ISSN 2176-3135

INDUSTRIAL TRIAL OF SERPENTINE ADDITION INTO BURDEN OF #5 BLAST FURNACE IN WISCO[1]

YANG Jialong[2]
LU Longwen[2]
FU Lianchun[2]
LI Huaiyan[2]

Abstract

The trial of serpentine directly addition into ferrous materials of #5 blast furnace had been carried out within 10 days beginning on 22 Sep., 2010. The total consumption of serpentine was about 1400 t. About 1000kg serpentine was added in each charging. MgO and CaO content in serpentine were 38% and 32% respectively. The purposes of the trial were: (1) Modifying MgO content in slag to 9~10.5% so as to buffer the negative effects of higher Al2O3 content in slag. (2) Reducing MgO content in sinter from 2.8% to 2.0% so as to get relative improved tumbler strength of sinter. Overall, the performance of blast furnace had been obviously improved and the stable and consistent furnace operation had also been realized in the period of conducting the trial.

Keywords: Blast furnace; Ferrous materials; Burden; Viscosity; Fluidity.

1 Technical contribution to the 6th International Congress on the Science and Technology of Ironmaking – ICSTI, 42nd International Meeting on Ironmaking and 13th International Symposium on Iron Ore, October 14th to 18th, 2012, Rio de Janeiro, RJ, Brazil.

2 Wuhan Iron And Steel Corporation, Wuhan City, China 430083. Corresponding author: YANG Jialong, email: jialongyang@126.com, Cell phone:13986132069

ISSN 2176-3135

1 FOREWORD

Before 2007, the yearly average Al2O3 in slag at WISCO was controlled below 15.5% which would not cause problems on slag fluidity and blast furnace could work steadily under an ordinary operational condition. But because of the breaking out of worldwide financial crisis, the alumina value in imported ferrous material had been raised steeply after 2008 which resulted in serious troubles on hearth activity and smoothness of slag exhausting. #7BF had suffered from more than two month abnormal situation caused mainly by excessive rising of alumina (17-19 wt%) in slag and then worsening the fluidity of slag and hearth process. How to deal with the influences of high proportion of Al2O3 in slag on blast furnace stable operation was an important project which must be finished as early as possible. There are three measures can be employed to buffer the negative influence of high slag alumina content: (1) Purchasing high quality lower Al2O3 raw materials which will lead to the increase of hot iron cost; (2) Increasing slag volume by lowering Fe value of burden material which will make a furnace operated in an none efficient way, and also lead to spending more money to produce unit of hot iron. (3) Reasonably increasing the value of slag so as to match the high proportion of alumina in slag, and relevantly reducing the viscosity of hot slag. Researches and practices had shown that item 3 was the best answer among those listed measures. So increasing sinter MgO from normally below 2.0% to about 3.0% had been carried out which resulted in the obviously decrease of tumbler strength and worsen the permeability in the blast furnace. As a result, to ensure the necessary sinter strength another manner of hoisting slag MgO through adding serpentine directly to the furnace burden material just in the stock house was proposed by operators and engineers at ironmaking plant. So some industry trials related to direct charging serpentine into iron bearing material had been implemented within 10 days beginning on 22 Sep., 2010. The sinter TI and slag fluidity were improved accordingly as the trial was successively carried out on the #5 BF which indicated the trialed course would be technically and economically reasonable for treating the situation of the increased alumina content in ferrous burden materials. Some basic information of trialed blast furnace are listed in table 1

Table 1. Typical properties and operational parameters of trialed #5 blast furnace in WISCO

Inner volume (m3)	Hearth diameter (m)	Tuy-eres	Tapp-ing hole	Top pressure (MPa)	Iv prod-uctivity (t/m3.d)	Coke rate (kg/tHm)	PCI rate (kg/tHm)	Ore batch (t)	O/C	Slag rate (kg/tHM)	Hot metal temperature (℃)
3200	12.4	32	4	0.23	2.5-2.8	305-330	165-190	93-100	4.3-4.8	310-340	1485－1510

2 ADJUSTMENT OF BURDEN COMPONENT DURING SERPENTINE ADDITION TRIAL

Before carrying out the trial, BF should be maintained in relative stable operation state, and some main operational parameters should be also kept in fundamental consistent. It took two days for sintering plant to reduce the proportion of MgO in blending

ISSN 2176-3135

materials when serpentine was decided to be charged into BF.

2.1 Carrying on Relevant Calculations before Charging Serpentine

2.1.1 The often-used burden component and some operational parameters

Ten days operational data were crunched to support the relevant calculation. Table 2 lists the average burden material component of No.5 BF in a period of ten days before conducting the trial.

Table 2. Commonly used burden component and parameters on # 5 blast furnace

Sinter (%)	Pellet (%)	Austr. Lump (%)	Hainan lump (%)	Ore batch (t)	Total Coke batch (t)	Coke batch (t)	O/C	PCR for a batch (t)	Hot iron for a batch (t)	Ore consumed (t/tHM)
61.0	25.0	11.0	3.0	95.0	22.1	19.5	4.30	10.4	58.01	1.64

2.1.2 Compositions of ferrous materials and serpentine (Refer to Table 3)

Table 3. The composition of iron bearing material and serpentine

Item	TFe	FeO	SiO_2	AL_2O_3	CaO	MgO	Mn	S	P
Name	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Sinter	55.4	7.86	5.33	2	10.29	2.45	0.4	0.03	0.08
Pellet	63	0.45	4.63	1.19	0.54	0.1	0.2	0.04	0.036
Aus. lump	62.08	0.4	3.21	1.38	0.47	0	0.26	0.021	0.056
Hai lump	55.73		12.97	1.05	0.21	0	0	0.03	0
Serpentine	9.15		32.7		0.65	37.5	0	0.028	0.014
Coke	0.752		5.92	4.51	0.68	0.167	0	0.64	0
PCI	0.654		4.70	4.14	0.47	0.146	0	0.37	0

2.1.3 Slag calculation results for each batch of burden material before the trial (Refer to table 4)

Table 4. Slag components and composition for each batch of materials before the trial

Slag volume (t)	Slag/ iron (t/tHM)	Basicity	Volume of each component (t)						Component (%)					
			CaO	SiO2	MgO	Al2O3	S	MnO	CaO	SiO2	MgO	Al2O3	S	MnO
17.5	0.301	1.05	6.35	6.06	1.64	3.04	0.21	0.20	36.27	34.62	9.18	17.4	1.2	1.147

2.2 Relevant Calculations after the Trial of Charging Serpentine

Calculations were conducted based on the given burden material compositions etc. The results indicated that as burden components of sinter and pellet were kept unchanged (mentioned in table 1), the Aus. Lump would be increased from 11% to

ISSN 2176-3135

14%, corresponding the reduction of Hai lump to 0%, through adding certain serpentine in each batch material for adjustment of slag basicity. During the calculation the MgO in sinter was designed to be 2.0%, the Fe value was raised to 55.8%. Results are listed in Table 5.

Table 5. Slag components for each batch of materials after the addition of serpentine

No.	Serpen -tine (kg)	Basicity	Volume of each component （t）						Components （%）					
			CaO	SiO2	MgO	Al2O3	S	MnO	CaO	SiO2	MgO	Al2O3	S	MnO
C	800	1.053	6.36	6.04	1.53	3.06	0.21	0.21	36.53	34.7	8.818	17.6	1.21	1.2
D	1000	1.042	6.36	6.11	1.61	3.06	0.21	0.21	36.24	34.79	9.174	17.4	1.2	1.19

It is obviously from table 4 that “D” should be better than the other one. If “D” is selected, then the corresponding calculated burden material components should be as shown in Table 6.

Table 6. The reasonable burden material components after direct charging of serpentine

Sinter (%)	Pellet (%)	Aus. Lump (%)	Hai Lump (%)	Serpentine /batch (kg)	Ore batch (t)	Total coke batch (t)	Coke batch (t)	PCR for a batch (t)	Hot iron/batch (t)	Ore consumed （t/tHM）
61.0	25.0	14.0	0.0	1000	95.0	22.1	19.5	10.5	58.47	1.62

2.3 The Actual Components of Burden after the Trial of Adding Serpentine

The overall blast furnace actual burden material components maintained the same as the theoretical calculated results. But because the sinter basicity fluctuated occasionally during the test, lead to a little bit adjustments on the volume of charged serpentine. The general blast furnace operational parameters had been roughly retained the same as those calculated results in reference period, and maintained the weight of serpentine more than one ton for each batch material (check Table 7):

Table 7. The variations of burden material components during the industrial trial

Date of trial	Burden material components
2010-09-22	Sinter: 60% ＋ Pellet:27% ＋ Aus. Lump:13% ＋ Serpentine:1t
2010-09-23	Sinter: 60% ＋ Pellet:27% ＋ Aus. Lump:13% ＋ Serpentine:1t
2010-09-24	Sinter: 63% ＋ Pellet:23% ＋ Aus. Lump:14% ＋ Serpentine:1t
2010-09-25	Sinter: 63% ＋ Pellet:23% ＋ Aus. Lump:14% ＋ Serpentine:1t
2010-09-26	Sinter: 63% ＋ Pellet:23% ＋ Aus. Lump:14% ＋ Serpentine:1.2t
2010-09-27	Sinter: 63% ＋ Pellet:23% ＋ Aus. Lump:14% ＋ Serpentine:1.5t
2010-09-28	Sinter: 61% ＋ Pellet:25% ＋ Aus. Lump:14% ＋ Serpentine:1.3t
2010-09-29	Sinter: 63% ＋ Pellet:25% ＋ Aus. Lump:12% ＋ Serpentine:1t
2010-09-30	Sinter: 63% ＋ Pellet:21% ＋ Aus. Lump:16% ＋ Serpentine:1t
2010-10-01	Sinter: 63% ＋ Pellet:20% ＋ Aus. Lump:17% ＋ Serpentine:1.2t

ISSN 2176-3135

3 SINTER QUALITY VARIATIONS DURING THE TRIAL OF MgO REDUCTION

During the trial of direct serpentine addition into blast furnace, MgO content in sinter should be controlled to round 2.0% theoretically. Because the AL2O3 content in blending materials had already been reduced to about 2.0%, and the AL2O3 in blast furnace slag had also been reduced to around 16% ahead of the implementing of the trial. As a result, before the test the MgO value in sinter had already reduced from about 2.9% on early September, to 2.5% or so in reference stage. Actual MgO content in sinter was basically controlled to around 2.0% during the trial; Because of bigger fluctuation with sinter basicity within the trial period, had led to somewhat influences to the result of sinter grain size distribution and other indexes. But in-situ observation, comments and production statistics from the third sintering workshop's operators indicated that the actual qualities of sinter such as granularity component, strength, uniformity of color after cooling down etc. had improved correspondingly and matched with the reduction of MgO content from 2.5% to about 2.0%. The common point of view is that reasonably reducing MgO content in sintering blends will possess obvious effect on the improvement of sinter properties, those including：

3.1 Improving The Components Of Granularity (Table 8)

Table 8. The influence of lowing MgO content on sinter quality and granularity distribution at the third sintering workshop of WISCO

Date	TFe(%)	FeO(%)	CaO (%)	SiO2 (%)	Ro	MgO (%)	S(%)	Al2O3 (%)	>40mm	25-40 mm	16-25 mm	10-16 mm	5-10 mm	<5 mm	TI (%)
20100905	55.5	7.43	10.5	5.07	2.1	2.84	0.02	1.98	10.08	26.78	19.92	21.97	17.0	4.25	79.47
20100906	55.9	7.34	10.3	5.38	1.9	2.74	0.02	2.19	6.66	18.34	24.54	21.19	24.1	5.14	79.00
20100906	55.9	7.36	10.1	5.22	2.0	2.89	0.02		8.83	19.13	23.78	22.94	20.5	4.74	79.67
20100907	56.0	7.65	10.2	5.39	1.9	2.39	0.02	2.00	7.87	17.88	21.72	23.56	23.1	5.81	79.67
20100908	54.5	8.23	11.26	5.74	2.0	2.99	0.03	2.03	8.10	18.33	23.64	23.36	22.4	4.13	79.30
20100909	55.1	8.75	11.28	5.52	2.0	2.76	0.03	2.01	7.68	17.91	23.41	23.14	23.2	4.57	79.10
20100909	56.2	8.15	10.0	5.27	1.9	3.09	0.02		9.46	20.27	22.45	19.64	19.5	5.67	79.10
20100910	56.1	7.75	10.0	5.46	1.8	2.58	0.03	2.07	10.72	20.55	25.16	22.30	17.0	4.25	78.87
20100910	55.5	6.84	10.2	5.36	1.9	3.05	0.04		9.03	26.04	22.19	20.88	17.4	4.42	78.90
Avg.1	55.6	7.72	10.4	5.38	1.9	2.81	0.03	2.05	8.71	20.58	22.98	22.11	20.5	4.78	79.23
20100923	56.5	7.23	10.2	5.28	2.0	2.11	0.02	1.83	13.29	23.34	22.19	19.19	17.9	4.06	79.00
20100923	56.1	6.35	10.1	5.13	2.0	2.16	0.02		9.94	23.65	25.30	19.59	17.7	3.75	79.33
20100924	57.2	6.94	9.63	5.25	1.8	2.14	0.02	1.79	13.65	20.85	23.20	18.29	19.9	4.10	79.13
20100924	56.7	7.07	9.69	4.91	2.0	2.14	0.02		12.41	20.35	22.73	20.16	19.4	4.88	79.67
20100925	55.9	7.40	10.5	5.35	2.0	2.42	0.03	2.04	12.60	24.92	25.49	21.83	10.7	4.37	80.06
20100925	55.9	7.21	10.2	5.40	1.9	2.33	0.02	2.07	14.31	21.99	20.88	22.71	15.9	4.15	79.33

ISSN 2176-3135

20100927	56.6	7.40	10.7	4.70	2.3	2.01	0.03	1.77	15.34	27.63	24.50	16.49	10.5	5.50	79.66
20100927	55.8	7.50	10.1	4.87	2.1	1.91	0.02		14.21	27.67	22.29	19.70	10.5	5.53	80.00
20100928	56.6	6.80	9.71	5.12	1.9	1.62	0.02	1.90	6.36	25.07	23.74	24.84	15.2	4.69	79.80
20100928	56.6	6.54	9.58	5.54	1.7	1.52	0.02		17.99	19.72	18.33	19.90	17.1	6.88	78.67
20100929	57.3	7.70	9.10	5.61	1.6	1.88	0.02	2.00	12.46	23.40	18.81	20.36	19.4	5.56	80.76
20100929	56.4	6.97	9.65	5.26	1.8	2.20	0.02		14.74	21.91	20.48	17.28	19.3	6.21	78.93
20100930	56.0	6.83	10.8	5.50	2.0	2.19	0.02	1.89	14.35	22.02	23.23	19.97	14.9	5.47	80.00
20100930	55.7	7.20	10.4	5.25	2.0	2.48	0.03		12.58	23.51	24.19	21.40	13.11	5.20	79.60
Avg.2	56.4	7.08	10.0	5.23	1.9	2.08	0.02	1.91	13.16	23.29	22.53	20.12	15.8	5.03	79.57
Avg.2— Avg.1	0.73	-0.64	-0.41	-0.15	-0.0	-0.74	0.00	-0.14	4.44	2.71	-0.45	-1.99	-4.63	0.25	0.34

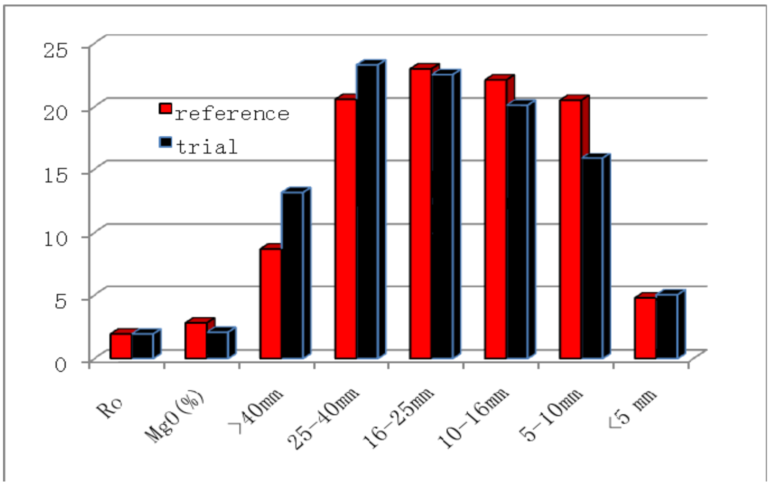

Figure 1. The comparison of some items between reference period and trial period

It is easy to know from the table 7, as MgO value was reduced from2.81% to 2%, the proportion of sinter grain size >16 mm increased from 52.27% to 58.97% with a net increment of 6.7%, while the proportion of those sinter granularity in 5-10mm decreased about 4.63%; Obviously, as the MgO content in sinter decreased from about 2.8% to around 2.0%, the particle size distribution would be distinctly improved. The sinter tumbler strength also displayed a little bit improvement（check Figure1）.

ISSN 2176-3135

3.2 Increasing the Ratio of Finished Sinter Product (Table 9)

Table 9. The influence of MgO content on tumbler strength and the ratio of finished product

Date	MgO (%)	Basicity	TI (%)	Ratio of finished product (%)
2010.09.25	2.42	1.91	79.33	83.04
2010.09.22	2.33	1.69	78.67	79.81
2010.09.29	2.20	1.83	78.93	80.36
2010.09.21	2.16	1.93	77.33	80.19
2010.09.23	2.16	1.98	79.33	82.08
2010.09.24	2.14	1.97	79.67	81.18
2010.09.27	1.91	2.09	80.00	82.50
2010.09.28	1.52	1.73	78.67	82.41

3.3 Decreasing the Total Sinter Return Ratio (Table 10)

Table 10. The main operation parameters of #3 sintering strand on 21-29, September, 2010

Date	Blending fine(%)	Return Sinter	Mixed flux (%)	Calcined lime (%)	powdered Coal (%)	Water in blending (%)	Negative pressure (pa)
2010.09.21	29.0	47	4.00	1.8	2.70	6.5	-12
2010.09.22	31.5	44	4.60	2.0	2.90	6.4	-11
2010.09.23	28.0	47	5.10	2.0	2.80	6.4	-10
2010.09.24	34.0	41	5.20	1.8	2.80	6.5	-12
2010.09.25	32.0	44	4.60	1.8	2.75	6.5	-12
2010.09.26	34.0	41	5.20	1.8	2.75	6.4	-9
2010.09.27	39.0	35	6.20	1.8	2.85	6.4	-11
2010.09.28	27.0	50	3.20	1.8	2.70	6.6	-12
2010.09.29	29.0	47	4.10	1.8	2.70	6.5	-15

Because of the MgO and basicity was only 1.52% and 1.73% on 28 of Sep., this was not a normal sinter, so that the data can be neglected on this day; on the other hand, MgO was only began to be reduced in the middle shift on 21, Sep. so data of that day could also be ignored. So it was apparently that the sinter return ratio during 24-27 maintained in a significant lower value, and the return sinter ratio had reduced by 3-8% compared with reference period.

4 THE COMPARISON OF BLAST FURNACE OPERATIONAL INDEX BEFORE AND DURING SERPENTINE ADDITIONAL TRIAL

Some negative affects appeared during carrying on serpentine addition trial, including: (1) the mud gun could not push enough mud into tapping-hole from 22 to 26 on Sep., 2010, which lead to the uncompleted discharging of hot metal and slag, caused wind rate shrinking from 6450m3/min to around 6100m3/min, and further more worsened the overall furnace performance within that period of time. Further more, there existed some faults occurred at stock house on September 27, and resulted in consecutive

ISSN 2176-3135

(about 6 hours) appearance of lower stockline, which had done a certain amount of damage on furnace ordinary operation. The limit using of oxygen on Sep. 30 also had negative influences on furnace. It has been commonly recognized that the phenomena outlined above will be surely bringing about bad effects on blast furnace productivity and efficiency. Even so, the blast furnace operational condition had improved obviously during the rest period of trial time, and intensifying and efficient furnace performance were realized in the normal trial period. Compared with the reference period of time, the total coke and fuel ion during trial period displayed the tendency of overall reduction by 9.6 kg/tHM and 12.3 kg/Thm respectively. The net fuel rate had reduced by about 10 kg/tHM deducting the positive effect of increasing sinter Fe value by 0.4%. In addition, in the test period, the mud gun had not maintained to a best state, the iron and slag discharging time always had not been long enough to exhaust completely the hot iron and slag, that would affect the hearth process, all of which would somewhat influence the intensive and effective operations. Except the influences of forced lowering top-pressure and mud gun failure, the coke rate and technical indexes should be certainly better than those of in the reference time. Therefore, serpentine direct addition to the blast furnace would exhibit a positive effect and would be beneficial to improve the technical and economic index for a given blast furnace (refer Table 11 and Figure 2).

Table 11. Comparisons of partial BF operational indexes between trial period and reference period

Date	Daily production	IV productivity	Coke rate	Coal rate	Nut coke rate	Fuel rate	TFe
	ton	t/m^3.d	kg / tHM	kg / tHM	kg / tHM	kg / tHM	%
2010-09-10	7525.2	2.352	359.6	196.8	38.3	594.7	59.03
2010-09-11	7383	2.307	341.4	196.9	43.7	582	59.00
2010-09-12	7939.4	2.481	358.8	189.1	45.2	593.1	58.98
2010-09-13	8272.7	2.585	331	184.9	40.3	556.2	59.04
2010-09-14	8272.8	2.585	353	181.1	44.2	578.3	58.89
2010-09-15	8679.8	2.712	323	165.1	44.1	532.2	59.57
2010-09-16	8321.3	2.6	335	176.8	45.1	556.9	59.02
2010-09-17	8515.3	2.661	321	171.5	43.4	535.9	59.13
2010-09-18	8014.5	2.505	333	174.5	52.6	560.1	58.77
2010-09-19	8019	2.506	306	179	44.1	529.1	58.92
2010-09-20	8013.3	2.504	325	180.8	45.2	551	59.21
2010-10-21	8081.7	2.526	331	185.4	45.6	562	59.05
Ref. Av.	8086.5	2.527	334.817	181.825	44.3167	560.958	59.03
2010-09-22	7980.5	2.494	314	176	46.2	536.2	59.60
2010-09-23	7849.1	2.453	324	169.9	48.7	542.6	59.53
2010-09-24	8234.8	2.573	308	176	46.5	530.5	59.23
2010-09-25	8164.7	2.551	320	183.6	44.5	548.1	59.10
2010-09-26	7794.6	2.436	326	180	43.1	549.1	59.29
2010-09-27	8053.4	2.517	339	184.7	47.6	571.3	59.06

ISSN 2176-3135

2010-09-28	8150.5	2.547	319	185.5	47.4	551.9	59.65
2010-09-29	8354.8	2.611	335	177.6	47.1	559.7	60.06
2010-09-30	8070.9	2.563	321	177.9	46.6	549.1	59.31
Trial Av.	8072.8	2.52275	323.125	179.163	46.3875	548.675	59.197
Trial Ave.- Ref. Ave.	-13.7	-0.00425	-11.6917	-2.6625	2.070833	-12.2833	0.34

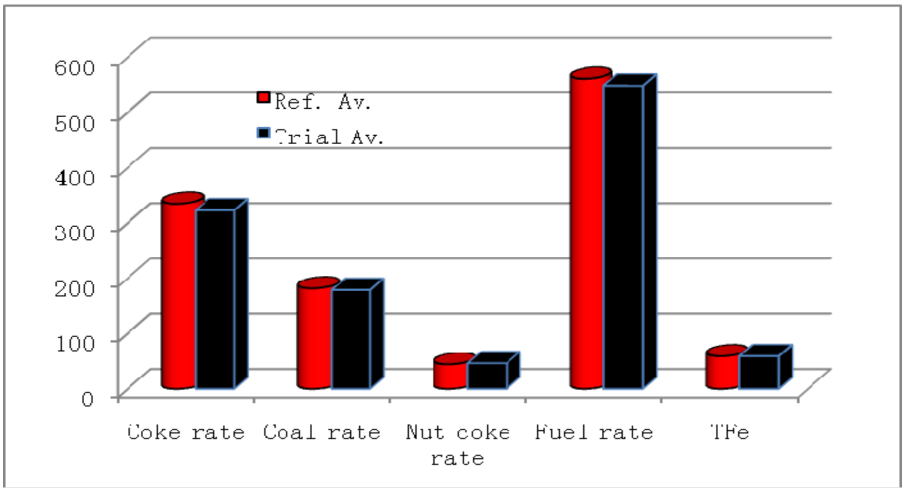

Figure 2. A comparison of fuel consumption between referring period and trial period.

4 THE TRANSITION OF SLAG FLUIDITY AND SLAG COMPOSITION DURING SERPENTINE ADDITION TRIAL (refer to the table 12)

Table 12. The transition of slag composition during reference period and industrial trial

Date	Basicity	SiO2%	CaO%	MgO%	Al203%	FeO%	MnO%	TiO2%	S%
2010-09-11	1.18	31.98	37.72	9.12	15.68	0.29	0.22	0.77	1.06
2010-09-12	1.15	32.27	37.19	9.05	15.89	0.32	0.24	0.72	1.03
2010-09-13	1.10	32.85	36.34	8.90	15.58	0.27	0.25	0.73	0.97
2010-09-14	1.12	32.87	36.73	9.12	15.78	0.31	0.19	0.73	1.04
2010-09-15	1.14	32.35	36.86	9.23	16.22	0.28	0.17	0.69	1.05
2010-09-16	1.11	30.72	36.71	9.03	16.08	0.26	0.16	0.65	1.07
2010-09-17	1.15	32.27	37.29	9.18	16.28	0.27	0.16	0.62	1.10
2010-09-18	1.17	32.08	37.50	9.23	16.18	0.28	0.14	0.59	1.12
2010-09-19	1.16	32.32	37.41	8.98	16.18	0.28	0.18	0.67	0.99
2010-09-20	1.15	33.15	37.34	8.75	16.18	0.33	0.19	0.78	1.02
2010-10-21	1.17	32.09	37.48	8.58	16.35	0.25	0.17	0.81	1.05
Ref. Ave.	1.15	32.27	37.14	9.02	16.04	0.29	0.19	0.71	1.05
2010-09-22	1.13	32.50	36.77	8.86	17.01	0.25	0.18	0.77	1.05
2010-09-23	1.09	32.83	36.02	9.48	16.56	0.26	0.22	0.85	0.96
2010-09-24	1.12	32.82	36.87	9.36	16.27	0.28	0.22	0.75	1.04
2010-09-25	1.15	32.53	37.32	8.96	16.68	0.29	0.19	0.69	1.07

ISSN 2176-3135

2010-09-26	1.16	32.29	37.20	9.53	15.89	0.39	0.19	0.63	1.05
2010-09-27	1.15	32.28	36.90	9.55	16.33	0.33	0.17	0.69	1.07
2010-09-28	1.10	33.16	36.56	9.56	16.54	0.24	0.21	0.70	1.01
2010-09-29	1.07	34.25	36.24	9.06	17.09	0.22	0.24	0.69	1.06
2010-09-30	1.14	32.97	37.59	8.75	16.30	0.27	0.22	0.67	1.12
Trial Ave.	1.12	32.89	36.84	9.28	16.46	0.29	0.21	0.71	1.05
Trial Ave.-Ref. Ave.	-0.02	0.62	-0.31	0.27	0.42	0.00	0.02	0.00	0.00

It is easy to know from table 11 that the average MgO content in slag reached 9.28% during the trial. There was 0.27% increment compared with reference period which exhibited a suitable matching with the corresponding AL2O3 increment by 0.42% （Figure 3）.

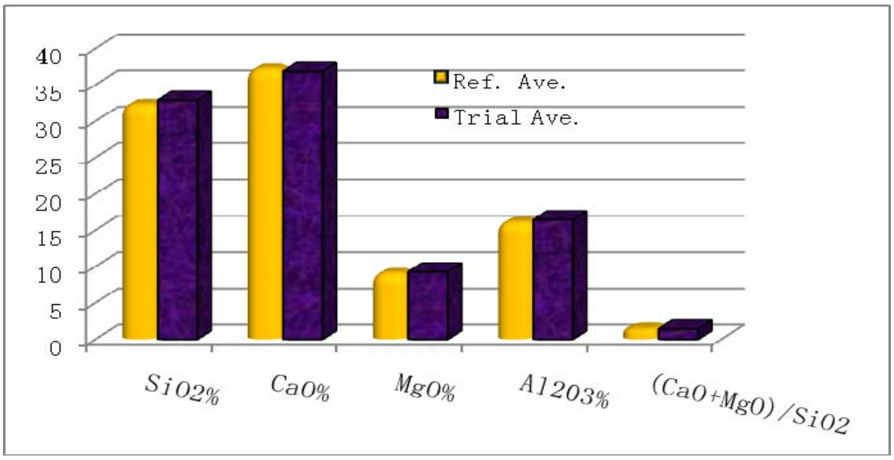

Figure 3. The comparison of slag composition between reference period and trial period.

The actual overall slag fluidity might be obviously improved, which could conclude from the phenomenon of “the BF hearth temperature had increased from 589℃ to 623℃ within ten days of the serpentine direct addition trial”.

The variation of hearth temperature (beneath ceramic cup and at the upper surface of carbon brick) is shown in figure 4. It was very clear that with time moved from the reference period to trial period the hearth temperature increased correspondingly, that indicated the hearth had become more active, hot metal and slag could be pushed out more completely. The hot metal temperature fluctuation was limited in a range of 1502-1508℃,that means the hot metal holding a sufficient thermal reserving.

ISSN 2176-3135

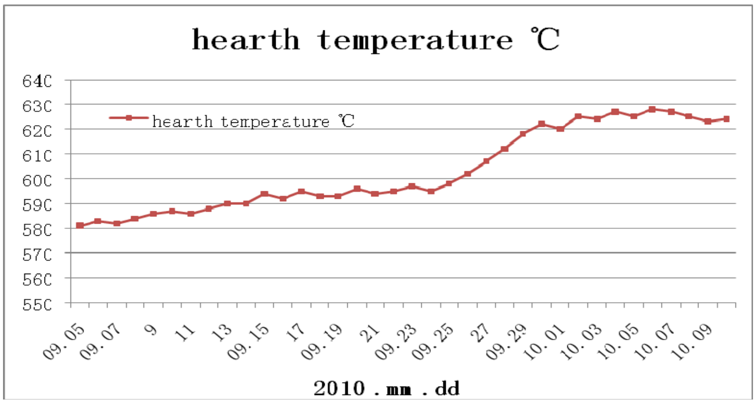

Figure 4. the variation of hearth temperature during reference period and trial

5 THE TRANSITION OF BLAST FURNACE PERFORMANCE DURING THE SERPENTINE ADDITION TRIAL

As outlined before, the MgO content in sinter had been decreased to a normal value of 2.18%, which contributed mainly to optimizing of sinter granularity configuration and that in turn would be helpful to realize a stable and consistent blast furnace operation during the industrial trial. The MgO values both in sinter with an average value of 2.08% and in slag with an average value of 9.28% satisfied the planned trial targets. Comparing with reference period, and with the exception of casthouse trouble and the limitation of using oxygen enrichment, the overall BF working situation had been partially improved during the trial: (1) the proportion of charged central coke decreased from 25% to 21% and which lead to an increment of gas utilization by 0.9%; (2) the activeness of the hearth process had improved, which caused by the tendencies of partially decreasing of slag viscosity and the partly increasing of enthalpy of hot metal and slag.

6 THE EXTENSION IMPACTS OF SERPENTINE ADDITION TRIAL ON BLAST FURNACE PERFORMANCE

As mentioned before the hearth working activity had significantly improved Because of the implementation of serpentine addition industrial trial. And the furnace performance had been obviously improved during the later portion of the trial: Blast volume rising gradually, iron slag liquidity modified. As a result, No.5 BF had effectively buffered the negative influence of hearth problem caused by raised Al2O3 in slag by about 0.7% in all of the production blast furnaces at WISCO during the first ten-days of October in 2010. And as a comparison, the productivity of #5 BF which once carried out the serpentine addition trial exhibited significantly higher than those #6BF and #7BF within the same period of time (see the Table13).

Table 13. Partial indexes' comparison on #5BF, #6BF and #7BF during the first ten-days of October

ISSN 2176-3135

BF No.	IV volume (m3)	Date	Daily Production	Productivity	AL2O3 in slag
			ton	t/m^3.d	%
5	3200	The first ten-day of Oct.	8549.52	2.672	16.59
6	3200	The first ten-day of Oct.	7682.25	2.401	16.78
7	3200	The first ten-day of Oct.	7895.27	2.467	16.78

6 CONCLUSIONS

Two industrial trials of serpentine direct addition in burden material and reduction MgO in sinter produced at #3 sintering machine, had been conducted during the third ten-day of Sep. in 2010. During the trial of reducing MgO content from around 2.9% to about 2.1%: the sinter grain size distribution improved, > 16 mm ratio increased by about 7%, 5-10mm decreased by some 4.5%, the yield increased by 1-2%, the return sinter was also reduced correspondingly. Meanwhile the blast furnace slag liquidity had gotten a markedly improved, and the hearth, gradually became active. The trialed blast furnace had maintained the stability and some main indexes of the BF improved obviously with the exception of casthouse troubles and some other affecting factors. Many useful trial data such as the blast furnace burden component, burden and gas distribution, slag fluidity variation related to different level of MgO in slag and slag temperature etc., which would be a valuable reference for the future using of direct charging of serpentine. Through the serpentine addition trial, #5 BF had effectively buffered the negative impacts of Al2O3 rise, and lead to a higher productivity than the other two furnaces with the same IV., during the following ten days after the trial.