Practice on the Application of Electrostatic Dust Filter for the Fumes of FeMn Furnaces

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Abstract

In this paper the operating practice of application of electrostatic dust filter to fume removal in ferroalloy furnaces is described. Performances of the filter, properties of fumes, technological flow process of furnace gas cleaning and results of fume removal are also presented, thereby illustrating that electrostatic filter is the best device for fume removal which opens up a new route for the treatment of gaseous effluents from feroalloy furnaces.

1. Introduction

Enormous volume of fumes and dusts are generated in the production of ferroalloys, not only polluting the environment, but also jeopardizing the health of the operating people. The two methods of treatment of fumes and dusts with dry bag filter and wet venturi scrubber have their respective advantages and disadvantages.

Cooperating with Anshan Research Institute of Electrostatic Techniques, our plant used the electostatic filter for the treatment of fumes from high C FeMn and SiMn furnaces. Experimental results have shown that the filter can also be used in the case of other ferroalloys to meet the requirement of discharge standard.

In 1989, a set of electrostatic filter equipment was installed on a 12. 5 MVA semi-closed furnace in our plant. Practice from running over several years have shown that the electro-static filter is a device of high efficiency, low power consumption, safe and reliable operation, easy maintenance, long life and without secondary pollution. It proves to be the best way for fume removal from ferroalloy furnaces and can be spread to the whole trade of ferroalloys.

2. Characteristics and analysis of dusts in furnace gases

2. 1 Amount of furnace gas

The amount from 12. 5 MVA semi-closed furnace from measurement is 40503 Nm^3/h in the case of high C FeMn and 38062 Nm^3/h in the case of SiMn.

2. 2 Dust concentration in furnace gas

The dust concentration is mainly determined by the conditions of raw materials, smelting and temperature of gas, generally with large fluctuations. From measurement the dust concentration is 4000-4800 mg/Nm^3 in the case of high C FeMn and 1700-2300 mg/Nm^3 in the case of SiMn.

2. 3 Temperature and moisture content of furnace gases

The highest temperature of furnace gases from semi-closed FeMn and SiMn furnaces is around 500℃; the moisture content is 1-2% (vol.). The temperature and moisture content directly relate with the thickness of burden layer and the moisture content of raw materials.

2.4 Characteristics and analysis of the dust in furnace gases

The physico-chemical properties of dusts in furnace gas will determine the measures to be taken and the results of dust removal. For various parameters of fumes and dusts in the cases of FeMn and SiMn, see Tables 1, 2, 3 and 4; for the curves showing the relationship between the specific resistance of fumes and temperature, see Fig. 1.

From the above data, it can be gathered that the characteristics of these fumes are lightness and fineness, low density, uneasy sedimentation, strong cohesiveness and relatively strong adhesiveness on metals or textiles. The dust in the high temperature furnace gas is inclined to be of high specific conductance. The dust is also difficult to pile up and to remove.

Table 1 Physico-chemical properties of dusts

Ferroalloy	True sp. gr. (g/cm^3)	Apparent sp. gr. (g/cm^3)	Average radius of particle (μm)	Specific surface area (cm^2/g)	Resting angle	Property of ppt in water (mm/mln)
HC FeMn	2.9	0.895	5.05	7402.8	53	0.861
SiMn	3.0	0.654	3.24	8467.5	58	0.623

Table 2 Chemical composition of fumes (%)

Ferroalloy	MnO	SiO_2	Fe	CaO	MgO	Al_2O_3	P
HC FeMn	25.65	23.00	2.00	6.73	4.19	4.30	0.048
SiMn	14.94	21.70	4.00	4.48	3.68	5.10	0.110

Table 3 Distribution of sizes of dust particles (μm), %

Ferroalloy	>50	50-40	40-30	30-20	20-10	10-5	5-3	<3
HC Mn	0	5.8	5.7	6.4	5.4	3.8	57.1	15.8
SiMn	0	14.2	1.1	1.6	1.9	3.0	32.9	45.3

Table 4 Specific conductance of dusts ($\Omega \cdot cm$)

Temperature (℃)	HC FeMn fume	SiMn fume
Room temperature		5.91×10^{8}
50	1.17×10^{11}	8.45×10^{9}
75	1.31×10^{11}	2.29×10^{10}
100	1.06×10^{12}	3.46×10^{11}
125	2.27×10^{12}	2.86×10^{11}
150	2.79×10^{12}	2.46×10^{11}
175	3.77×10^{12}	1.10×10^{11}
200	5.89×10^{12}	5.00×10^{10}
225	7.58×10^{12}	1.70×10^{10}
250	1.39×10^{13}	3.64×10^{9}
275		1.76×10^{9}
300		5.48×10^{8}

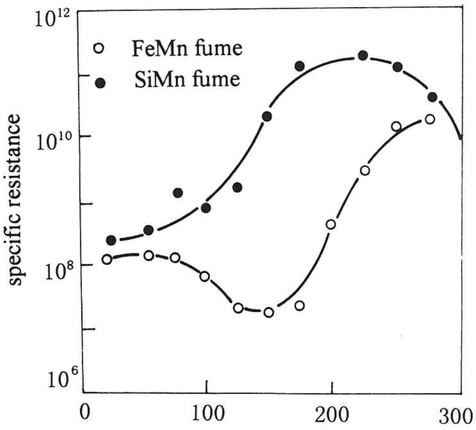

Fig. 1 Relationship between specific resietance of fume and temperature

3. Operating characteristics of electrostatic filter

The charateristic is that an electrostatic field strong enough to ionize the gas between two metallic electrodes with two different radiuses of curvature is maintained by applying high DC voltage. The electrons, positive and negatives ions resultant from the ionization of gases adhere to the dust particles passing through the electric field and transform the dust into charged particles.

In order to raise the efficiency of electrostatic filter, based on its operating principles, 4 electrostatic fields were taken into consideration in the designing and also the techniques of precharge electrostatic precipitation and alternately changing of distance between electrodes were used. The first 2 fields are mainly for precharge electrostatic precipitation and the last 2 fields are mainly for cleaning fine fumes of high specific resistance.

Fumes from ferroalloy furnaces are of such small partic le size (the average being 2. 15-5. 05mm) and of such high specific resistance that it is not easy to recover them. After precharge electrostatic precipitation, the radius of particulate matter increases by 20-50 times, which greatly increases the air gap in the dust layer of dust collecting electrodes, resulting in the lowering of specific resistance and thus raising the efficiency of dust collection.

4. Flow process of fume removal with electrostatic filter

Large quantities of high temperature furnace gas generated from ferroalloy production first pass through the water-cooled flue and air-cooled heat exchanger to lower the temperature to below 300℃ and then enter the electrostatic filter for dust collection. The cleaned gas whose dust concentration has been reduced to acceptable levels is transported by a drawing fan to the chimney to vent. The collected dust after being vibrated and knocked by a vibrating and knocking device on the electrode plates falls down into a bucket and is delivered to the sinter shop to be sintered into ore sinters and returned to smelting. The flow process is illustrated in Fig. 2.

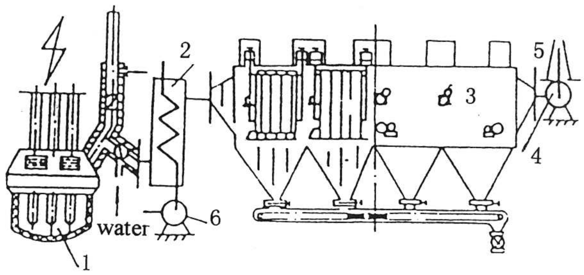

Fig.2 Schematic diagram of electrostatic dust filter on a 1.25MVA furnace

1	furnace	4	aspirator
2	heat exchanger	5	chimney
3	lectrostatic filter	6	force fan

5. Main technical parameters of electrostatic filter

For the parameters, see Table 5.

Power consumption of the system: drawing fan motor 75kW; air-cooled heat exchanger fan motor 45kW; rocking arm hammer mechanical vibrating and knocking motor 0. 5kW × 4 = 2kW, totalling 122kW.

6. Result of dust collection with electrostatic filter

After putting into operation and running for several years, it is proved that the effect of the filter is obvious, efficiency reaching 97-99% and dust concentration being reduced to below 100 mg/Nm^3 which is lower than the discharge standard stipulated by the State. For the result of operation, see Table 6.

Table 5 Main technical parameters of electrostatic filter

No.	Name of item	Unit	Amount
1	Amount of fume	m^3/h	78000
2	Fume temp at inlet	℃	250-350
3	Electric field type		Dry, horizontal, single chamber, 4 fields, steel body
4	Effective cross section area of field	m^2	24
5	Air velocity in field	m/sec	0.9
6	Distance between electrodes	mm	300-400
7	Type of dust-collecting electrode		C480
8	Type of corona electrode		Star type line
9	Effective dustcollecting area	m^2	2765.4
10	Driving speed	cm/sec	3.8
11	Retention time of fume in the field	sec	17.8
12	Type of vibration-knocking		Rocking arm hammer, mechanical
13	High voltage power supply, (voltage)	kV	72、100
14	High power supply, (current)	mA	400、600
15	Efficiency of fume removal	%	98.5
16	External size	mm	27920x7500x13570
17	Total weight	t	157

Table 6 Effect of fume removal for high C FeMn andSiMn

No.	Name of item	Unit	HC FeMn	SiMn
1	Furnace gas amount at inlet	Nm^3/h	40503	38062
2	Furnace gas amount at outlet	Nm^3/h	45753	46262
3	Furnace gas temp at inlet	℃	220	190
4	Furnace gas temp at outlet	℃	170	160
5	Fume conc at inlet	mg/Nm^3	4404.3	2005
6	Fume conc at outlet	mg/Nm^3	97.2	60.1
7	Fume flow at inlet	kg/h	178.39	76.4
8	Fume flow at outlet	kg/h	4.67	2.48
9	Gas flow speed at inlet	m/sec	41.76	50.7
10	Gas flow speed at outlet	m/sec	18.31	19.9
11	Ambient temp	℃	17	25
12	Efficiency of dust collection	%	97.37	96.4

7. Technical and economical analysis

7.1 Under the condition of normal running of high voltage electrostatic equipment, the efficiency is generally between 97-99%. In the case of high dust content, the discharged concentration at the exit is 43 mg/Nm^3 and 97.2 mg/Nm^3.

7.2 Owing to the high specific resistance and fineness of fumes, reverse ionization occurs frequently, exerting serious influence on the efficiency of fume removal and stable running of equipment. For this reason, precharge electrostatic precipitation and alternately changing of the distance between electrodes for the purpose of enhancing the adaptability to the dust concentration of different kinds of fumes and dusts were used in the designing, thereby solving effectively the difficult problem of gas cleaning in ferroalloy production and providing useful experiences.

7.3 According to the measured data, the average radius of particles decreases from 5. 05μm when entering the filter to 2. 15μm when leaving the filter. With cleaning by the filter again and again, the radius of particle will become smaller and smaller and the specific resistance will become larger and larger. Only by adopting the technique of alternately changing the distance between electrodes can the efficiency of the filter be ensured.

7. 4 The environmental condition was improved through the operation of the electrostatic filter device. 1300 tons of Mn dust can be collected annually and used for the preparation of sintered ore.

7. 5 Mechanically driven equipment are few and the motors are of small power, thus saving power consumption.

7. 6 Operation is safe and reliable; a long life is reflected in marked reduction of daily service.

8. Comparison of electrostatic filter and bag filter

8. 1 During the eighties, the investment in electrostatic filter is higher than that of bag filter; the former being 1. 56 million yuan and the latter being just over 1 million yuan for a 12. 5 MVA SiMn furnace. Currently the electrostatic filter is invested at 2. 30 million yuan while the bag filter requires over 5 million yuan. Economically, the electrostatic filter is more favorable.

8. 2 The electrostatic filter is so safe and reliable in operation and so lifelong that major overhaul is required only once every decade. The electrostatic filter in our plant is still running smoothly after eight years' safe operation.

8. 3 Maintenance work is scarce and cost is low.

8. 4 The electrostatic filter is superior to bag filter with respect to performances and effects.

8. 5 In short, the electrostatic filter is superior to bag filter in every respect-environment at the post, pollution elimination, environmental benefit, social benefit and economical benefit.

9. Conclusion

9. 1 The application of elctrostatic dust filter to ferroalloy furnace is technically successful.
According to the data of Anshan Electrostatic Institute, the specific resistances of the fumes of various ferroalloys are all between 8 to 10Ω • cm ; thus this technique can be applied to all ferroalloys. It will open up a new route for the gas cleaning and promote the environmental protection in the ferroalloy industry.

9. 2 Electrostatic dust filter has many outstanding advantages such as high efficiency of dust collection, low power consumption, high temperature resistance, safe and reliable operation, low maintenance cost, long life, small loss from resistance, no secondary pollution and ability to capture ultra-fine fumes and dusts of 0. 01mm. Therefore, it can be concluded that electrostatic filter applied to ferroalloy furnaces is an optimum solution for fume removal.

9. 3 Fume concentration at the exit of chimney is lower than 100 mg/Nm^3, satisfying the demand of the national standard. Not only will environmental benefit be obtained through eliminating pollution by waste gas and protecting the environment, but also remarkable social benefit and definite economical benefit will be obtained.

References

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