A Preliminary Study on Pellet-Sintering of Chromite Fines

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Abstract

In this paper, the technological process of pellet-sintering of chrome ore fines is presented. The process is characterized by low cost, good strength and uniform size of pellets. The pellet-sintered ores produced can be used in the smelting of high-carbon ferrochromium in place of the original lumpy ores. The results are of great significance to the improvement of both economical and technical indexes as well as economic benefits.

1. Introduction

With the decrease of the supply of Cr lumpy ores in the international market year by year, ferroalloys manufacturers have had to use ore fines more and more. Compared with lumpy ores, ore fines are of extensive origins and low costs. However , they have to be processed into lumps before fed into the furnace.

At present , the commonly used method for processing Cr ore fines consists of briquetting and pelletizing. Pelletizing is further divided into cold-hardening and pre-reduction. In the briquetting process ore fines with sizes less than 6 mm can be used; nevertheless, in the pelletizing process the ore fines must be ground beforehand in order that the particles of 200 mesh size constitute over 80% (for annular kilns, over 60% is allowable).

In 1995, the ferrochromium market turned bright. Therefore, the two silico-manganese furnaces in Zunyi Ferroalloys Co. were switched over to smelt high-carbon ferrochromium. Cr ore fines and Cr ore concentrates were imported. Unsuitable to be directly fed into the furnace, these ores had to undergo pelletizing treatment. By using a 80m² belt-type sintering machine (cooling on machine) originally used for treating Mn ore concentrates and drawing on the mature experience of pelletizing of Mn ore fines, success was achieved by using composite binding agent, promoting the solid reaction of sintering of pellets and controlling the sintering temperature.

During the two months of May and August in 1995, 15469 tons of high quality pellet-sintered Cr ores satisfying the demands of electric smelting were produced and used in the production of high carbon FeCr.

The characteristics of the technology are that Cr ore fines which are difficult to be briquetted can be processed into pellets on the existing equipment in the pelletizing shop by addition of specially made composite binding agent and by use of special pelletizing technology and control of sintering temperature. The pellet-sintered ores are of uniform sizes, pressure resistant strength over 650 N per pellet and rotating drum index $>$ 78%. Smelting of the pellet-sintered ores in electric furnace has shown that it can be used in place of lumpy ore completely.

2. Properties of main raw materials

Cr ores used in pellet-sintering are Indian Cr ore fines and South African Cr concentrates. Additives are bentonite and organic binder. Fuels consist of producer gas and coke breeze.

For compositions and sizes of various raw materials, see Tables 1, 2 and 3.

Table 1 Composition of Cr ores and bentonite, %

Raw materials	Cr_2O_3	Fe	SiO_2	CaO	MgO	Al_2O_3	S	P
Indian Cr ore fines	46.89	12.9	5.89	0.43	9.12	12.51	0.0196	micro
SA Cr ore concentrate	43.75	19.38	3.32	0.51	7.89	12.21	0.022	micro
Bentonite		2.10	60.26	3.12	4.30	15.59		

Table 2 Chemical composition of coke breeze, %

Raw materials	Fixed C	Volatiles	Ash	S	in ash		
					CaO	SiO_2	Al_2O_3
Coke breeze	63.65	5.55	30.8	1.22	6.38	49.95	23.14

Table 3 Distribution of particle sizes of raw materials (mm), %

Raw materials	>3	3—1	1—0.246	0.246—0.125	0.125—0.074	<0.074
Indian ore fines	21.70	20.15	10.31	11.42	16.18	20.24
SA ore concentrate			1.06	98.45	0.49	
Bentonite						100
Coke breeze	11.40	62.75	9.19	8.92	3.60	4.14

3. Main equipment for pelletizing

φ1100×600 mm heavy duty mixer
φ5000mm disk pelletizer
Roller type screen
Roller type distributor
80m² belt type sintering machine
Ignition furnace
310 kW and 381kW tandem type aspirator
220 kW heat recovery fan
570 kW blast cooling fan
Single roll crusher
Plate conveyor
Vibrating screen

4. Technological conditions

Flow process of pellet-sintering of Cr ore fines (see Fig. 1).

4.1 Technology of pellet-sintering of Cr ore fines

In many countries Cr ore fines prior to pelletizing should undergo grinding to produce particles passing through 200 mesh sieve at a percentage of over 80%. Indian ore fines used in our plant passing through 200 mesh constitute just 20.24%

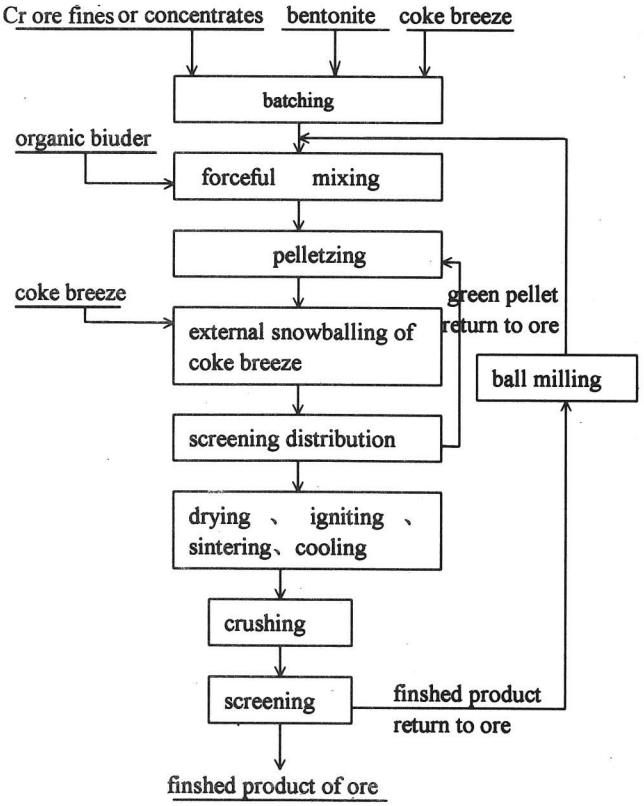

Fig.1 Flowsheet of pellet sintering of Cr ore fines

and more than 98% of South African Cr ore concentrates is of the size 0. 246-0. 125 mm. They are far from the conditions required for pelletizing. In connection with these features, we adopted the following steps:

4. 1. 1 Use of organic binders (organic polymer solution): In addition to a certain proportion of bentonite, a small amount of organic binder solution is also added to facilitate the pelletizability of the materials.

4. 1. 2 Use of φ1100 × 600 mm heavy duty mixer: With continuous rotation of shaft equipped with rakes and addition of organic binders solution and a certain amount of water, a thorough mixing of materials is obtained. The water content in the mixture is controlled within 8—9%.

4. 1. 3 In connection with the high hardness of Cr ores, the pelletizer was reformed into ceramic bottom plate and casting-stone fixed scraper. Strong magnetic descaler was installed in the water addition device. For the effects on pelletizing, see Table 4. Diagram of flow-sheet of pellet-sintering of Cr ore fines.

Note: Inspection of quality of green pellets carried out after sieving .

Table 4 Quality index of green pellets

Ore	Water content %	size			Falling strength (times/pellet)	Pressure resistance (N/pellet)
		6—12 mm, %	12—20 mm, %	>20 mm, %		
Cr ore fines	11. 9	42. 23	50. 34	7. 43	12. 5	5. 4
Cr ore concentrate	12. 6	57. 51	39. 75	2. 74	11. 8	4. 8

4. 1. 4 Separate addition of solid fuels: After sieving, coke breeze is partly delivered into bin of burden-proportioning room and partly to the bin of external snowballing. Externally snowballed coke breeze was added through 1. 5m disc feeder. The amount of feeding is realized by control of adjustable speed electric motor. The place for the addition of externally snowballed coke breeze is inside the disc pelletizer after the pelletizing treatment, i. e. , the qualified green pellets produced will enter again the disc pelletizer for external snowballing. The amount constitutes about 90% of the total of coke breeze. Since most of the coke breeze are located in the outer layer of green pellets or between the pellets, the combustion of coke breeze is both complete and rapid which is very favorable to the high temperature sintering of Cr ores.

4. 2 Essentials of the technology of pelletizing of Cr ore

Some unfavorable factors exist in the pellet-sintering with 80m² belt-type sintering machine, such as low negative pressure on the aspirator (6500Pa) and thin layer of burden for sintering. In order to improve the metallurgical performace of the pellets and the percentage of qualified products, great attention was paid to the following practices:

4. 2. 1 Strictly control the amount of organic binders added and water content of mixed materials. Make good use of heavy duty mixer to promote thorough mixing. Water content is controlled within 8-10% prior to pelletizing.

4. 2. 2 Enhance the pelletizing operation to improve the quality of pellets. The size of green pellets should be controlled within 6 — 20 mm. The water content in the green pellet should be controlled less than 13%.

4. 2. 3 Strictly control the amount of coke breeze added according to the proportioning in order to reduce fluctuation.

4. 2. 4 Strictly control the temperature of drying at <350 C , temperature of ignition at 1250 C.

4. 2. 5 Reasonably control the motor speed and the height of spreading of burden : motor speed 0. 6 — 1. 0 m/min, height of burden layer 150—200 mm.

4. 2. 6 Control well the end point of pellet sintering. The temperature of exhaust gas from 10 # bellow should be >300 C.

5. Performances and characteristics of pelletized ores

The pelletizied Cr ore is of grape-shaped spherical structure. It keeps not only the external appearance of pelletized ores, but also the structural characteristics of sintered ores. It is also of uniform size and good reducibility. Moreover, its strength is capable of meeting the requirement of smelting in electric furnace. For the technological indexes and quality features, see Table 5 and Table 6.

Table 5 Main technical indexes of pellet sintering

Item	Pellet sintering of Cr ore fines	Pellet sintering of Cr ore concentrate
Utilization coefficient t/m2h	0.35	0.34
Pressure resistance N/pellet	800	650
ISO rotating drum exponent %	79.56	78.32
Energy consumption kg st. coal/t	63.5	65.4
Height of burden layer mm	200	200
Particle size of pellet (6—12mm) %	94.51	93.54

6. Result of use of pellet-sintered Cr ores

The success brought out by the use of pellet-sintering technology in the processing of Cr ore fines has solved the difficult problem of directly feeding the fines into the furnace. Considerable amounts of Cr ore fines and ore concentrates can be treated with the sintering machine using the technology of pellet-sintering.

Comparison of the results of smelting in a 9000 KVA electric furnace from April to December in 1995 has shown that the pellet-sintered Cr ores are of reasonable structure and uniform sizes and is capable of smelting to high C FeCr in place of the original lumpy ores. Compared with the production using original lumpy ores with addition of ore fines or using ore fines with addition of ore concentrates, many economical and technical indexes of production using addition of pellet-sintered ores are improved with varying degrees, such as recovery of metals, power consumption of smelting, etc. (see Tab. 7)

Table 6 Characteristics of pellet-sintered Cr ores

Ore	Cr2O3 %	Fe %	S %	Shape
Indian Cr ore	46.28	12.54	0.018	Grape
SA Cr ore	39.25	16.53	0.030	Grape

Table 7 Production quota of high C FeCr in 9000 KVA electric furnace

Date	Ore fines used(kg/t)	Ore conc used (kg/t)	Lump ore used (kg/t)	Pellet used (kg/t)	Recovery(%)	Power(kWh/t)
April	1060		1065		81.60	3778
May	780		702	385	90.70	3574
June	643		786	644	85.83	3333
July	1212			682	87.18	3127
Aug	821		361	1037	81.43	3604
Sept		214	2078	82	79.56	3690
Oct		861	1393	155	77.31	3636
Nov		1024	1068	480	71.04	3500
Dec	721	1879			70.40	4458

7. Discussion

7.1 Selection of binder

During the experiment of pelletizing, the use of bentonite as binder is very ideal for the Indian Cr ore fines, However, it is not so in the case of South African ore concentrates. Through repeated trials, adjustment of the proportioning of bentonite, improvement of heavy duty mixer and pelletizer, use of magnetized water and choice of organic binders, the effect of pelletizing the South African ore fines is greatly improved and the strength of green pellets is greatly enhanced; yet it still falls short of the effect of pelletized Indian ore fines. The authors consider that the amount of addition of bentonite and the choice of organic binder and its amount of addition are the keys to the effect of pelletizing of South African Cr ore concentrates.

7.2 Characteristics of hardening of pellets

Cr oxide in the original Cr ore is a high melting point substance. During the process of sintering of pellets, the large amount of heat evolved from the combustion of coke breeze causes the solid reaction between SiO_2 in the binder (and ore) and Cr oxides or Fe oxides, forming Cr_2O_3-SiO_2 or FeO-SiO_2 eutectics and producing a certain amount of liquid phase to endow the pelletized ores with a high strength.

7.3 Control of temperature of sintering

During the process of sintering of pellets, control of suitable temperature in burden layer to harden the pellets as much as possible is very crucial. The main steps taken are that during the sintering by aspiration adjust the amount of addition and the way of addition of coke breeze. The proportioning of coke breeze is 5—8% in excess of theoretical amount by calculation.

The way of addition of coke breeze is that 10% is added in the burden room, i. e., internal proportioning; 90% is snowballed after pelletizing to make it evolve sufficient heat to meet the requirement of sintering (see Table 8). At the same time, since 10% of coke breeze is added inside the pellets to form a relatively uniform mixture of coke breeze and ore fines, a uniform porosity is easily produced inside the pellets, thereby promoting the reduction reaction of pellet-sintered Cr ores in electric furnace.

Table 8 Result of measurement of temperature in burden layer

Ore	T_{max}(℃)	
	Middle of burden layer T_{max}(℃)	Bottom of burden layer
Pellet-sintered Cr ore fines	1350	1342
Pellet-sintered Cr ore concentrate	1305	1302

8. Conclusion

(1) The technology of pellet-sintering Cr ore fines (or Cr ore concentrates) is technically feasible, the advantage being high rate of qualified products, good performances of pellets and low power consumption.
(2) To ensure the steadiness of the process and improve the quality of pellets, the proportion of coke breeze should exceed the theoretical amount by 5 — 8%, among which 10% for internal proportioning, 90% for external snowballing. Control of ignition temperature at 1250 C is suitable.
(3) The pellet—sintered Cr ores produced by this technological process are of good strength, uniform size and good reducibility, capable of replacing the original lumpy ores and improving economical and technical indexes of smelting.