

# Review on the Development of Electrical Precipitation Industry in China

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**Abstract** This paper reviews the development environment and business situation of the Electrical Precipitation Industry in China, 2011. A general technical progress of the industry, research and applications of the new technology are introduced. Prospects are made about the future development of the industry.

**Keywords** new standard for environmental protection; electrical precipitation; new technology; industry prospect

## 1 Current development of the industry

### 1.1 Development environment of the industry

With the ever increasing demands upon environmental protection, China has formulated more strict standards for soot emission, "Air Pollutants Emission Standard for Thermal Power Plant" (GB13223-2011) limits the soot emissions from coal-fired power plants rating to  $30\text{mg}/\text{Nm}^3$ , and to  $20\text{mg}/\text{Nm}^3$  in key areas. It has been the second time to raise the discharge standard for pollutants from thermal power plant in China since 2004.

In order to promote and provide guidance for the progress of electrostatic precipitation technology, from 2009 to 2010, the Electrical Precipitation Committee of China Association of Environmental Protection Industry(CAEPI) organized "The Guidance Book for Coal-fired Power Plant Electric Precipitator Design", the purpose of which is to regulate the market, to guide a scientific and reasonable selection and design in the electrical precipitation industry, to improve the current none-standardized configuration designs, such as insufficient electrical fields (usually 4 fields) and insufficient specific dust collection area (usually  $70 - 100[\text{m}^2/(\text{m}^3/\text{s})]$ ), to ensure that the equipments meet discharge standards, and to improve the overall technical level of the industry. Through analyses of coal composition in China and its influences on the performance of electrical precipitation, of the running condition of domestic precipitators, of specification for the foreign electrostatic precipitator and the corresponding selection and design flow, guiding opinions for selection and design are proposed, and supports are provided for suppliers, designers and construction companies, and management departments to make scientific and rational choice of electric precipitators. In the second half of 2010, Electrical Precipitation Committee also composed "The Guidance Book for Selection and Design

of Power Supply in electrostatic precipitator". The publication of guidance books for the bulk body and power supply of electrostatic precipitator, forcefully enhances the level of selection and design for electric precipitators, standardizes the market of the industry, and improve the quality of the equipments.

With the growing economic strength of China, demands upon environmental protection will increase along time. The usages and applications of the electrostatic precipitator of today, both in the developed countries and in China, fully justified the electrostatic precipitator as the primary equipment and technical solution for precipitation, even though the national standards for soot emission to be raised strictly to  $30\text{mg}/\text{Nm}^3$  and more.

### 1.2 Business Situation of the Industry

From a survey of 50 enterprises within the industry in 2011, the total contract sum of 28 private enterprises reached 17,795,000,000 RMB Yuan, with the total output value of 15,580,000,000 Yuan, sales income of 13,404,000,000 Yuan, and exports value of 2,522,000,000 Yuan. According to statistics, there are 200 units and more engaged in the research, design, equipment manufacturing, installation, debugging, and related accessories business of electrical precipitation in China, amongst which are included colleges and universities, scientific research units and equipment manufacturing enterprises.

The electrical precipitation technologies in China have been accumulated upon the independent research and development, through digestion, absorption and re-innovation processes after the introduction of technologies from Europe, America and other developed countries, and finally developed into self-contained technologies with own intellectual property. These technologies have been improved and promoted during the long-term engineering practice, and the corresponding products have gained favor from a dozens of countries and have showed strong advantage for competition on the international markets. By statistics, the export value of electrical precipitation product reached more than 2,500,000,000 RMB Yuan in 2010 and 2011 in China, accounting for about 20% of the output value of the electrostatic precipitator.

The rapid progress of electrical precipitation of China in recent years, was initiated by a group of backbone enterprises, comparable to supranational corporations in the world.

## 2 Technical Progress of the Industry

### 2.1 Overall Technical Progress of the Industry

The electrical precipitation industry in China has developed into an industry with excellent equipments and complete supporting business sectors after the endeavor of several generations of people in the past 50 years. There are more than 200 manufacturing enterprises engaged in the electrical precipitation industry, as well as a number of colleges and universities, research and design Institutes. The electrical precipitation products in China can meet not only the domestic demands, a considerable amount of the products are exported to dozens of countries and regions. The 50 enterprises in the 2011 survey account for 80% of the total number units, amongst which, 28 enterprises in foreign trade reached a sum exporting value of 2,600,000,000 RMB Yuan. China has become the No. 1 producer for electrical precipitation equipment in the world.

Electric precipitator has a very wide application range, involving a variety of businesses. The Electrical Precipitation Committee of China Association of Environmental Protection Industry (CAEPI) organized the backbone enterprises and experts to carry out investigations and studies on the application of electrical precipitation in domestic industry in recent years. From the perspective of electrical precipitators of coal-fired power boiler, which accounts for 75% of the total electrical precipitators in the country, statistics, induction and analysis were conducted, with a combined decades of experience of research and engineering application, the adaptability of electrical precipitation to the major domestic power coal was comprehensively studied and testified, and the economical efficiency of all kinds of precipitation equipments was analyzed objectively. A large number of detailed domestic and foreign examples shows that the electrostatic precipitator is technically mature, can realize energy saving in low emission conditions, and is an precipitation equipment applicable for the domestic situations. Meanwhile, through comprehensive comparison, electrostatic precipitators have the advantages of lowest energy consumption, longest life span, safe and best reliability, lowest total cost for both operation and installation of the equipment. The longer the operation time, the more significant economical efficiency.

At the same time, China has accelerated the pace of R & D for electrical precipitation technology. On the fourteenth China academic conference of electrical precipitation held in Chongqing in October 2011, some papers presented some discussion on the wet method for electrical precipitation and the coagulation effects of extremely fine granules. For regions where the land has been intensely de-

veloped, the carrying capacity of the environment is weak, or the atmospheric environmental capacity is small, the ecological environment is fragile, air pollution is liable to happen and strict control is required, the wet electrical precipitation should be utilized. In the early nineteen seventies, there were some application examples of wet electrical precipitation techniques in the metallurgical industry in China. No further popularization was made because of the low requirements of national standards for emission. Some foreign practical experience on electrical precipitation shows that with the application of wet electrostatic precipitator or dry-wet electrical precipitator, the emission concentration can be confined below  $5mg/Nm^3$ . Wet electrostatic precipitator can ensure emission conforming to discharge standards, as well as the synchronous regulation on PM2.5, wet fog, heavy metals, organic gas and compound pollutants.

### 2.2 Development trends of electrical precipitation

There are 40 units of 1,000MW units, 913 units of 600MW in China. Although the design requirements at that time was  $50 - 100mg/Nm^3$  for the smoke and dust concentration at the outlet of electrostatic precipitator, generally 4 of the electric field, but after the third party test, most of the smoke and dust concentration at the outlet of electrical precipitator is less than  $30mg/Nm^3$ , and even outlet concentration is less than  $20mg/Nm^3$  at multiple units, amongst which emission concentration is less than  $10mg/Nm^3$ . There are also examples of smoke and dust concentration less than  $30mg/Nm^3$  at the outlet of electrostatic precipitator for 600MW units.

In the past 40 years, scientists and technicians of electric precipitator industry have been dedicated to the technology innovations persistently, on the basis of continuous improvement of performance for conventional electric precipitators. Since entrance into the 21st century, the new technologies of electrical precipitation in China have been mainly focused on the sticky problems that seriously restrict the low emission of smoke and dust, for example, how to solve the PM2.5 collection, the reduction of secondary dust, and overcoming the influence of high dust-resistivity ratio, etc. Substantial achievements are made upon technologies like rotating electrode electrostatic precipitation technology, low temperature electrostatic precipitation technology, ultra-low temperature electrical precipitation technology, high frequency and high voltage power supply technology, electrostatic-fabric integrated precipitation technology, wet electrostatic precipitation technology, etc. Development and application of these fore mentioned technologies broke the inherent technical bottleneck of conventional electric precipitator, and greatly enhanced the overall competitiveness of electrical pre-

precipitation industry in China.

### **2.2.1 Rotating electrode electrical precipitation technology**

This technology was determined by the China Association Environmental Protection Industry to be one of the new key technologies of electrical precipitation for development and promotion during the Twelfth Five-Year Plan, and was included in the 2011 Catalog of National Encouraged Major Technical Equipment for Environment Protection (The Ministry of Industry and Information Technology File No. [2011]54 ) and in the 2012 Catalog of National Key Applied Technologies for Environment Protection.

Rotating electrode electrostatic precipitator is a highly efficient electrical precipitation equipment. The precipitation mechanism is the same with that of the conventional electrical precipitator, and is composed of the front fixed electrode electric field (conventional electric field) and backward rotating electrode electric field. The anode part of rotating electrode electrical field is installed with a rotary anode plate and a rotary dust cleaning brush. Before the dust adhered to the rotary anode plate reaches the back corona thickness, it will be removed completely by the spinning cleaning brush arranged within the none electrical field, so the phenomenon of back corona will not happen, the secondary dust will be minimized, the driving in speed of the dust is increased, efficiency of the electrostatic precipitator improved dramatically, emission concentration is reduced, and meanwhile, the sensitivity to the change of coal type is also reduced.

There have already been several sets of 300MW and more units with rotating electrode electrostatic precipitator in operation in China. By the end of 2012, The total installation capacity of contracts signed for 300MW and more units with rotating electrode electrostatic precipitator has exceed 17,000MW, amongst which, there were 2 sets on 1,000MW units and 8 sets on 600MW.

### **2.2.2 Low temperature electrostatic precipitation technology**

The low temperature electrostatic precipitator reduces the running temperature of smoke and gas entering the electrostatic precipitator from normal state ( $120^{\circ}\text{C}$  -  $160^{\circ}\text{C}$  ) to low state ( $90^{\circ}\text{C}$  -  $110^{\circ}\text{C}$  ), usually controlled  $10^{\circ}\text{C}$  above the acid dew point) by means of the low temperature economizer (basically in the exchanger of which, the condensed water from steam engine exchanges heat with the hot flue gas. Extra heat is transferred to the condensed water from steam engine, to reduce the vapor consumption of the low pressure heater within the circuit of condensed water from steam engine). Due to the reduced exhausting temperature, the volume of flue

gas entering the electrostatic precipitator is reduced, dust-resistance ratio is lowered, and the precipitation efficiency is increased correspondingly. So the dual purpose of the utilization of waste heat and the improvement of precipitation efficiency is achieved.

At present, there are more than 7,200MW of total installation capacity of operating units with this technology in China. 3 sets on 1,000MW units and 1 set on 600MW units. The total installation capacity of contracts signed for 300MW and more units with low temperature electrostatic precipitator has exceed 17,000MW, amongst which there were 7 sets on 1,000MW units and 7 sets on 600MW.

### **2.2.3 Ultra-low temperature precipitation technology**

The temperature of flue gas with the ultra-low temperature precipitation technology is between  $90^{\circ}\text{C}$  and  $95^{\circ}\text{C}$ , and should be lower than the acid dew point temperature of the flue gas. This cause most of the  $\text{SO}_3$  in the flue gas to condense within the heat exchanger, to be absorbed and neutralized by the alkaline substances in the flue gas. The resistance ratio of the flue gas is greatly reduced, and the characteristics of the dust gas is improved substantially. This method can greatly improve the efficiency of precipitation and get rid of most of the  $\text{SO}_3$  in the flue gas at the same time.

There are no industrial applications of ultra-low temperature electrical precipitation in China. This technology is one of the major precipitation technologies in the coal-fired power plants in Japan. There has been companies commenced to do research works upon this technologies in China since 2010, and many Chinese companies showed strong attentions to this technology at present days.

### **2.2.4 High frequency and high voltage power supply technology**

The high frequency power supply technology utilizes the modern power electronics technology. The three-phase power supply passed through three-phase rectifier becomes DC power, which is then inverted into high frequency AC current over 10KHz. Through the high frequency transformer and high frequency rectifier and filter, a high frequency current of several KHz is obtained and is supplied to the electrical field of precipitator.

The application of high-frequency power supply upon precipitators is a revolutionary breakthrough of the power technology on the electrostatic precipitator. Its high efficiency, energy saving characteristics has been widely recognized. There has been 4-5 year since the application of high-frequency power supply in precipitation industry. This technology is applied in many engineering projects and great breakthrough has been achieved.

### 2.2.5 Electrostatic-Fabric integrated precipitation technology

The electrostatic-fabric integrated precipitation technology makes use of the combined advantage of both electrostatic precipitator and fabric filter to improve the efficiency of precipitation, and overcomes the disadvantage of the single precipitation mechanism respectively. The electrostatic-fabric integrated precipitator collects more than 80% of the dust entering the precipitator by the first electrical field of the precipitator, the concentration of the dust gas entering the following fabric filter is greatly reduced, the wearing effects of the dust gas upon the filtering bag is alleviated, especially the filtering characteristics of the dust in the filter is improved by the electric charge effect of the front stage electric field, the permeability and cleaning performance of the filtering bag is improved, the drag effects is reduced, filtering speed can be raised, filtering area can be reduced, cleaning cycle can be prolonged, the service life span of filtering bag and pulse can be increased, and operation and maintenance costs can be reduced.

Since March, 2003 the first electrostatic-fabric integrated precipitator was put into operation, this technology has already played a significant effect under situations where the discharge standards was not reached and the space is limited for the reconstruction of installed electrostatic precipitator. The electrostatic-fabric integrated precipitator should also be a good alternative under conditions where the dust-resistance ratio is relatively high.

### 2.2.6 Wet electrostatic precipitation technology

The working mechanism of wet electrostatic precipitator is exactly the same with that of dry electrostatic precipitator, different from cleaning dust by vibration, the wet electrostatic precipitator uses liquid to wash the electrode surface and clean the dust.

In recent years, there are more and more haze weather in the large and medium-sized city in China, which has seriously affected the healthy working and living environment of the city residents. The high concentration of PM<sub>2.5</sub> (mainly PM<sub>0.1</sub>-PM<sub>1</sub>) in the city environment is a major cause of haze weather. "Standard for Ambient Air Quality" (GB3095-2012) sets a limit for PM<sub>2.5</sub> concentration and gives a schedule for the monitoring implementation. How to control PM<sub>2.5</sub> concentration, has already become a urgent problem to be solved. Wet electrostatic precipitator as a equipment for final fine treatment to atmospheric compound pollutants is an ideal equipment for the precipitation of fine particles from coal-fired power plants and industrial boilers (including PM<sub>2.5</sub>, SO<sub>3</sub> acid mist and dust aerosols), heavy metals( such as Hg, As, Se, Pb, Cr, etc.), organics (such as polycyclic aromatic hydrocarbons

and dioxin) , and compound pollutants. It is especially suitable for the dispose of "gypsum rain" from the desulfurizing tower.

The wet electrical precipitation technology has gradually be used for the thermal power units, there has been a set in operation on a 300MW thermal power unit, signed contract for 2 sets on 1,000MW units, several sets in preparation on 600MW units and more. The wet electrical precipitation technology has been used in thermal power plants for nearly 30 year, It was mainly used for the removal of the acid mist from wet flue gas desulfurization(WFGD) that cannot be collected, controlling the PM<sub>2.5</sub> emissions and solving the turbidity problem of flue gas emission, the soot emission concentration can be controlled under 10mg/Nm<sup>3</sup> and even under 5mg/Nm<sup>3</sup> Some leading Chinese Companies have introduced wet precipitation technology of advanced level for horizontal flue gas. The technology can be applied to large-scale coal-fired units of million grade.

## 3 Prospects on the development of the industry

The global climate change is a serious threat to the atmosphere for human life. It is the wave of the future to pursue the development of low carbon economy. Industry sectors will gradually reduce the dependence upon fossil fuels, and increase investments upon clean energy. That is the inevitable development trend of history.

It should be noted that, China is still a developing country with an enormous population. The demand for energy will be more urgent, with the speeding up of industrialization and urbanization process. At the end of 2010, the installation capacity per capita in China is about 0.70KW, lower than 1KW level in developed countries. In 2010, the power consumption per capita in China is 3126KWh, equivalent to that of the United States in 1956, and South Korea in 1993. These fully shows the urgency of energy development in China.

"The energy industry must ensure the demands upon energy from both the economic growth and the improvements of people's living conditions for a long time. In general, the high-speed growth trend of energy industry will still be maintained during the period of The Twelfth Five-Year Plan. We have established a plan that the installed electricity capacity is expected to reach 1,470,000,000 KW in 2015, probably 1,840,000,000 KW in 2020, and 2,470,000,000 KW. This should be a rather conservative estimation", pointed out by the leadership of Energy Conservation and Technical Equipment Division in the China National Energy Bureau on "The Sixth Electric Equipment Innovation and Development Forum China 2011"

Due to the particularity of energy structure in

China, the situation of coal-based energy supply will not change radically in a fairly long period of time. Confronted with the rapid growth of energy demands and the limited capacity of the environment, we must adopt more strict environmental emission standards. So there is still a great market potential in the air pollution control industry, and much remains to be done.

At present, most of the precipitation equipments in thermal power plants adopt electrostatic precipitators. Especially, large capacity units have more priority over the small ones in electric power construction, and large capacity units, such 1,000 MW and 1,200MW will be the future direction. So the adaptability of electrical precipitation to the new environmental standards has become the focus of attention of the industry.

The implementation of “Emission Standards for Air Pollutant from Thermal Power Plant” ( GB13223-2011 ) , has risen actually and effectively the entry requirements into the electrical precipitation industry, and objectively reshuffle the market environment of the industry to a more orderly manner. So the strict trend of emission standards means a good news of profit for the electrical precipitation industry in China. It is essential to make the best use of the opportunity, firmly develop new technologies, such as rotating electrode electrostatic precipitation, fine particle collection enhanced, low temperature electrostatic precipitation, wet electrostatic precipitation and high frequency power supply technology, etc, construct as soon as possible a batch of model projects with high standard, low emissions, low energy consumption, and meet the new climax of the electrical precipitation industry. Through a joint efforts of all the enterprises, China will strive to transform from a big into a strong country of electrical precipitation industry in the shortest time possible.