The possibility of predicting CRI/CSR of metallurgical coke using cokes prepared at laboratory scale (80 g)

M.F. Vega*, E. Díaz-Faes, C. Barriocanal

Instituto de Ciencia y Tecnología del Carbono (INCAR-CSIC). Oviedo. Spain

Introduction

Steelmaking industry demands high quality coke, which is the most important raw material fed into the blast furnace. A high-strength coke is necessary to support the burden and maintain the permeability required to ensure the pass of liquids and gasses. Coke reactivity is one of the most commonly applied parameters for evaluating coke quality. The NSC test (ASTM-D5341) is the most widely accepted by the steel industry for this purpose. This method involves measuring the reactivity to CO_2 at high temperature (CRI index) and the strength of the coke after reaction (CSR index). The ECE-INCAR reactivity test has also proven to be an effective method at laboratory scale for evaluating the reactivity of coke. One advantage of this method is the low quantity of sample necessary (7 g) to carry out the test, which make it in a possible method to predict the CRI/CSR of a coke merely by laboratory scale testing.

Objective

The aim of this work was to predict the CRI/CSR of a coke by means of a laboratory scale carbonization (80 g). To that end, a relationship between the quality of cokes prepared at different scales, i.e. semi-pilot (17 kg) and laboratory (80 g) will be established.

Experimental

SEMI-PILOT SCALE CARBONISATION TEST

MOVABLE WALL OVEN

Capacity: 17 kg

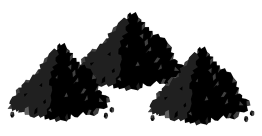
Wall temperature: 1100 ºC

Final Tª in the centre of the charge: 950 ºC

Particle size: 80 % < 3 mm

Coal moisture: 5 wt.%

MATERIALS



22 bituminous coals

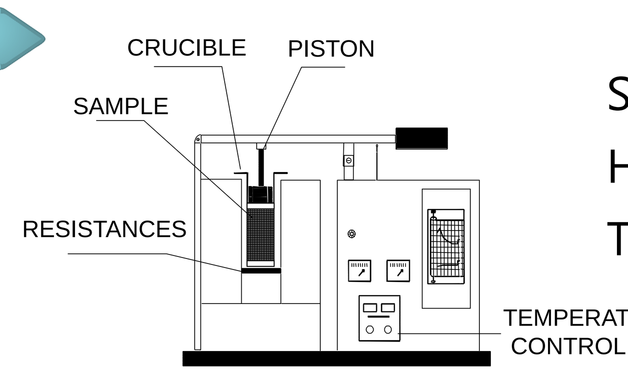
Different Geographical Origin

Volatile Matter: 18.4 – 33.4 wt.% db

Maximum Gieseler Fluidity: 19- 41034 ddpm

LABORATORY SCALE CARBONISATION TEST

SOLE HEATED OVEN



Sample mass: 80 g

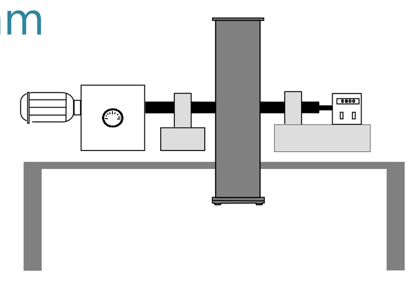
Heating temperature: 1050 ºC

Time: 2 h

NSC TEST

MECHANICAL STRENGTH AFTER REACTION

CSR = % > 9.5 mm



Revolutions: 600

Velocity: 20 rpm

REACTIVITY TOWARDS CO_2

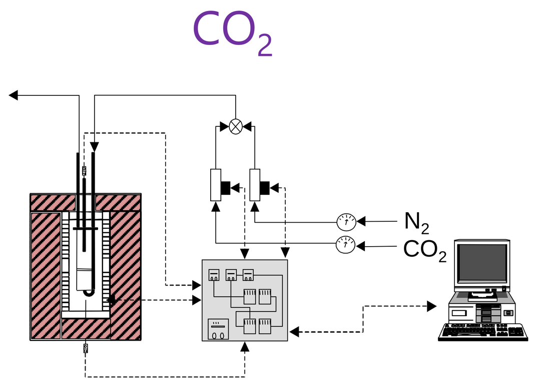
CRI = % weight loss

Coke weigh: 200 g

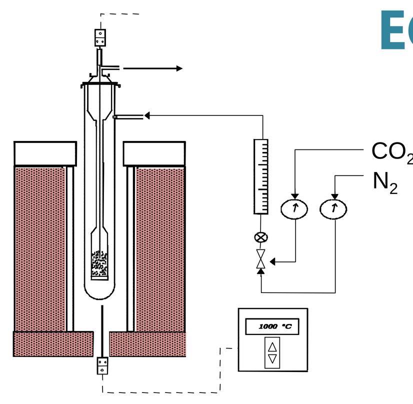
Coke size: 19 - 22.4 mm

Temperature: 1100 ºC

Time: 2 h



ECE-INCAR REACTIVITY TEST



$R_{ECE-INCAR}$ = % weigh loss

Coke weight: 7 g

Coke size: 1-3 mm

Temperature: 1000 ºC

Time: 1 h

Results and Discussion

COALS CHARACTERISTICS

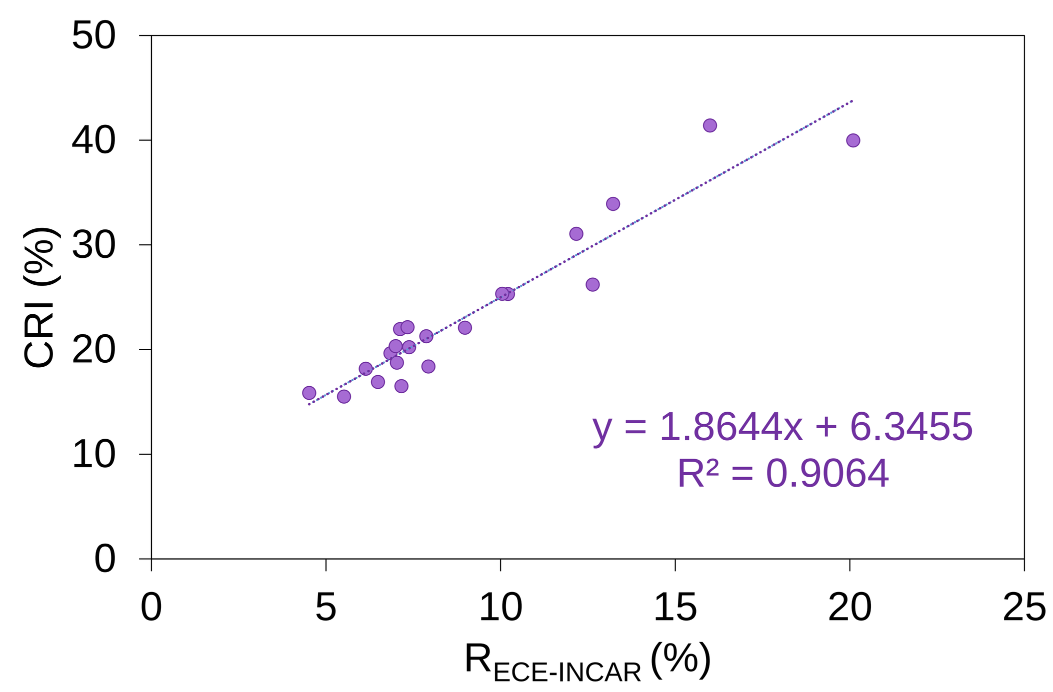
Coal	Origin	Ash (wt.% db[a])	VM[b] (wt.% db[a])	MF[c] (ddpm)	Tr-Ts[d] (ºC)
C1	USA	9.5	18.4	448	47
C2	AUS	8.6	19.1	19	54
C3	AUS	9.4	19.3	103	70
C4	AUS	9.4	19.7	125	62
C5	USA	8.8[e]	19.9[e]	234	76
C6	USA	8.5	20.3	436	96
C7	AUS	9.8	20.4	192	81
C8	AUS	10.3	20.4	41	71
C9	AUS	7.1[e]	21.6[e]	595	84
C10	AUS	10.3	21.8	119	72
C11	AUS	9.5	22.1	221	78
C12	USA	8.2	22.7	971	96
C13	USA	10.7[e]	23.3[e]	163	72
C14	AFR	11.0	23.5	354	87
C15	AUS	7.9[e]	23.7[e]	377	78
C16	USA	8.3	28.9	41034	120
C17	POL	10.5	30.7	3532	84
C18	USA	7.3	30.9	11047	96
C19	USA	7.0	31.1	8679	84
C20	POL	6.9	32.3	2655	78
C21	USA	7.4	33.1	39903	115
C22	USA	7.2	33.4	25418	100

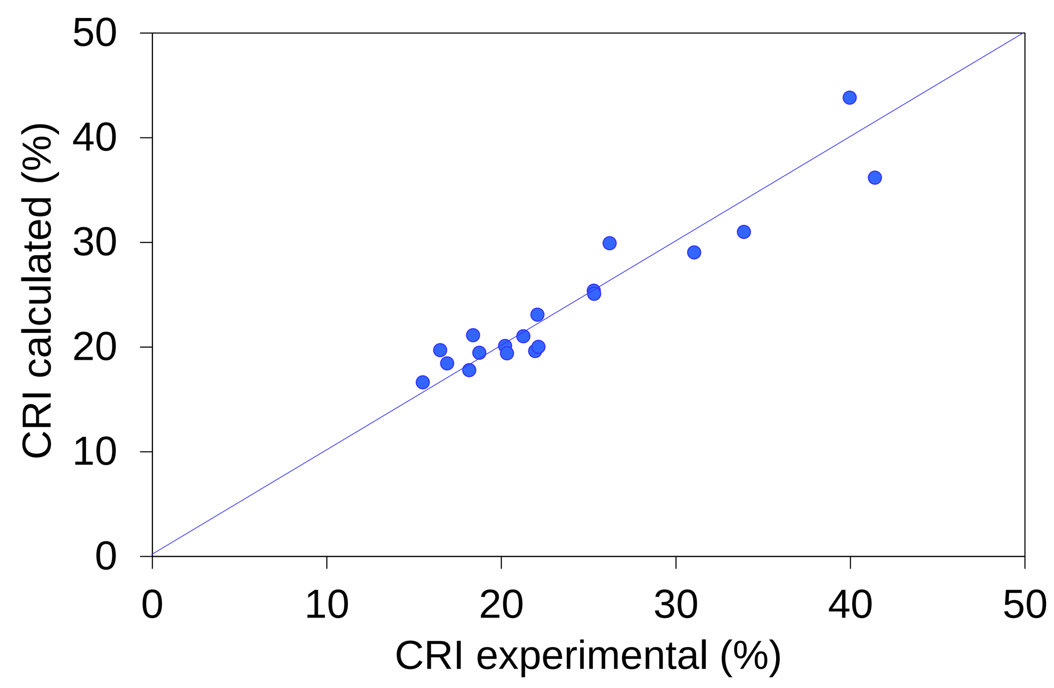
[a] Dry basis. [b] Volatile matter. [c] Maximum fluidity expressed in dial divisions per minute (ddpm). [d] Plastic range. [e] Thermogravimetric data (ASTM E1131-03 standard procedure).

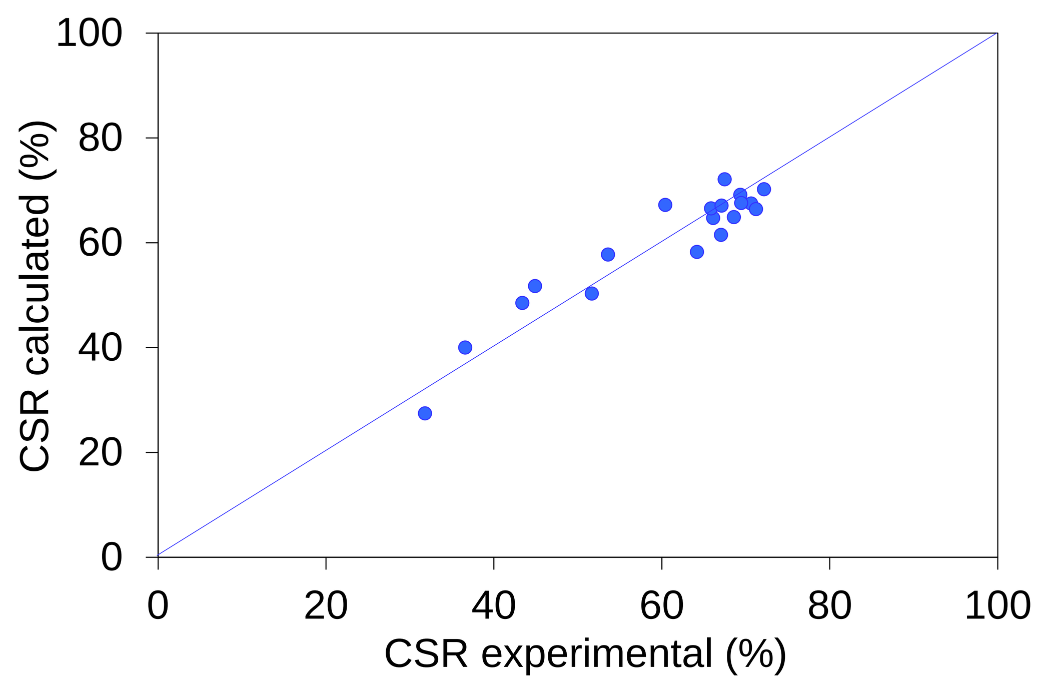
The coals were selected for this study from those normally used by the coking industry. They cover a wide range of volatile matter content between 18.4 wt.% and 33.4 wt.%. The thermoplastic properties of the coals varied greatly with values of Gieseler maximum fluidity from 19 to ca. 40000 ddpm. The samples analyzed cover a broad spectrum of the CRI/CSR range, including cokes destined for use in the blast furnace (CSR ca. 70-60 %) as well as cokes that are outside this range.

COKE QUALITY

A linear correlation with a high correlation coefficient was observed between the CRI of semi-pilot cokes with $R_{ECE-INCAR}$ index of the lab-scale cokes.







The CRI and CSR indices of the cokes prepared in the 17 kg oven were linearly related with the index $R_{ECE-INCAR}$ of the laboratory cokes by the following expressions: $CRI = 1.861\ R_{ECE-INCAR} + 6.342$ with a correlation coefficient $R^2 = 0.905$ and $CSR = -3.073\ R_{ECE-INCAR} + 89.292$ with a correlation coefficient of $R^2 = 0.891$.

Conclusion

Coke reactivity and mechanical strength after reaction (CRI/CSR) can be predicted by applying the $R_{ECE-INCAR}$ reactivity test to cokes produced at laboratory scale.

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