

Acoustic Horn Made Electrostatic Precipitator Collecting Plate and Hopper Clean in Zhangjiakou Power Plant

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Abstract

The two 4-fields, 230 m² flow area, magnetic hammer top rapping precipitators of a 300MW unit in Zhangjiakou Power Plant encountered dust accumulation and clogging difficulties, especially in third and fourth fields. By mounting acoustic horns of SQ-75 type, produced by Liaoning zhongxin Automatic Instruments Company, for one channel, four fields on the top, in the sidewalk between electric fields and in the hopper, dust scale up and accumulation problems were eliminated. Operation voltage and current were increased by 6% and 28% respectively. Working principle and detailed description are given.

Brief Introduction

The application of acoustic horn for ESP electrodes cleaning in China was only beginning in recent years. Due to general low sulfur of Chinese coal, high resistivity ash and higher than 15m electrodes, troubles of

dust adhering on the collecting plates were often encountered in Chinese power plants. By installation of domestic produced acoustic horn as additional rapping, this problem was solved in many cases, such as in Zhangjiakou Power Plant.

Zhangjiakou Power Plant has two 4-fields, 230m² flow area, electro-magnetic hammer top rapping precipitators for its 300MW unit. The dusts sticking on the 15meter high collecting plates, especially those of third and fourth fields could not be rapping down by pure hammer rapping. Thickness of dust layer accumulated to about 8mm thickness (Fig.1). Besides, hoppers block up was encountered also, often made ESP shutting down. By using acoustic horns, satisfying cleaning for collecting plates and hoppers was achieved. ESP could work normally.

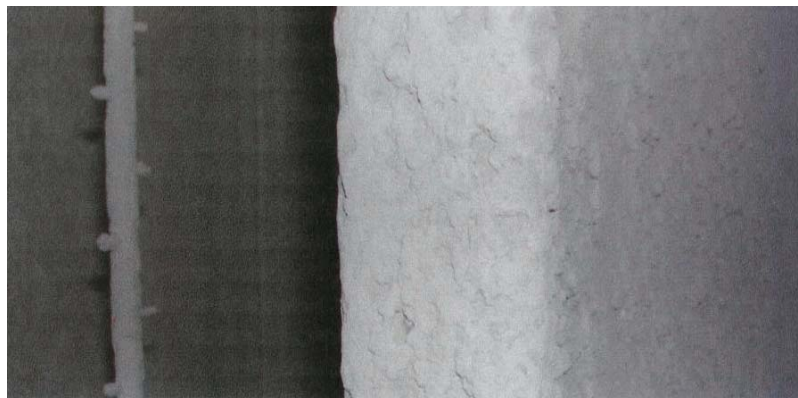


Fig. 1 Dust built up on ESP electrodes before acoustic horn rapping

Principle of Sonic Cleaning

Because reflected by the sidewall or top plate, the propagation of longitudinal sonic wave in precipitators can be treated as free sonic field, point source and semi-sphere type as shown in Fig. 2.

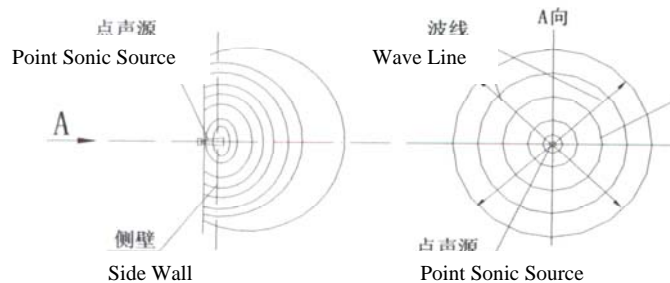


Fig 2. Semi-sphere propagation of sound wave

Sonic wavelength λ in air of 20°C, atmosphere pressure is:

$$\lambda = cT = c31/f$$

where: c ---propagate velocity in air, equal to 344m/s
 T and f ---period and frequency, Sec and Hz
 When using a 75 Hz frequency, $\lambda = 344 \times 31 / 75 = 4.59\text{m}$

Sound pressure P is:

$$L \bar{P} = 20 \lg \bar{P} / P_0$$

$$P_m = 2^{0.5} \sqrt{3} \bar{P}$$

Where: $L \bar{P}$ ---effective value of sound pressure grade, dB
 \bar{P} --- effective value of sound pressure, N/m^2
 P_0 ---base value of sound pressure $= 2 \times 10^{-5}$, N/m^2 ,
 P_m ---amplitude sound pressure, N/m^2

Amplitude acceleration a created by sound wave is:

$$a = 2^{0.5} \sqrt{3} \bar{P} \omega / \rho c$$

Where: ω ---angular velocity $= 2\pi f$
 ρ ---air density, $= 1.204 \text{ kg/m}^3$ (at 20°C, 1 atmosphere pressure),

Considering 75 Hz frequency and gravitational acceleration $g = 9.81 \text{ m/sec}^2$, the parameters of a SQ-75 type acoustic horn are calculated as Table 1.

Sonic wave propagate is really the process of sound pressure varies depressively and densely from P_0 to P_m . From Table 1 we can see that for a SQ-75 acoustic horn, it can produce 40~623 atmosphere pressure and 6.4~102 g amplitude acceleration to the surfaces of 0~16m apart from its exit. If the sonic wave is incline acting on the surface, the pressure and acceleration will be reduced by a factor of sine function.

Because the wavelength of a 75 Hz frequency is 4.59m, generally greater than the dimension of obstacles, so that sonic wave can make a detour motion without influencing its effect greatly.

Table 1 Parameters calculated for SQ-75 acoustic horn

Distance from exit	m	Exit	2	4	6	8	12	16
Sound pressure grade LP	dB	150	144	138	135	132	129	126
Sound pressure P	10^2N/m^2	6.32	3.17	1.59	1.13	0.8	0.56	0.4
Amplitude sound pressure Pm	10^2N/m^2	8.94	4.48	2.25	1.59	1.13	0.8	0.56
Amplitude acceleration a	g	102	51	25.6	18.1	12.9	9.1	6.4

Installation of Acoustic Horn

Fig.3 shows the precipitator and the position of acoustic horns. Totally ten acoustic horns were installed, among which seven were installed on the top (one for first field, two for second, third and fourth fields each), three were installed at the lower sides opposed to the three passageways between 1-2, 2-3 and 3-4 fields. Thus, both upper ends and lower ends of collecting plates could be strongly vibrated by the sonic waves. Numbers were given to each acoustic horn as in Fig.3. The installation methods of top and side acoustic horns are shown in Fig.4 respectively. Fig.5 are their photographs.

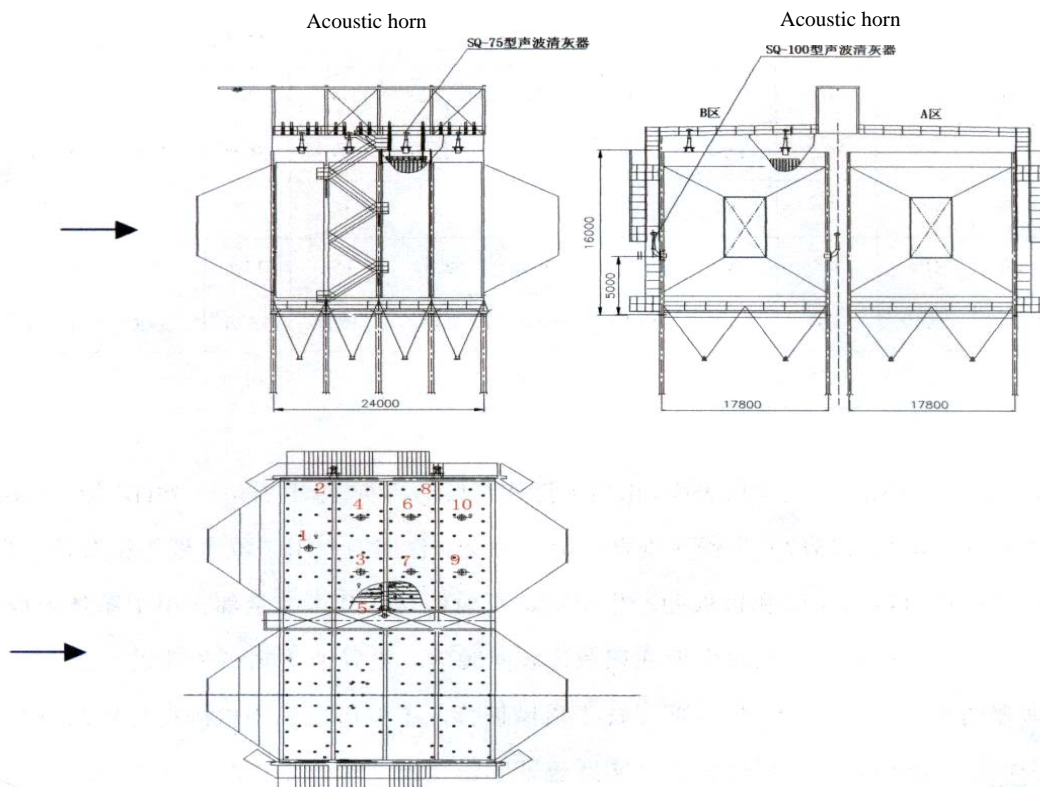


Fig. 3 Acoustic horns Install at the top and side wall of ESP

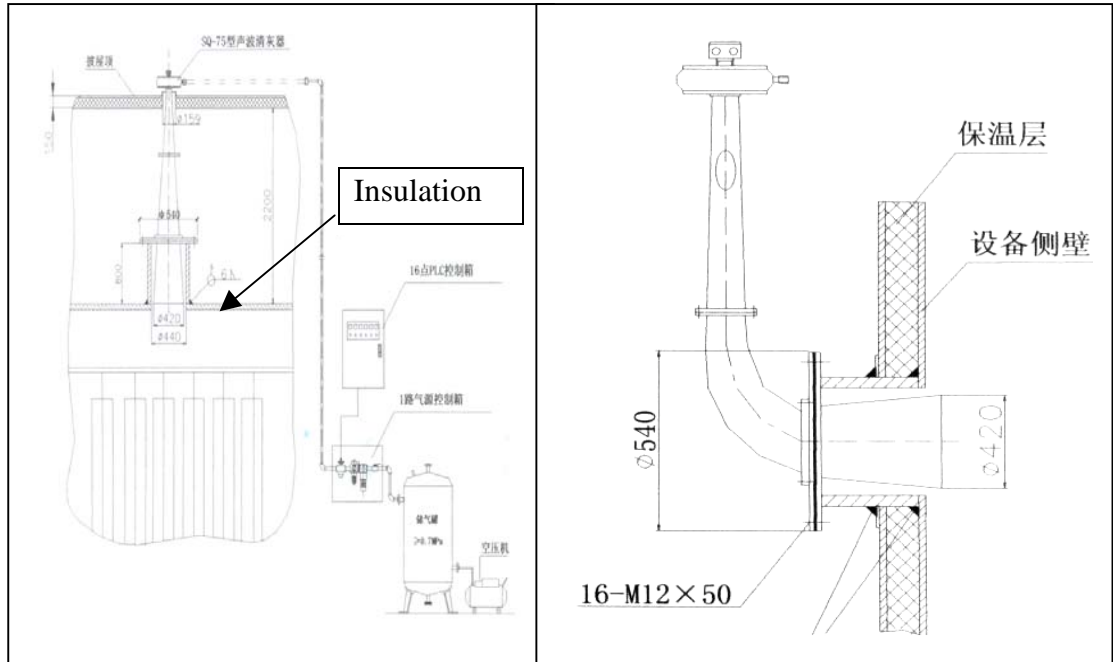


Fig. 4 Top and side mounting of acoustic horn



Fig. 5 Photographs of acoustic horn

Table 2 Two control variants

Position	Rapping Variant	1 field Top		1,2 field Passage		2 field Top		2,3 field Passage		3 Field Top		3,4 Field Passage		4 Field Top	
		#	1	2	3	4	5	6	7	8	9	10			
Rapping time (Sec)	A	5	5	6	6	8	10	10	10	5~10	5~10				
	B	5	5	5	5	10	10	5~10	5~10						
Time interval (Min)	A	1	1	2	2	2	2	2	2	60~120					
	B	2	2	5	3	5	3	60~120							
Rapping period (Min)	A	15									60~120				
	B	20.6									60~120				

Sonic Rapping Tests

Cleaning Effect in Precipitator Box

First, only using two SQ-75 type acoustic horns on the top of third field, we found the cleaning effect was better than mechanical rapping. Secondary current was increased (See Table 3). No fine dust reentrainment and noise exceeding standard were found.

Table 3 Comparison between using or not using acoustic horns

Date testing	of	Operating condition	Secondary voltage (KV)	Secondary current (mA)
Feb. 2003	16,	Without sonic horn	68	350
April, 2003	16,	Using two top sonic horns	72	450

Then, a long time continuous operating test was going on. After 60 days operation, we entered into the precipitator and carefully observed the dust accumulation on the collecting plates. We found there were obviously marks of dust falling off on the collecting surface. Many marks presented the forms of snowflake like spots or the original color of steel plate (Fig. 6).



Fig. 6 Dust particulates were falling down when sound rapping



Fig. 7 Cleaned collecting plates after sonic rapping

While, at same time and working condition, in another part of the same precipitator, there were no such marks of dusts falling down. The fingernail scratch depths of with and without sonic cleaning were different obviously.

We also observed the effect of sonic cleaning outside of the precipitator. Opening the lower manhole, we saw the dust layer crackling, falling from the plate surface. The small white particulates of Fig. 6 represented the residual dust granules when sonic rapping was undertaking. These proved the good cleaning effects of acoustic horn. Fig. 7 shows the cleaned collecting plates after sound rapping.

Cleaning Effect in Precipitator Hoppers

In the hopper of fourth field of another precipitator, we installed a SQ-1000G type acoustic horn. Before the horn working, the hopper was filled with dusts to an enough high level. At this situation, in the past, bridging or clogging of dust in hopper often occurred.

Starting the air-lock rotating valve, we found no dusts falling down from hopper, which shown bridging or clogging existed. Then, starting the acoustic horn 3 to 5 times by local hand control, low frequency voice was heard. Soon afterwards, warm and dusts began falling out from hopper. After this short test, normal continuous running of acoustic horn was going on by computer remote control. There was no bridging or clogging in hopper again.

Summary

The use of acoustic horns in Zhangjiakou Power Plant was rather successful. Some other applications in iron/steel industry are also satisfying. It proved that provide selection and installation correct, dusts accumulation on the electrodes surfaces and clogging in the hoppers, induced by insufficient mechanical rapping, can be cleaned or dredged by low frequency sonic wave. Some times solely using acoustic horn instead of mechanical or electromagnetic rapper is also possible. Simple, no obvious moving parts and flexible install make it to be another valuable dust build up breaking device.

References

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