95 percent Dofasco Blend, 5 percent coke fines
- (c) 93 percent Dofasco Blend, 7 percent coke fines

A comparison of the results of the un-preheated and preheated tests on each of these blends reveals that a marked increase in stability and hardness occurred in each case (see Table 4). The un-preheated charges contained approximately 6 percent moisture and returned a bulk density (db) in the oven of about 45 lb/ft³. The preheated charges gave a bulk density (db) of about 55 lb/ft³.

It is of interest to note that in the additional three tests (Table 5) in which the moisture as charged was approximately 2.5 percent and the bulk density (db) was about 50 lb/ft³, the stability and hardness values were equivalent to those obtained by preheating.

The coking time for the additional three tests averaged 9 hours, 20 minutes, whilst the times for the preheated charges and the un-preheated charges at 45 lb/ft³ were 7 hours, 30 minutes and 8 hours, 15 minutes, respectively.

The coking pressure did not increase to any degree due to preheating.

TABLE 1 Chemical Analyses of Component Coals

Identification	2254-75	2253-75	2509-75	2511-75	2513-75	2551-75
Laboratory Number	2254-75	2253-75	2509-75	2511-75	2513-75	2551-75
Description	100% DOFASCO Blend Not preheated (Test 76-74)	100% DOFASCO Blend Preheated (Test 75-74)	95% DOFASCO Blend Coke fines 5% Not preheated (Test 77-74)	95% DOFASCO Blend Coke fines 5% Preheated (Test 79-75)	93% DOFASCO Blend Coke fines 7% Not Preheated (Test 81-75)	93% DOFASCO Blend Coke fines 7% Preheated (Test 83-75)
<u>Classification</u>						
Rank (ASTM)						
International System						
Specific Volatile Index						
Carbon (dmmfb)						
<u>Proximate Analysis (db)</u>						
Ash	6.3	6.2	6.4	6.6	6.8	7.0
Volatile Matter	29.4	28.5	27.3	27.5	27.6	27.0
Fixed Carbon	64.3	65.3	66.3	65.9	65.6	66.0
<u>Gross Calorific Value (db)</u>						
Btu per pound						
<u>Ultimate Analysis (db)</u>						
Carbon						
Hydrogen						
Sulphur	0.72	0.76	0.70	0.66	0.66	0.81
Nitrogen						
Ash						
Oxygen (by difference)						
<u>Ash Analysis (db)</u>						
SiO ₂						
Al ₂ O ₃						
Fe ₂ O ₃						
TiO ₂						
P ₂ O ₅						
CaO						
MgO						
SO ₃						
Na ₂ O						
K ₂ O						

TABLE 2 Physical Tests and Fusibility of Ash of Component Coals

<u>Identification</u>		2254-75	2253-75	2509-75	2511-75	2513-75	2551-75
Laboratory Number		2254-75	2253-75	2509-75	2511-75	2513-75	2551-75
Description		100% DOFASCO Blend Not preheated	100% DOFASCO Blend Preheated	95% DOFASCO Blend Coke fines 5% Not preheated	95% DOFASCO BLEND Coke fines 5% Preheated	93% DOFASCO Blend Coke fines 7% Not preheated	93% DOFASCO Blend Coke fines 7% Preheated
<u>Coal Pulverization</u>							
<u>Sieve Analysis</u>							
Passing	Retained On						
	1/4 in. %	0.9	0.8	2.2	N/A	1.4	N/A
1/4 in.	1/8 in. %	7.0	7.5	7.0		9.0	
1/8 in.	1/16 in. %	22.1	21.4	21.2		23.7	
1/16 in.	1/32 in. %	26.7	20.6	19.2		18.0	
1/32 in.%	43.3	49.7	50.4		47.9	
Total Passing	1/8 in. %	92.1	91.3	90.8		89.6	
<u>Grindability</u>							
Hardgrove Index							
<u>Fusibility of Ash</u>							
Initial Deformation Temp. ... °F							
Softening Temp. Spherical ... °F							
Softening Temp. Hemispherical ... °F							
Fluid Temp. °F							

TABLE 3 Thermal Rheological Properties of Component Coals

<u>Identification</u>						
Laboratory Number	2254-75	2253-75	2509-75	2511-75	2513-75	2551-75
Description	DOFASCO Blend 100% Not Preheated	DOFASCO Blend 100% Preheated	DOFASCO Blend 95% Coke fines 5% Not preheated	DOFASCO Blend 95% Coke fines 5% Preheated	DOFASCO Blend 93% Coke fines 7% Not preheated	DOFASCO Blend 93% Coke fines 7% Preheated
<u>Linear Expansion</u>						
Bd. 52 lb/ft ³ at 2% moisture...%	-9.7	N/A	-14.6	N/A	-14.2	N/A
<u>Gieseler Plasticity</u>						
Start	°C 403	408	404	409	407	407
Fusion Temp.	°C 416	421	418	421	419	420
Max. Fluid Temp.	°C 443	446	446	442	444	442
Final Fluid Temp.	°C 487	485	480	477	480	480
Solidification Temp.	°C 490	489	483	481	483	483
Melting Range	°C 84	77	76	68	73	73
Max. Fluidity	dd/m 6,800	925	1,825	925	1,550	1,035
Torque	g.in. 40	40	40	40	40	40
<u>Dilatation</u>						
Ti - Softening Temp.	°C 357	358	357	360	358	356
Tii - Max. Contraction Temp.	°C 421	425	423	427	425	426
Tiii - Max. Dilatation Temp.	°C 469	470	469	469	468	467
Contraction	% 26	29	27	28	26	28
Dilatation	% 179	117	154	106	123	102
<u>Free Swelling Index</u>						
F.S.I.	7	7	8	7½	6½	6½

TABLE 4 - Carbonization Data

Project No. 03-5-0/9-17

Koppers Oven - Clover Bar

Test Identification Number.....	76-74	75-74	77-74	79-75	81-75	83-75						
Data of Test.....	19-12-74	18-12-74	30-12-74	8-1-75	14-1-75	23-1-75						
Laboratory Number.....												
Description.....	100% DOFASCO Blend Not preheated	100% DOFASCO Blend Preheated	95% DOFASCO Blend Coke fines 5% Not preheated	95% DOFASCO Blend Coke fines 5% Preheated	93% DOFASCO Blend Coke fines 7% Not preheated	93% DOFASCO Blend Coke fines 7% Preheated						
CARBONIZATION DATA												
Net Weight of Charge (wet).....lb	361.3	401.8	356.9	410.2	335.3	420.0						
Moisture in Charge.....%	5.8	Nil	5.5	Nil	5.6	Nil						
ASTM Bulk Density (wet).....lb/ft ³	41.0	-	41.8	-	41.7	-						
Oven Bulk Density (db).....lb/ft ³	45.1	53.3	44.7	54.4	44.5	55.7						
CARBONIZATION RESULTS												
Gross Coking Time.....hr:min	8.17	7.29	8.15	7.29	8.09	7.31						
Maximum Wall Pressure.....lb/in ²	0.43	0.40	0.52	0.40	0.50	0.62						
Coke Yield Actual.....%	69.8	71.5	72.1	73.0	73.0	73.4						
Mean Coke size.....in	2.05	2.12	2.35	2.38	2.17	2.65						
Apparent Specific Gravity.....	0.81	0.89	0.83	0.95	0.85	0.97						
Screen Analysis of Coke (cumulative percentage retained on)												
3 inch sieve.....	8.7	12.2	21.4	24.1	11.1	34.8						
2 inch sieve.....	48.9	54.0	62.3	64.1	59.4	69.7						
1 1/2 inch sieve.....	78.2	77.9	85.6	83.2	81.8	84.1						
1 inch sieve.....	92.2	92.5	94.3	94.3	93.5	92.9						
3/4 inch sieve.....	94.9	94.6	95.8	96.3	95.2	94.6						
1/2 inch sieve.....	95.7	96.3	96.6	97.3	96.2	95.7						
Percentage -1/2 inch (breeze).....	4.3	3.7	3.4	2.7	3.8	4.3						
Tumbler Test (ASTM)												
Stability Factor.....	49.9	54.5	51.5	56.8	52.1	56.0						
Hardness Factor.....	61.8	66.6	63.1	67.1	61.5	65.7						
Japanese Drum Test (JIS) (cumulative percentage retained on)												
50 mm sieve.....	21.5	6.1	22.0	7.5	31.0	10.1	26.1	9.0	26.7	9.4	26.9	14.1
25 mm sieve.....	86.3	69.2	89.4	73.5	88.6	73.6	88.9	74.1	89.8	74.0	86.9	72.2
15 mm sieve.....	93.0	80.7	94.3	83.6	93.9	82.4	94.4	84.5	94.1	81.4	94.1	82.8
Average Flue Temp °F	1977°	1968°	1989°	1980°	1988°	1986°						
Productivity lb/H σ(db)	28.7	38.4	29.5	40.1	30.0	41.0						
Energy Required Btu x 10 ⁶ (db)	4.25	3.83	4.32	3.86	4.27	3.95						

TABLE 5 - Carbonization Data

- Koppers Oven - Clover Bar

PREHEATED STUDY

Project No.: 03-5-0/9-17

Test Identification Number.....	129-75	130-75	131-75			
Data of Test.....	30-7-75	5-8-75	7-8-75			
Laboratory Number.....						
Description.....	100% Dofasco Blend	95% Dofasco Blend 5% Coke Fines	93% Dofasco Blend 7% Coke Fines			
<u>CARBONIZATION DATA</u>						
Net Weight of Charge (wet).....lb	386.9	388.0	385.0			
Moisture in Charge.....%	2.6	2.3	2.4			
ASTM Bulk Density (wet).....lb/ft ³	48.3	48.8	48.3			
Oven Bulk Density (db).....lb/ft ³	50.0	50.3	49.8			
<u>CARBONIZATION RESULTS</u>						
Gross Coking Time.....hr:min	9:12	9:15	9:35			
Maximum Wall Pressure.....lb/in ²	0.58	0.58	0.51			
Coke Yield Actual.....%	70.0	72.9	73.5			
Mean Coke size.....in	2.08	2.29	2.39			
Apparent Specific Gravity.....	0.91	0.92	0.94			
<u>Screen Analysis of Coke</u> (cumulative percentage retained on)						
3 inch sieve.....	9.2	17.8	22.4			
2 inch sieve.....	50.0	60.7	63.9			
1 1/2 inch sieve.....	80.3	82.6	85.2			
1 inch sieve.....	94.3	94.6	94.8			
3/4 inch sieve.....	96.1	96.4	96.2			
1/2 inch sieve.....	96.9	97.3	97.1			
Percentage -1/2 inch (breeze).....	3.1	2.7	2.9			
<u>Tumbler Test (ASTM)</u>						
Stability Factor.....	53.7	56.2	57.2			
Hardness Factor.....	66.3	67.0	66.5			
<u>Japanese Drum Test (JIS)</u> (cumulative percentage retained on)						
	*	**	*	**		
50 mm sieve.....	24.5	9.9	22.7	9.0	39.5	17.6
25 mm sieve.....	89.2	73.5	90.1	75.4	91.7	76.7
15 mm sieve.....	93.5	82.6	94.4	83.9	93.7	83.9
Average Flue Temperature.....°F	1976	1984	1971			

*30 Rev. **150 Rev.

Please Note: The tests shown on the above Table were conducted without preheat but at a higher bulk density than the corresponding non-preheat tests on Table 4.

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TABLE 6

Analyses of Coke Oven Charges and Resultant Cokes

<u>Identification</u>	76-74	75-74	77-74	79-75	81-75	83-75
Test Number.....	76-74	75-74	77-74	79-75	81-75	83-75
Date Charged.....						
Description.....	100% DOFASCO Blend Not preheated	100% DOFASCO Blend Preheated	95% DOFASCO Blend Coke fines 5% Not preheated	95% DOFASCO Blend Coke fines 5% Preheated	93% DOFASCO Blend Coke fines 7% Not preheated	93% DOFASCO Blend Coke fines 7% Preheated
<u>Coke Oven Charge</u>						
Laboratory Number.....	2254-75	2253-75	2509-75	2511-75	2513-75	2551-75
<u>Proximate Analysis (db)</u>						
Ash.....%	6.3	6.2	6.4	6.6	6.8	7.0
Volatile Matter.....%	29.4	28.5	27.3	27.5	27.6	27.0
Fixed Carbon.....%	64.3	65.3	66.3	65.9	65.6	66.0
Sulphur (db).....%	0.72	0.57	0.70	0.66	0.66	0.50
<u>Resultant Coke</u>						
Laboratory Number.....	2256-75	2255-75	2510-75	2512-75	2514-75	2552-75
<u>Proximate Analysis (db)</u>						
Ash.....%	8.2	8.1	8.6	8.8	8.9	9.0
Volatile Matter.....%	0.4	0.5	0.7	0.5	0.7	0.6
Fixed Carbon.....%	91.4	91.4	90.7	90.7	90.4	90.4
Sulphur (db).....%	0.65	0.66	0.66	0.70	0.66	0.59

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APPENDIX 1

M E T A L S R E D U C T I O N A N D E N E R G Y C E N T R E

P R O J E C T A U T H O R I Z A T I O N

SECTION: 03-1; 03-2; 03-3; 03-4; 03-5

SHORT TITLE: DOFASCO 17 (preheat)

PROJECT CODE: 03-5-0/9-17

DATE PREPARED: November 26, 1974.

PROJECT TITLE: Preheated Coal Studies for the Dominion Foundries and Steel Company Limited (DOFASCO) Hamilton, Ontario (Investigation No. 17).

ORIGIN: The project originated during a telephone conversation from J.E. Ludberg, DOFASCO Coke Plant Superintendent, to J.C. Botham November 22 and follow-up discussion November 26, 1974. As the project is related to preheated coal and antifissurant studies and since the information will be made available to CCRA members with industrial feed-back, the project will be included in the CCRA sponsored priority research projects. (See letter J.C.B. to J.E.L. dated Nov. 26, 1974).

SCOPE AND OBJECTIVES:

To carry out technical-scale oven tests (Koppers Oven) on a blend of coal from the DOFASCO North coke plant. The blend will be carbonized (as received) and preheated (450°F) with and without coke breeze additions, with the objective of determining the wall pressures generated and the quality of the coke produced.

EXPECTED BENEFITS:

DOFASCO will require increased coke oven capacity at their Hamilton works. With limited space available in the Burlington Bay area to build new ovens, increased coke production is possible from their existing ovens by means of preheating the coke oven charges. The pre-carbon method is the most adaptable system for their Kopper Type ovens. Before installing this method the company must have assurance that the coals do not expand excessively when preheated and the coke quality is not adversely affected.

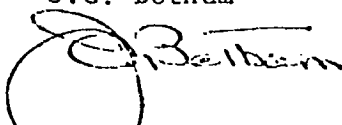
PROJECT REQUIREMENTS:

- (A) Tests and Analyses - Koppers MW oven - 6 tests (min); Bench-Scale testing - 6 samples; E/C - 3 samples; Chemistry - 6 samples
- (B) Personnel - Clover Bar Laboratory - 1 prof; 1 tech; 2 operators
Ottawa Laboratory - 2 prof; 3 tech; chem. lab.

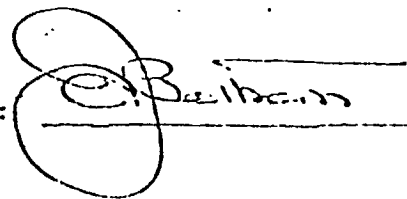
PROJECT SCHEDULING:

Week of November 24, 1974 (tentative)

PREPARED BY: J.C. Botham



APPROVED:



DATE: