The Airflow Distribution Design of ESP-FF Hybrid Dust Collector and the Application at Balco Power Plant in India

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Abstract: The airflow distribution of ESP-FF hybrid dust collector was researched completely in this paper. The airflow in the front electric field with a traditional airflow distribution form is non-uniform, which decreases the collection efficiency of ESP. Meanwhile, the airflow rising velocity in the back fabric filter chamber is increased, which decreases pulse cleaning efficiency else. A new airflow distribution developed by Zhejiang Feida Enviro., can make the airflow in the ESP area more uniform and the airflow rising velocity in the FF area slower, which can improve the performance of the ESP-FF hybrid dust collector. ESP-FF hybrid dust collector with this design has been applied at Balco power plant in India, which has been continuous operating from May, 2010. The dust emission is less than 4mg/Nm^3.

Keywords: electric precipitator retrofit, ESP-FF hybrid dust collector, airflow distribution design, stepped construction

1. General

China is the largest coal produce and consume country in the world nowadays. To the end of 2011, the installed power generation capacity of China had exceeded 10.6×10^6 MW, including coal generation 7.07×10^6 MW accouting for about 67%.

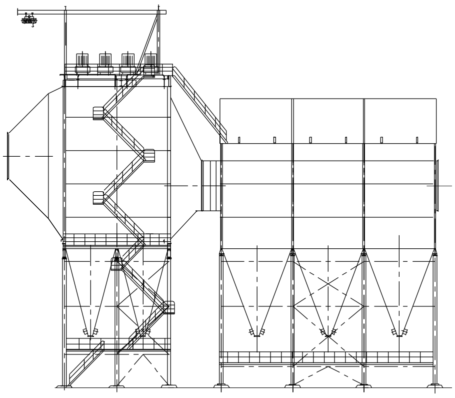
Although most of the exsiting dust collecting facilities equipted for coal-fired units in China are ESPs nowdays, as a result of the problems of varied burning coal, ESP sensitivity to coal/ash, removal efficiency of PM2.5 particals, and particularly the new standard which specified the dust emission limit at 30mg/Nm^3 and key regions reduced to 20mg/Nm^3 implemented from 2012/1/1, ESP technology used in the coal-fired power plant in China is facing new challenges.

ESP-FF hybrid dust collector combined with the respective characters of ESP and FF, is one of the effective dust emission controls, especially for PM2.5 emission, with high collection efficiency, and has been developing rapidly in China.

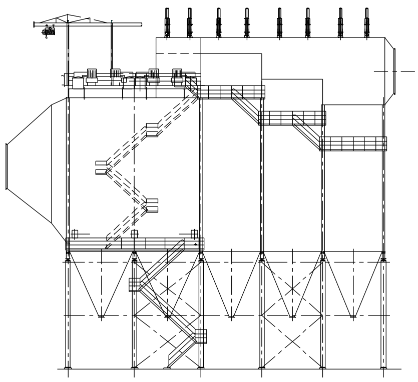
2. Basic form of ESP-FF hybrid dust collector

ESP-FF hybrid dust collector is a new high-efficiency dust collector combined with ESP and FF working principle. The front ESP collects about 80% of the rough dust and then the left fine dust will be collected with the charged powder layer accumulated on the FF.

ESP-FF hybrid dust collector can be divided into integrated type and separated type. ESP area and FF area in the former type are laid in one case while the two parts are connected by duct in the latter type (Figure 1). The integrated type has lower resistance but also worse protection from high-temperature gas and maintenance convenience, so that integrated type is suitable for ESP retrofit while separated type is suitable for new project.



（a）Integrated type



（b）Separated type

Figure 1 Basic form of ESP-FF hybrid dust collector

There has not been a long time ESP-FF hybrid dust collector application, and the forms are still being explored that the differences on forms may cause the performance diversity. ESP-FF hybrid dust collector developed by Zhejiang Feida Envio. improved the airflow distribution so as to that the performance characters could be applied and operating efficiency be ensured. ESP-FF hybrid dust collector with this design has been applied at Balco power plant in India, which has been continuous operating from May 2010, the emission of dust is less than 4mg/Nm^3, satisfied the requirements to dust emission of power plant fully.

3. Airflow optimized program

As directly connected with the key qualifications, such as collection efficiency, ash-removal efficiency, service life of filter bag, resistance of complete machine, etc., internal airflow distribution is the core technology for integrated ESP-FF hybrid dust collector.

There is usually a perforated plate set between ESP area and FF area to make gas passed through the bottom ESP area up to FF area. [1]This airflow distribution could have two problems, one of which is that the airflow distribution in ESP area may be non-uniform that the airflow speed in the lower part is faster than the upper part [2], which will decrease the collection efficiency of ESP area, The other one is the ash-removal efficiency decreasing due to the sedimentation of dust falling off from the surface of filter bag by bottom up airflow. A new gas distribution[3]-[4] has no perforated plate between ESP area and FF area is designed by Feida Envio. with the FF area stepped arrangement. The general thinking of it is to increase the airflow into FF area from a horizontal direction as much as possible. Changes in this way not only improved the flow field uniformity of ESP area, but also increased the ash-removal efficiency of FF area by decreasing the rising velocity.

Recently, application of CFD simulation technology in the design of airflow distribution is extending in a wide range. This paper also used the CFD simulation technology to make researches on airflow uniformity of ESP area, scouring speed, can speed and flow rate balance, etc. In order to determine the basic form of airflow distribution rapidly, small-scale trial and 1:1 full-scale simulation two methods are adopted.

3.1 Small-scale trial

Establish a small-scale model so as to reduce the amount of calculation and rapidly determine the whole airflow distribution form by comparing the results, mostly the FF area horizontal layout form and split-level layout form of the two models in the same initial conditions.

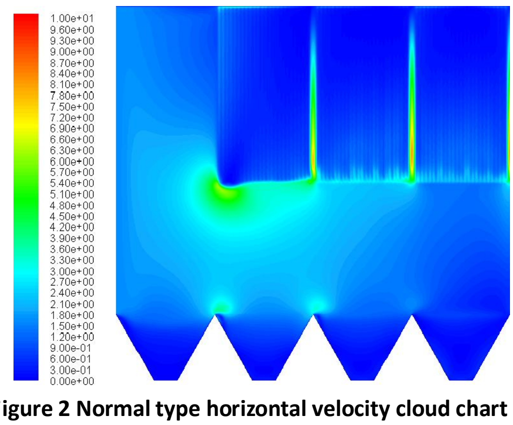


Figure 2 Normal type horizontal velocity cloud chart

As can be seen from these horizontal velocity cloud charts of Figure 2 and Figure 3, the horizontal velocity in stepped type ESP-FF hybrid dust collector is more uniform than that in the normal type ESP-FF hybrid dust collector, with no local high speed, which can effectively reduce the wear and tear of filter bag caused by dust scouring.

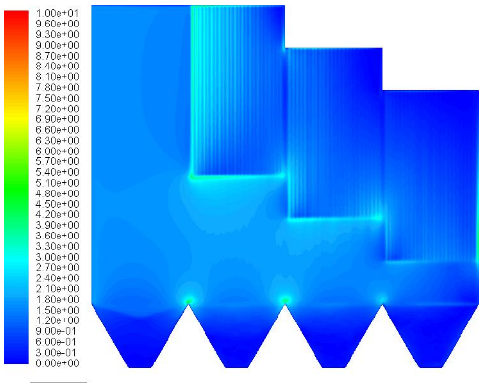


Figure 3 Stepped type horizontal velocity cloud chart

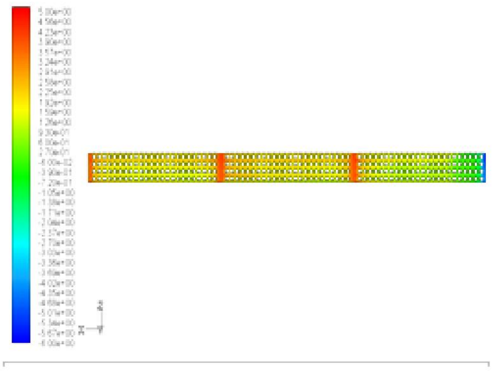


Figure 4 Normal type rising velocity cloud chart

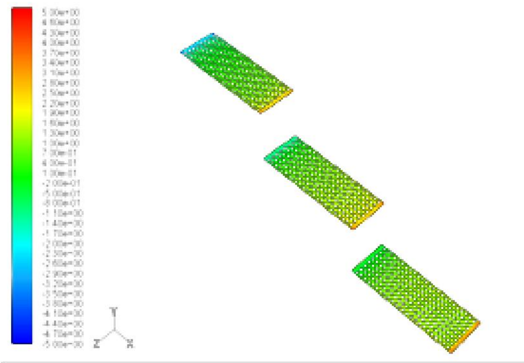


Figure 5 Stepped type rising velocity cloud chart

As can be seen from Figure 4 and Figure 5, the arrangement of filter chambers in stepped type is similar to setting a shrunken duct in the underside that gas can enter into each filter chamber evenly. While in the normal type the rising velocity is fast and distribution is uneven that may cause ash-removal difficulties or even early breakages on filter bag due to part of high speed. Compare the airflow distribution numerical modeling data in 2 and identify the chamber with the No. of 1, 2, 3 along with the airflow direction, we got the results as shown in the following Figure 6 and Figure 7.

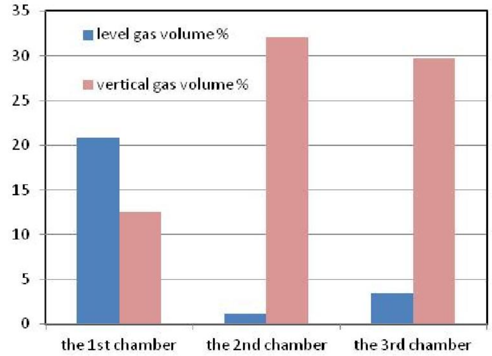


Figure 6 Normal type flow rate distribution ratio

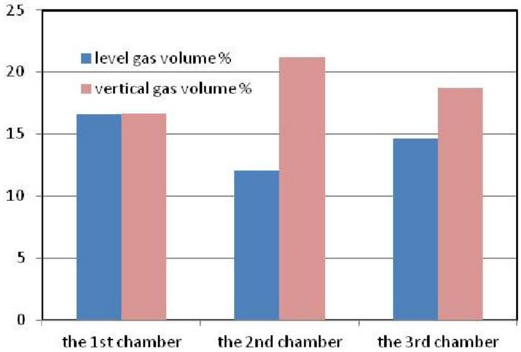


Figure 7 Stepped type flow rate distribution ratio of horizontal flow and vertical flow in each chamber horizontal flow and vertical flow in each chamber

As can be seen from the figures, flow rate of updraft changed dramatically in the stepped airflow distribution. About more than 90% of the airflow enters into chamber 2 and chamber 3 from the bottom by using of a normal type, while the ratio of the updraft dropped to around 60% by using of the stepped type. Thus, benefit from the air distribution optimized design, velocity of updraft in the after two filter chambers decreased by about 50% and updraft between the three filter chambers changed to be more uniform. It is not only in favor of increasing the ash-removal efficiency of FF area, but also beneficial to extending the service life of filter bag.

3.2 Full-scale simulation

The following figure is the midsection velocity distribution cloud chart which was calculated from a full-scale model based on a large power station adopted with stepped ESP-FF hybrid dust collector.

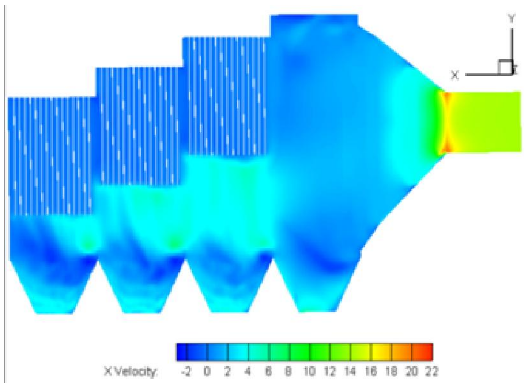


Figure 8 Midsection horizontal velocity cloud chart of ESP-FF hybrid dust collector

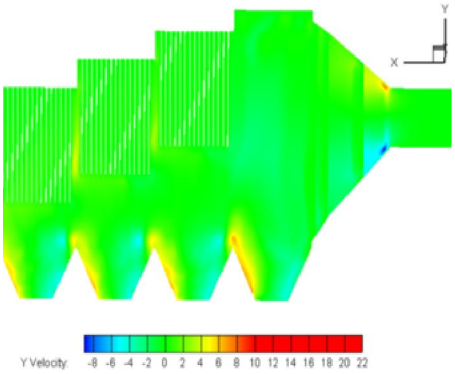


Figure 9 Midsection vertical velocity cloud chart of ESP-FF hybrid dust collector

As can be seen from the figures, after passing through the devices such as inlet hood, internal perforated plate, inducers and so on, flue gas flow rate decreased from about 15m/s at the inlet hood to about 1m/s at the static area with a good uniformity.

In order to preserve the scouring speed to filter bag within the value of calculation so as to avoid the early damage of filter bag caused by wear and tear, a special filter bag and inducer device should be arranged at the transition region between ESP area and FF area, where the flue gas changes to be very complex, to distribute the airflow in the region reasonable.

It can be seen from Figure 9 vertical velocity cloud chart that, the rising velocity of airflow is mostly below 2m/s, and there are some regions where the flue gas velocity is downward, both of which are beneficial to ash removed from the filter bag falling off to the hopper. Although there are some high-speed areas in the region between dust chambers, they can be controlled by retrofitting choke devices. Airflow distribution optimized design has laid a favorable foundation for the reliable operation of ESP-FF hybrid dust collector.

4. ESP renovation project of India BALCO power plant

BALCO power plant is in Korba district, Chhatisgarh State, India. There are four sets of 135MW unit in this plant, each of which is equipped with ESP with five electric fields, but the soot emission concentration of each ESP is up to 200mg/m^3, failed to meet the designing effect. Renovation on the original ESP was organized by Zhejiang Feida Envio. with ESP and FF hybrid dust collect technology in 2010.

Table 1 Coal analysis

Proximate Analysis (% by weight)			
SI. No.	Description	Design Quality	Worst Quality
1	GCV (kcal/kg)	3300	3000
2	Ash	41.6	45
3	Volatile matter	22	21
4	Fixed carbon	24.5	22
5	Moisture	11.9	12
6	Total	100.0	100

The coal and fly ash characters of Balco plant are as Table 1 to Table 3 below:

Table 2 Coal analysis

SI. No.	Description	Design Quality	Worst Quality
1	SiO_2	54.9	59.6
2	Al_2O_3	25.4	30.75
3	Fe_2O_3	9.3	6.5
4	TiO_2	1.3	1.75
5	P_2O_5	0.1	0.47
6	K_2O	0.3	0.27
7	CaO	3.1	0.25
8	MgO	1.8	0.08
9	Na_2O	0.3	0.15
10	SO_3	2.3	0.03
11	Mn_3O_4 Undetermined	0.7	0.15

Table 3 Ash analysis（%）

Element Analysis (% by weight)			
SI. No.	Description	Design Quality	Worst Quality
1	Carbon %	37.6	35.2
2	Hydrogen %	2.1	2.2
3	Oxygen %	5.6	4.2
4	Nitrogen %	0.8	0.8
5	Sulfur %	0.4	0.6
6	Ash %	41.6	45
7	Moisture %	11.9	12
8	GCV	3300 kCal/kg	3000

This renovation on ESP is arranged as stepped layout form by using of Feida's patented technology. The two electric fields in front was reserved, while the after three electric fields was dismantled the internal parts such as discharge electrodes and collecting plates, with filtration system installed. Original casing, hoppers and steel structures were reserved.

The basic design parameters of ESP-FF hybrid dust collector are shown in Table 4.

Table 4 Basic design parameters

SI. No.	Description	Unit	Data
1	Gas volume	m^3/h	1.200,000
2	Inlet dust concentration	g/Nm^3	98
3	Outlet dust concentration	mg/Nm^3	<50
4	Gas temperature	℃	145
5	Fibric type		Needle felt
6	Fabric material		PPS
7	Fabric area	m^2	16800
8	Filtration velocity	m/min	1.2

This retrofit started from March 2010, ended in May 2010, lasted for 50 days. The appearance of reformed ESP-FF hybrid dust collector is as shown in Figure 10. Figure 11 shows the chimney emissions of ESP (the left chimney) and ESP-FF hybrid dust collector (the right chimney). It is easy to see the heavy smoke from the untransformed chimney while the emissions from the reformed one almost can not be observed. It’s obviously that this renovation project is extremely successful.

Figure 10 Reformed ESP-FF hybrid dust collector

Figure 11 Emission comparison of ESP and ESP-FF hybrid dust collector

5. Conclusions

1) Distributing the airflow inside of ESP-FF hybrid dust collector reasonable by using of CFD numerical simulation, working out the best filter bag arrangement and inducer device so as to preserve the uniformity of airflow, the scouring speed to filter bag, and the rising velocity within a reasonable range will make the reliable operation of bag filter and ash-removing.
2) Blaco power plant which had reformed the ESP to ESP-FF hybrid dust collector by using of Feida's patented technology, soot emission concentration is less than $4mg/Nm^3$ and has been continues operating for more than 2 yeas with good running effects.

6. References

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