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Estimation of Coal Charge Homogeneity

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Under conditions of worsening raw material resources base for coking one of primary tasks is to make the degree of coal charge mixing close to 98-99 % by its all indexes because their uneven distribution in the coke drum affects the coke quality.

Keywords: COAL, CHARGE, DEGREE OF MIXING, CHARGE QUALITY, COKE

Introduction

Formation of physic-chemical and mechanical properties of coke takes place in the process of coal heat treatment. Requirements to coal subjected to reprocessing are defined by possibilities of laminar coking process. They are maintenance of set properties of coal charge (concentration of moisture, ashes, sulfur, volatile-matters, bulk weight, fractional makeup, caking capacity, cokeability, etc.) in amounts corresponding to one coke drum charge and in its each small volume with the purpose to produce coke that satisfies the requirements of current blast-furnace practice [1].

In this connection one of major measures related to raise of coke quality is maintenance of high degree of mixing coal concentrates from which the charge for carbonization is composed since it makes it possible to produce coke with homogeneous structure.

The material composition and technological properties of coal charge components considerably differ from each other. To provide conditions of caking and coke formation in the coal charge, a close contact between grains of its components is important and grains of badly sintered coals should be surrounded by grains of well sintered coals. This is achieved by intimate mixing of coal charge components at its corresponding granulometric composition. So it is necessary to pay a special attention to proper mixing of coal charge components and provide a uniform composition of coal charge during its preparation for carbonization [2].

Currently up to 15 coal concentrate grades are delivered to JSC “ArselorMittal Kryvyy Rih”. The charge is composed of 9-12 coal grades. Coke quality is defined by, first of all, optimum composition and quantity of coal concentrates. Unsteady supply of such a great number of coal grades and variation of their physic-chemical parameters reduce coke quality and stability of its parameters. To produce coke with stable quality even at small amount of coal concentrates, it is necessary to solve a problem of effective mixing (homogenization) of coal charge for carbonization.

When preparing charge, a hammer grinder is considered to be one of effective blending machines, but what is efficiency at such amount of coal concentrates? The authors have tried to answer this question in present investigation.

Results and Discussion

Variations of parameters of technical, plastometric and petrographic analysis of coal concentrates are presented in **Tables 1** and **2**. It follows from tables that all parameters of coal concentrate quality varied between very wide limits. Variations of parameters of coke quality produced on 5-6 batteries in March, 2010 are presented in **Table 3**. It follows from the table that cold impact strength parameters of coke M_{25} and

M_{10} as well as parameters CRI and CSR do not satisfy requirements of current blast-furnace practice.

Using coal charge sampling procedure, we have selected 200g snap sample for definition of technical, plastometric and petrographic parameters of the charge and 16 kg samples for determination of bulk weight and granulometric composition of the charge.

Before sampling, the department carried out preventive measure and adjustment of hammer breaker. Proximate analysis of selected charge samples, bulk weight, granulometric composition and petrographic parameters are introduced in **Table 4**. Using mathematical statistics methods, I. Z. Shatokha suggested the formula for definition of degree of charge mixing by any parameter of its quality [1, 3, 5]

$$\varphi = (1 - \sqrt{\frac{\sigma_m^2 - \sigma_a^2}{\sigma_n^2 - \sigma_a^2}}) \cdot 100 \qquad \text{(Eq. 1)}$$

where σ_m^2 - dispersion of mixed coal charge parameter; σ_n^2 - dispersion of absolutely not mixed charge parameter; σ_a^2 - dispersion caused by errors of selection and their analysis. For parameter of volatile-matter content $\sigma_a^2 = 0.03$.

The dispersion of quality parameter for absolutely non-homogeneous charge is calculated by formula [3]:

$$\sigma_H^2 = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2 \cdot m_i}{\sum_{i=1}^{n} m_i} \qquad \text{(Eq. 2)}$$

where $\overline{X}$ - weighted mean value of coal charge quality index; X_i - quality index of *i*-charge component; m_i - participation of component in the charge, %; n - amount of components in the charge.

Table 1. Change of technological and plastometric parameters of quality of coal concentrates applied in March 2010 at JSC "ArselorMittal Kryvyy Rih"

Grade, dressing works	Content in charge, %	Technical analysis, %	
		W_t^r	A^d
Ж – Ukrkoks	4-9	9.4-11.2	7.2-10.5
Ж – Kievskaya	7-13	10.2-13.4	7.0-8.1
К – Ukrkoks	4-6	8.3-12.2	7.2-8.4
К – Udachnaya	4-10	7.7-11.8	8.1-8.9
К – Uzlovskaya	3-10	9.2-12.7	5.7-6.8
К – Severnaya	20-27	7.5-14	7.6-9.3
2Ж – Pechorskaya	16-27	4.9-13.3	8.1-9.3
MV – Integrity CS USA	10-16	5.4-8	8.4-8.8
HV – Integrity CS USA	9-12	5.5-8	7.4-9.3
ГЖ – Eagle Blend USA	10-22	6.1-8	7.6-8.2

Grade, dressing works	Technical analysis, %		Plastometric parameters, mm	
	S^{td}	V^{daf}	x	y
Ж – Ukrkoks	1.68-2.26	32.3-32.5	23-27	19-24
Ж – Kievskaya	1.91-2.35	30.4-32.4	2-12	23-28
К – Ukrkoks	1.79-2.18	24.1-29.3	19-30	13-20
К – Udachnaya	0.74-0.76	28.4-29.5	16-21	14-15
К – Uzlovskaya	1.78-1.95	22-24.4	18-21	14-15
К – Severnaya	0.38-0.47	23-24.2	35-42	14-17
2Ж – Pechorskaya	0.51-0.68	30.7-32.4	26-36	16-22
MV – Integrity CS USA	0.82-1.04	29.0-34.0	28-38	18-23
HV – Integrity CS USA	0.8-1	29.8-37.5	29-46	18-22
ГЖ – Eagle Blend USA	0.85-0.95	34.7-35.2	34-44	17-20

Table 2. Change of petrographic parmeters of quality of coal concentrates applied in March 2010 at JSC "ArselorMittal Kryvyy Rih"

Grade, dressing works	Petrographic parmeters, %							
	Average vitrinite reflectance Ro, %	Vitrinite Vt	Liptinite L	Semvitrinite Sv	Intertenite I	Total OK	Oxidized areas	Д
Ж – Ukrkoks	1.03-1.07	89-91	2-3		6-9	6-9		
Ж – Kievskaya	1.09-1.1	88-93	1		6-11	6-11		
К – Ukrkoks	1.18-1.4	87-92	1-3	0-1	6-12	6-12	2-4	0-0.7
К – Udachnaya	1.16-1.18	86-89	1-2		9-12	9-12		
К – Uzlovskaya	1.43-1.49	92			8	8	5-7	
К – Severnaya	1.12-1.16	43-52	0-5	1-5	47-52	48-55		
2Ж – Pechorskaya	0.97-1	69-80	0-2		19-29	19-29		
MV – Integrity CS USA	0.99-1.15	77-82	3-4	0-4	14-19	14-19		
HV – Integrity CS USA	0.89-1.16	79-82	3-5		15-16	15-16		
ГЖ – Eagle Blend USA	0.95-0.98	72-77	4-7		18-24	18-24		

Grade, dressing works	Petrographic parmeters, %						
	ДГ	Г	Ж	К	ОС	Т	А
Ж – Ukrkoks	2.4-2.6	0.3-20.3 0-0.3	69-99.4 94.7-96	0.3-11.7 4.0-5	0.6		
Ж – Kievskaya	0.3-3.7	0.3-19.6	26.6-64.6	6.8-30	0.3-49.4	2.9-13	1-11.3
К – Ukrkoks		0-0.3	62.0-66.0	33.3-37.3	0.4-0.7		
К – Udachnaya		0.7-1.6	0.6-10.5	33.7-43.7	37.7-55.8	8.9-9.3	0.3-1
К – Uzlovskaya		0.3-0.7	74.1-87.7	12.3-25.6	0.3-1.7		
К – Severnaya	0.6-1	8.0-14	84.4-91	0.3-3.6	0.3-1		
2Ж – Pechorskaya	0-0.3	9.6-24.4	36.4-88.4	0.6-19.8	0.0-15.7	0.0-3.7	
MV – Integrity CS USA	0.3-1.7	12.0-54.7	32.1-85.3	0.3-22.6	0-19.2	0-3.1	
HV – Integrity CS USA	3.7	19.3	87				

Table 3. Variation of coke quality on 5-6 batteries in March 2010

Moisture, %	Sulfur, %	Ashes, %	Volatile matter, %	M_{25}, %	M_{10}, %	>80, mm	<25, mm	CSR, %	CRI, %
3-8	0.77-0.95	11.4-13.2	0.7-1	79.3-84.5	8.1-10	2.2-8.8	7.1-13.6	37.2-44.1	44.1-37.2

The extent of charge mixing counted by volatile-matter content is 86.3 % which is far from optimum and economically feasible degree of mixing 97-98 % [4].

As already mentioned, degree of charge mixing defined by variation of its moisture should be 100 %, and we obtained its actual value 76.2 % while the moisture has a considerable effect on the bulk weight of the charge and quality of coke. We obtained lower value 45 % for one more parameter of technical composition of the charge – ashes content, and only degree of mixing by parameter of sulfur content was high enough – 94.7 % which was caused by insignificant variation of sulfur content in the coal charge.

However, the lowest degree of charge mixing 20.3 % was obtained for 0-0.5 mm class because amount of this fraction in the charge was very high - 46-49 % and it was very non-uniformly distributed in the charge. And as known the content of this fraction also has a considerable effect on the bulk weight of charge and coke quality [6].

The degree of charge mixing by parameters of its petrographic composition for vitrinite and sum of inert components are 89.7 and 88.2 % respectively, which is also not enough for optimum and economically feasible degree of mixing.

Table 4. Change of quality indexes of selected charge samples

Sample number	Thickness of layer, y, mm	Technical analysis of charge				Bulk weight, t/m^3
		W, %	A, %	S, %	V, %	
1	17	10.9	9.7	0.97	28.9	0.800
2	18	10.5	8.9	0.90	28.3	0.777
3	16	11.4	9.1	0.91	28.7	0.774
4	16	11.4	8.9	0.93	28.5	0.783
5	17	10.8	9.2	0.97	29.1	0.795
6	15	10.5	8.7	0.95	28.3	0.786

Sample number	Granulometric composition of charge				
	+6 mm	6-3 mm	3-0.5 mm	-0.5 mm	0-3 mm
1	4.83	9.52	43.03	42.62	85.65
2	5.98	8.52	38.68	46.82	85.50
3	4.39	8.54	51.29	35.78	87.07
4	5.83	8.38	39.72	46.07	85.79
5	5.07	10.19	51.67	33.07	84.74
6	4.11	10.41	47.39	38.09	85.48

Sample number	Petrographic parameters, %						
	Average vitrinite reflectance Ro, %	Vitrinite Vt	Liptinite L	Semvitrinite Sv	Intertenite I	Total OK	Oxidized areas
1	1.09	70	2	1	27	28	
2	1.09	68	1	2	29	31	
3	1.10	63	2	1	34	35	
4	1.10	65	3		32	32	
5	1.09	67	2		31	31	1
6	1.09	66	3	1	30	31	2

Sample number	Д	ДГ	Г	Ж	К	ОС	Т	А
1			10	69	16	3	2	
2		1	10	72	11	6	1	1
3		1	8	70	14	5	2	
4			9	70	13	6	2	
5			12	71	11	4	2	
6			12	65	17	4	2	

Analysis of obtained results even with account of selection errors and cutting of samples as well as their proximate analysis helps to ascertain that this charge requires additional mixing prior to supply in the coke drum.

Conclusions

Under conditions of worsening raw-material coking base and unsteady supply of coal concentrates to by-product coke plants it is necessary to give a special attention to problem of quality preparation of the charge subjected to carbonization. One of primary problems is making the degree of coal charge mixing close to 98-99 % by its all parameters as their non-uniform distribution in coke drum has a negative effect on coke quality.

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Оценка степени однородности угольной шихты

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В условиях ухудшения сырьевой базы коксования одной из важнейших задач является доведение степени смешивания угольной шихты по всем ее показателям до 98-99 %, так как неравномерное их распределение в коксовой камере сказывается на качестве кокса.