metals

MDPI

Article

Comparison of Energy Consumption and CO_2 Emission for Three Steel Production Routes—Integrated Steel Plant Equipped with Blast Furnace, Oxygen Blast Furnace or COREX

Jiayuan Song [1], Zeyi Jiang [1,*], Cheng Bao [1] and Anjun Xu [2]

[1] School of Energy and Environmental Engineering, University of Science and Technology Beijing, Beijing, 100083, China; songjiayuan2015@outlook.com (J.S.); baocheng@mail.tsinghua.edu.cn (C.B.)

[2] School of Metallurgical and Ecological Engineering, University of Science and Technology Beijing, Beijing 100083, China; anjunxu@metall.ustb.edu.cn

* Correspondence: zyjiang@ustb.edu.cn; Tel.: +86-10-6233-2741; Fax: +86-10-6233-2741

Table S1. The chemical composition of ore in TGR-OBF process.

Name	TFe/%	S/%	CaO/%	SiO_2/%	Al_2O_3/%	MgO/%
Lump ore	63.50	1.00	1.81	3.50	2.38	0.62
sinter	66.59	0.04	0.04	2.97	1.02	0.05
pellet	65.83	0.02	1.23	2.72	0.45	0.17
Name	**MnO/%**	**P_2O_5/%**	**H_2O/%**	**Fe_2O_3/%**	**FeO/%**	**Σ/%**
Lump ore	0.09	1.50	1.00	85.00	3.10	100
Sinter	0.05	0.00	0.00	94.66	0.42	100
Pellet	0.02	0.00	0.00	94.04	0.00	100

Table S2. The chemical composition of flux in TGR-OBF process.

Name	TFe/%	S/%	CaO/%	SiO_2/%	Al_2O_3/%	MgO/%
Limestone	0.10	0.00	54.46	1.82	0.13	0.42
Dolomite	0.70	0.00	29.16	4.79	2.20	18.98
Name	**MnO/%**	**P_2O_5/%**	**FeO/%**	**Fe_2O_3/%**	**H_2O/%**	**Loss/%**
Limestone	0.00	0.00	0.0013	0.00	0.02	42.92
Dolomite	0.00	0.00	0.00	1.00	0.00	43.17

Table S3. The chemical composition of coal and coke in TGR-OBF process.

Name	Cfix/%	EA/%					Ash/%						H_2O/%
		C	H	N	O	ΣV	SiO	Al_2O_3	CaO	MgO	Fe_2O_3	ΣA	
Coal	54	71.1	4.76	1.25	49.5	33.19	51.5	30.9	3.2	1.25	3.62	12.81	5.00
Coke	87.18	86.55	0.08	1.02	0.21	1.45	46.6	36.1	4.99	1.32	6.96	11.37	5.00

Table S4. The chemical composition of hot metal in TGR-OBF process.

Composition/%	Fe	Mn	Si	P	S	C	Σ
Value	94.85	0.02	0.65	0.09	0.04	4.35	100.00

Table S5. The chemical composition of slag in TGR-OBF process.

Composition/%	SiO_2	CaO	Al_2O_3	MgO	MnO	FeO	S/2	Σ
Value	36.93	42.44	11.01	7.98	0.11	0.71	0.96	100.00

Table S6. The chemical composition of oxygen blast furnace gas in TGR-OBF process.

Composition/%	CO	CO_2	H_2O	H_2	N_2
Value	41.1	36.1	4.1	7.9	10.8

Table S7. Distribution rate of elements in slag, hot metal and gas (TGR-OBF process).

Elements	Slag	Hot Metal	TGR-OBF Gas
Fe	0.002	0.998	-
Mn	0.3	0.7	-
P	0	1	-
S	0.85	0.07	0.05

Table S8. The operating parameters of TGR-OBF process.

No.	Parameters	Value
1	Direct reduction degree	0.12
2	Oxidation degree of gas	0.05
3	Basicity of slag	1.15
4	Coke ratio/kg·t^{-1}	180
5	Coal ratio/kg·t^{-1}	260
6	The volume of recycled gas in bosh/m^3	300
7	The volume of recycled gas in hearth/m^3	300
8	Temperature of oxygen blast/K	298
9	Temperature of recycled gas in bosh/K	1073
10	Temperature of recycled gas in hearth/K	1073
11	Temperature of hot metal/K	1450
12	Temperature of top gas/K	473
13	The mass of hot metal/kg	1000

Table S9. The chemical composition of ore in COREX process.

Name	TFe/%	S/%	CaO/%	SiO_2/%	Al_2O_3/%	MgO/%
Lump ore	63.5	1.00	1.81	3.50	2.38	0.62
Ore fine	63.5	0.00	1.85	3.30	2.65	0.62
Name	**MnO/%**	**P_2O_5/%**	**H_2O/%**	**Fe_2O_3/%**	**FeO/%**	**Σ/%**
Lump ore	0.09	1.50	1.00	85.00	3.10	100
Ore fine	0.08	2.20	0.80	85.00	3.10	100

Table S10. The chemical composition of flux in COREX process.

Name	TFe/%	S/%	CaO/%	SiO_2/%	Al_2O_3/%	MgO/%
Limestone	0.10	0.00	54.46	1.82	0.13	0.42
Dolomite	0.70	0.00	29.16	4.79	2.20	18.98
Name	**MnO/%**	**P_2O_5/%**	**FeO/%**	**Fe_2O_3/%**	**H_2O/%**	**Loss/%**
Limestone	0.00	0.00	0.00	0.00	0.02	42.92
Dolomite	0.00	0.00	0.00	1.00	0.00	43.17

Table S11. The chemical composition of coal and coke in COREX process.

Name	Cfix/%	EA/%					Ash/%						H_2O/%
		C	H	N	O	ΣV	SiO	Al_2O_3	CaO	MgO	Fe_2O_3	ΣA	
Coal	**54.00**	71.10	4.76	1.25	49.50	33.19	51.50	30.90	3.20	1.25	3.62	12.81	5.00
Coke	87.18	86.55	0.08	1.02	0.21	1.45	46.60	36.10	4.99	1.32	6.96	11.37	5.00

Table S12. The chemical composition of hot metal in COREX process.

Composition/%	Fe	Mn	Si	P	S	C	Σ
Value	94.85	0.02	0.65	0.09	0.04	4.35	100.00

Table S13. The chemical composition of slag in COREX process.

Composition/%	SiO_2	CaO	Al_2O_3	MgO	MnO	FeO	S/2	Σ
Value	37.84	43.52	7.35	8.45	0.87	0.67	1.30	100.00

Table S14. The chemical composition of COREX gas in COREX process.

Composition%	CO	CO_2	H_2O	H_2	N_2	CH_4
Value	41.4	21.8	13.6	21.8	0.5	1.0

Table S15. Distribution rate of elements in slag, hot metal and gas (COREX process).

Elements	Slag	Hot Metal	COREX Gas
Fe	0.002	0.998	-
Mn	0.3	0.7	-
P	0	1	-
S	0.85	0.07	0.05

Table S16. The operating parameters of COREX process.

No.	Parameters	Value
1	Metallization ratio of DRI/%	90
2	Oxidation degree of gas	5
3	Basicity of slag	1.15
4	Temperature of hot metal/K	1450
5	Temperature of top gas/K	623
6	Temperature of reduction gas/K	1123
7	Temperature of raw gas/K	1323
8	Temperature of cooling gas/K	298
9	Temperature of oxygen blast/K	298
10	The mass of hot metal/kg	1000

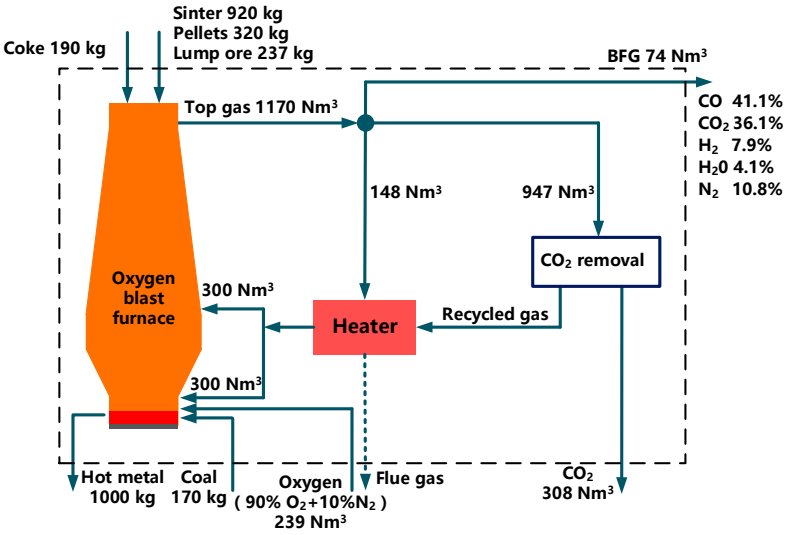

Figure S1. The parameters of TGR-OBF process.

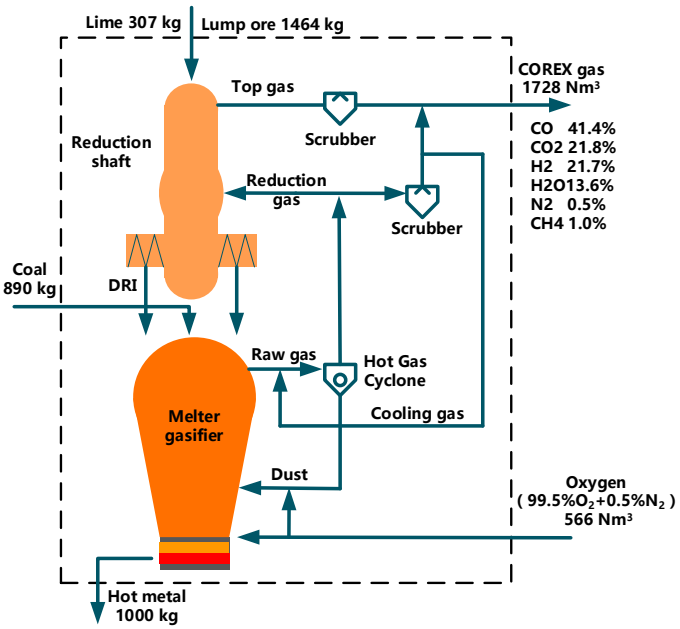

Figure S2. The parameters of COREX process.