Design and Application of the Dry-FGD Process in Sanming Steel No.2 Sintering Plant

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Abstract: In this paper, it summarizes the characteristics of sinter flue gas, and study the application of dry-type-FGD (flue gas desulphurization) process for Sanming Steel Co., Ltd. No.2 sinter plant flue gas treatment. This project has become a successful example for sinter flue gas desulphurization in steel industry.

Keywords: sinter flue gas, dry-type-FGD, application

1 INTRODUCTION

Through demonstrating and comparing the different scheme of FGD, Sanming Steel Co., Ltd. decided to adopt the dry-type-FGD process which designed by Longking Ltd. for its No.2 sinter plant sized 180 m^2[1].The designing work of this project was started in January 2007. In late May commencing to construct, and the FGD plant went into work completely at 18th October 2007. The dry-type-FGD plant perform well that desulphurization efficiency is higher than 91%, best at 98%, SO_2 emission less than 400 mg/m^3 and dust less than 50 mg/m^3, Each capacity target is better than designed one. Being one of the pivot FGD projects monitored by Environmental Protection Department of the province, it can reduce about 4000 t/a SO_2 emission after adding dry-type-FGD plant. It also became a successful example of sinter FGD in steel industry.

2 CHARACTERISTICS OF SINTER FLUE GAS AND DECISION OF THE SCHEME

As a kind of waste gas, sinter flue gas is generated when mixed sinter fired and sintering to shape under high temperature. Its features is showed as follow[2]:

- High temperature. It varies from 120 ℃–180 ℃ according to the different state of sintering process.
- Hold more dust, which mainly constituted of metal, metal oxide or incompletely burnt matters.
- High humidity. in order to improve the ventilation, the mixed sinter must be made into small balls with adding some water, therefore the humidity of the ash gas is higher, about 10%–15% with volume ratio.
- Contain erosive gas. It can generate some HCl, SO_x, NO_x and so on both in the process of goal gas fired in blast furnace and mixed material sintering to shape.
- Contain heavy metal pollution.

Sanming Steel Co., Ltd. took 4 times to measure every bellow of sinter plant in March 2007.The data is list in Table 1.

Table 1 Data of bellows in sinter plant

No.	SO_2 /mg·m^{-3}	Volume flow /Nm^3·h^{-1}	Dust /mg·m^{-3}	Temperature /℃	Flow rate m·s^{-1}	Weight of SO_2/kg·h^{-1}
11	106	10092	79.21	108	12.42	1.06
22	107	35018	86.24	107	13.44	3.74
33	164	36836	61.38	106	15.4	6.04
44	174	28002	84.28	93	8.89	4.88
55	1998	25614	81.65	91	8.94	51.18
66	3377	24234	101.51	93	8.71	81.84
77	4467	24188	198.77	86	6.24	108.04
88	7459	17704	315.16	94	7.76	132.06
99	9848	16144	332.79	108	9.37	158.98
110	8638	16778	375.67	160	9.72	144.92
111	7076	22518	385.54	298	13.01	159.34
112	5603	20596	418.81	395	15.36	115.40
113	3051	19634	351.44	409	11.61	59.90
114	988	19470	264.03	372	14.76	19.24
115	673	30052	249.23	317	22.72	20.22.

From the table we know: the average concentration of SO_2 emission from sinter plant is 3076 mg/m^3 .it presents the SO_2 concentration of gas higher in middle bellows than the ones in two poles of the sinter plant with 15 bellows in all. As bellows in two poles No.1–No.4, No.14 and No.15, whose average SO_2 concentration is just 346.1 mg/m^3, account for 46% flue gas, but it take 5.17% SO_2 emission of all; No.5–No.13 bellows ,whose average SO_2 concentration is 5398.2 mg/m^3, account for 54% flue gas and 94.83% SO_2 emission.

Owing to the SO_2 concentration vary from different bellows, two schemes of sinter FGD were drew, which were full desulphurization and selective desulphurization. The late scheme means the different SO_2 content flue gas is separately introduced into two ESP by setting two flue and two exhaust fans with number 2 and 3. The high SO_2 content flue gas from No.5–No.13 bellows is introduced into FGD system though No.2 exhaust fan, meanwhile the other flue gas is directly exhaust to chimney after ESP cleaning. Through a series of comparing the technically and economic advantage of two schemes, the selective desulphurization was chosen eventually. At the same time , the dry-type-FGD process of Longking was considered suitable for sinter FGD, with features of high efficiency, costless, reliable, standless, without waste water, byproduct easy to treat with and so on.

3 PRINCIPAL AND PROCESS OF DRY-TYPE-FGD FOR SINTER FLUE GAS DESULPHURIZATION

3.1 Principal

Dry-type-FGD is a process suitable for sinter FGD, which was developed by Longking based on the technic introduced from LLAG Ltd. Of Germany. The basic principal is[3]: Entering and being accelerated in the venturi shaped nozzles at the bottom of circulating fluid bed absorber, the flue gas react with the added absorbent and water, thereby harmful substances such as SO_x, HCl, HF, CO_2 in the gas is removed. After being accelerated when get through the venturi shaped nozzles, absorbent and recirculated desulphurization products carried by the flue gas is suspended and stirring heavily. So that there is maximal slip velocity between solids and flue gases. The reactive interface of solids have been renewing during solids scrubbing and hitting with each other, what strengthen the optimal heat and mass transfer behaviour within the circulating fluid bed absorber. See Fig. 1. Layout of the sinter FGD system of Sanming Steel Co., Ltd.

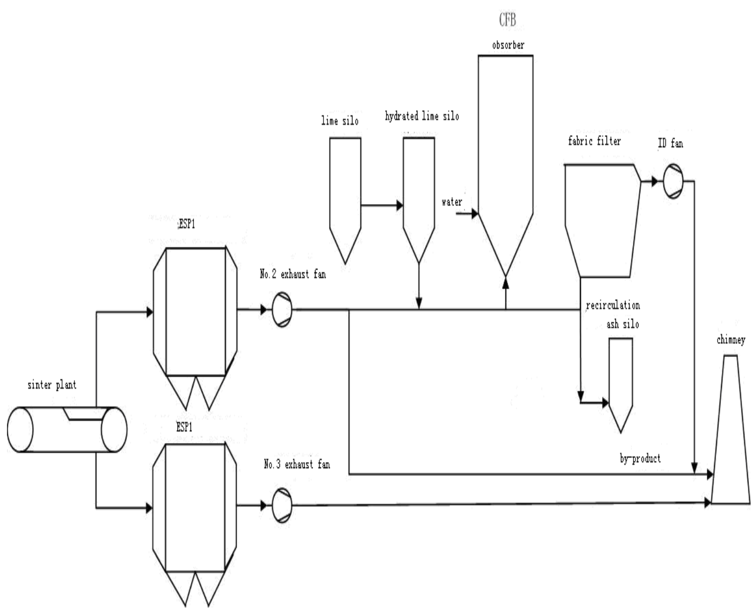

Fig. 1 Layout of the sinter FGD system of Sanming Steel Co., Ltd.

3.2 Design Conditions

(1) The parameters of the flue fas from the outlet of No.2 exhaust fan

Sanming Steel Co., Ltd. chose dry-type-FGD process for its flue gas from No.2 exhaust fan of sinter sized 180 m^2. The parameters are shown in Table 2.

(2) Quality of the absorbent

Lime used as the design basis for the dry-type-FGD system is expected as:

particle size ≤1 mm
purity ≥70%
reactivity (t60) ≤4 min (according to standard DIN EN459 -2, t_{60} = time in minutes when wet slaking curve reaches 60 ℃)

Table 2 The parameters of the flue gas from the outlet of No.2 exhaust fan

Parameters at FGD inlet	Value
Temperature /℃	120−180, highest 240
Relative pressure at /Pa	□500
Dust (st. dry)/mg·m^{-3}	50
Volume flow (st. wet)/m^3·h^{-1}	530000×0.55
Vapor/%	10−15

Parameters at FGD inlet	Value
SO_2 (st. dry) /mg·m^{-3}	5000
Runtime per year /h	7500

3.3 Design Data

Design data for FGD plant is list in Table 3.

Table 3 Design data for FGD plant

Items	Value
Guarantee efficiency /%	90
SO_2 concentration at inlet /mg·m^{-3}	5000
SO_2 concentration at outlet /mg.m^{-3}	400
Dust concentration of clean gas /mg·m^{-3}	50
Ca/S	1.3
Pressure drop of FGD plant /Pa	3800
Temperature of clean gas /℃	75
Power consumption (including ID fan) /kW	1056
Water consumption /t·h^{-1}	19.4
Lime consumption /t·h^{-1}	2
Ash output /t·h^{-1}	3.6
System useableness /%	98
air leak of FGD /%	≤5
Noise of equipment /dB (A)	≤85
Life of FGD system/year	30

3.4 Plant Description

The FGD plant is placed between the main road next to chimney and the path for glomeration workshop. The absorber and absorbent silos which ride above the main road of the factory are hold with steel girders on the concrete flat roof. The length between two girders is 8 meters. The distance from the top of flat roof to floor is 7 meters with 5.5 meters net height, which can satisfy the needs of the main road for traffic. Fabric filter lays linearly with the absorber, the flat level of whom is consistent with the absorber's. Some of equipment like fluidizing blowers can be put in the room between flat and floor. The ID fan lays on the floor and the control building on the second floor roof. Most assistant equipment, such as water system and absorbent preparation, surround the absorber. The arrangement of each equipment considers independent as well as reasonable disposal to furthest save the area. Here is the photo of the FGD plant (see Fig. 2).

Fig. 2 Photo of the FGD plant for the Sanming Steel Co., Ltd. Sinter flue gas treatment

3.5 Operation Condition and Expense

(1) Operation features of the system

Two prominent points of the FGD function are: Firstly, unlike lime serum and absorbent from humid hydrator which carry lots of water in order to adapt to the different SO_2 concentration, the absorbent and water is added to the CFB absorber independently, and is controlled separately. Water carried into the reactor by absorbent can't vapor in short time, the result of what the humidity of flue gas is increased, equipment downstream the absorber is easy to erode and the fabric filter will paste bags.

Second, when using a clean gas recirculation at a partial load of the CFB-FGD of less than 70 % of the designed load, the ID fan will be regulated by the pressure upstream of the absorber and the control damper in the recirculation gas duct will be open, by this the volume flow in the absorber is regulated under different raw gas flow load, moreover the fluidized bed layer built in the absorber is unchanged. The using of the clean gas recirculation make it possible that the FGD system operates by itself, which especially suits for situation that sinter plant accidentally out of work. The sinter flue gas will directly exhaust to chimney through bypass duct when an emergency and accident occurs.

The Distribute Control System menu of the FGD process for Sanming Steel Co., Ltd. is shown in Fig. 3.

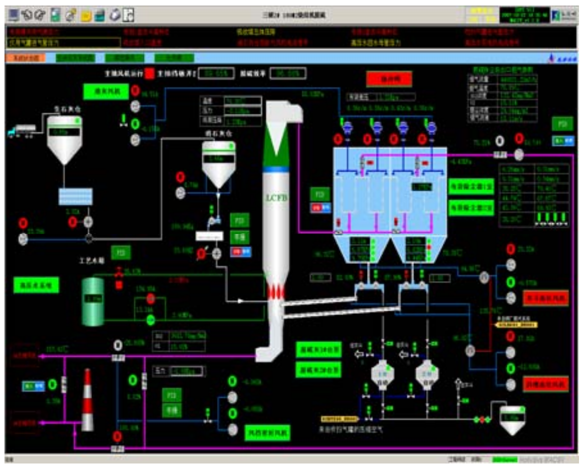

Fig. 3 The DCS menu

(2) The operation of the FGD

The sinter flue gas desulphurization system for Sanming Steel Co., Ltd. was successfully pass the 240 h examination in October 2007.The average emission of SO_2 is less than 400 mg/m^3,and efficiency states above 90%. There is the records of the system operation under different conditions. See Table 4.

Known from the record, performance of the FGD system is better than design one.

3.6 Cost

The operation cost of the FGD system is shown in Table 5.

Table 4 Records of the FGD system operation

Item	Situation 1	Situation 2	Situation 3	Situation 4	Situation 5
Volume flow at inlet /$m^3 \cdot h^{-1}$	346456	336218	369496	440831	331256
SO_2 at inlet /$mg \cdot m^{-3}$	4772	3896	4236	3986	5061
Emission SO_2 /$mg \cdot m^{-3}$	389	372	361	132	421
Emission Dust /$mg \cdot m^{-3}$	30.04	29.86	31.56	29.04	34.69
Temperature at absorber inlet /℃	142.72	144.59	147.01	157.62	139.09
Temperature at absorber outlet /℃	76.72	74.59	77.01	76.89	74.09
Flue gas load /%	89.11	83.96	80.86	89.65	84.02
Drop pressure of fluid bed /kPa	1206	1056	1251	1230	1306
Efficiency /%	91.84	90.45	91.48	96.68	91.68

Table 5 The operation cost of the FGD system

Items	Value	Remarks
Engineering investment/ten-thousand yuan	About 3000	Including the cost of ESP1, Civil engineering and installation
Lime consumption /$t \cdot h^{-1}$	1.5−1.7	Lime cost 200 yuan/t
Water consumption /$t \cdot .h^{-1}$	19.4	Water cost 0.22 yuan/t
Power consumption /$kW \cdot h^{-1}$	1056	Including ID fan, the price of power about 0.45 yuan /kW·h
Runtime per year /h	7500	
Payment /ten-thousand yuan	14.4	4 workers , and 36000 for each one per year
Depreciation /ten-thousand yuan	100	According to 30 years
Efficiency /%	90−98	
Operation cost per year / ten-housand yuan	700	Including depreciation, examine and repair and payment

4 CONCLUSIONS

The successful operation of this FGD project has reduced the average SO_2 emission from 5000 mg/m^3 to 400 mg/m^3 or less, and has greatly eased the air and environmental pollution. It indicates that dry-type-FGD technology of Longking is reliable and available, and it is also an important step for Sanming Steel Co., Ltd to reduce SO_2 emission in steel sinter industry.

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