Development of Chinese Electrostatic Precipitator Technology

LIN Youwen, LIU Weiping
(Committee for Electrostatic Precipitator, Wuhan, PR China)

Abstract: In this paper we review the development of Chinese Electrostatic Precipitator (ESP) in the passed 20 years, introduce the recent situation of our country's ESP technology and forecast the development prospect of ESP in China.

Keywords: Electrostatic Precipitator, ESP technology, technology development, technology progress

1 INTRODUCTION

In the second international conference of electrostatic precipitator held in November 1984 in Japan, the author wrote the paper named Development of Electrostatic Precipitator in China and made a presentation on the conference at the invitation from Mr. S. Masuda.

In the early 1980s, the ESP technology in China is in the primary stage, when the world's ESP technology had become mature commodity. Only more than 20 factories make body of ESP and power source. The ESP value output of 1982 was less than two hundred million. The biggest sectional area of ESP set in 1983 was 220 m^2. Most of the sectional areas were less than 100 m^2 in 1983, and ESP were mainly applied in industrial sectors such as steel industry, cement industry, chemical industry and papermaking industry.

Two and a half decades passed. Technology and industry of ESP in China have made a great progress. There are more than 200 organizations, which are engaged in ESP and its relevant industries. These organizations have formed an industry with considerable scale. Research, design, manufacture, installation and debugging are all involved in the field of ESP. And the industry covers colleges and universities, research and design institute and enterprises. Now there are there ESP body corporations whose annual processing capacity can be more than 100 thousand tons, more than 10 corporations whose annual processing capacity can be in the range of 30 thousand and 100 thousand tons. There are 3 power source corporations which can make 1000 power sources per year, more than 10 corporations which can make 300 to 1000 power sources per year.

By 2007, the whole contract value of the 21 ESP body corporations has reached 148765211 thousand Yuan, sales value has reached 8852699.8 thousand Yuan and export value has reached 919486 thousand Yuan. As the marketing requirement becomes larger and larger, in 21 century, output value of ESP in China increases dramatically.

Production and management situations in recent years of 13 key enterprises, whose sales incomes are most, are showed in Table 1.

Table 1 Production and management situations of 13 key enterprises in recent years

Year	Industrial Output (10000 yuan)	Sales Income (10000 yuan)	Export Value (10000 yuan)	Increase Amplitude (%)
2000	182086	139215	5652	
2001	213017	175165	4686	25.82
2002	287098	214693	7745	22.57
2003	335288	283102	7825	22.54
2004	428246	392698	11310	27.88
2005	638600	502166	15710.2	27.22
2006	764290.4	574358	60661	14.38
2007	1214291.9	730137	83720	27.12

In a conclusion, ESP in our country has a late beginning but rapid development.

National economy has developed rapidly since the reform and open-door policy being carried out, which provides broad market for the application of ESP. By the end of the last century, our country has become a great ESP power in the world. China has a large ESP production and using amount. ESP made in China not only meets the domestic requirement, but also be exported to decades of countries. Now the ESP industry has become one of competitive industries in Chinese environmental protection industry.

ESP applied in power plant is the most important part. Only several power plants used ESP before 1980. Quantity of ESP applied in power plant increased constantly from mid 1980s. Electric power industry became the biggest user of ESP after 1990. ESP quantity applied in power plant makes up 75% of total ESP quantity in China. From 1990 to 2000, dust emitted from power plant was kept below 4000000 ton while total thermal power units increased from 76011 MW to 220000 MW. ESP toke an important role in power plant dust treatment.

ESP applied in power plant in our country has a late beginning. The first ESP matching 300000 WK unit was set in Jiangsu Jianbi power plant in 1983; the first ESP matching 600000 WK unit was set in Anhui Pingyu power plant in 1989; the first ESP matching 900000 WK unit was set in Shanghai Waigaoqiao power plant in 2001; the first ESP matching 1000000 WK

unit was set in Zhejiang Yuhuan power plant in 2006.

According to this, the application of Chinese ESP is later than developed countries by 15 to 20 years. As the requirement of the market, especially the requirement of electric power industry, ESP technology in China has become the biggest ESP power in a short time.

So far, there are 10 enterprises which can produce ESP for 600 MW units in China, including Zhejiang Feida, Fujian LongKing, Lanzhou Electric Power Equipment Manufacturer, Tianjie Group, Shanghai Metallurgical & Mining Machine Manufactory, Zhejiang Sunyard, Shanxi Electric Power, Anhui EE, and Zhejiang Luzhou Environmental Protection. Enterprises which can produce ESP for 1000 MW units are Zhejiang Feida, Fujian Longking, Lanzhou Electric Power and Tianjie Group.

According to our statistics until Apr 2008, 17 ESPs for above 600 MW units were put into use before 2000, and the number increased several times after 2000. 220 ESPs for 600 MW units have been equipped, 102 are being manufactured and 108 are being designed. There are 2 ESPs for 900 MW units. And 10 ESPs for 1000 MW units have been equipped, 9 are being manufactured and 29 are being designed. There are much more ESPs for 20 MW–30 MW units. All these data indicates the fast development of ESPs in China.

2 DEVELOPMENT

China initiated ESP technology study in 1965. 3 m^2–60 m^2 two-field nine-series ESP designed in 1973 was centralized reflection of Chinese research results. It should be noted that, in late 1970s, Yuanbaoshan power plant introduced 173 m^2 ESP form Ruthmuhle of German, and Wuhan Steel Fireproof Factory introduced 81.9 m^2 ESP form Elex of Swiss. Those successful applications attracted great attention in China.

In Seventh Five-year Plan Period, our country listed "study of high efficiency ESP technology" into the National Key Project, greatly improved Chinese ESP technology and shortened the difference of foreign advanced level.

The most widely used horizontal ESPs and single-phase power sources in China are called conventional ESPs and conventional power sources.

After operation of more than 20 years, many enterprises of sales beyond a hundred million yuan sprung up in Chinese ESP industry. ESPs of Zhejiang Feida and Fujian Longking obtained the title of China Top Brand.

The development of technology and challenge of new emission standards encourage us to take seriously. Electrostatic Precipitation Committee paid great attention to technology development and innovation. From the foundation in 1985, ESP Committee hosted 12 nationwide academic conferences and 10 power source symposiums, and had more than 1000 papers.

Colleges, universities and scientific institutes are the main force of innovation in China, and the strong support of ESP development. The mechanism of ESP also develops, such as: data processing for flue gas characteristic and fly ash size, collection mechanism, bipolar charged collection for high resistivity fine particles, high concentration dust forced collection, agglomeration, magnetic enhanced atomization corona discharge for flue gas clean, airflow distribution in ESP and numerical computation, airflow distribution in wet ESP and simulation of skewed gas flow technology, effect of trough plate to the airflow distribution, suitable rapping and sound wave dust cleaning, flue gas conditioning, development of design software, simulation of ESP optimal control, ESP help system software, computer data collection of ESP, etc.

These technical innovations, will further improve the understanding of ESP theory, exploit the potential of ESP, and maximize the advantages of ESP. On the basis of independent research and overseas successful experiences, Chinese ESP technology is developed in the practical applications, as indicated below:

2.1 ESP

2.1.1 Lentoid ESP

Lentoid ESP was developed by Wuhan Science & Technology University and Wuhan University. This ESP has good hydrodynamic and electric performance with positive, negative corona electrode and lentoid electrode. The special of this ESP is the electric wind pass through the lentoid electrode, which can decrease the reentrainment and increase the migration velocity of particles. The results of ESP in the concrete plant shows that this ESP can save rolled steel (above 1/3).

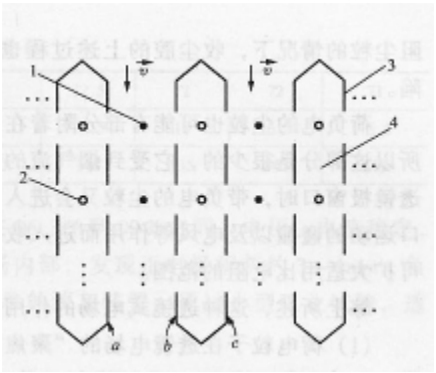


Fig. 1 Structure of Lentoid ESP
1. corona electrode 2. collection plate 3. lentoid electrode
4. collecting chamber

2.1.2 Tubular ESP

The tubular ESP was developed by Xi'an heavy Machinery institute and Yuqing science & technology co. Ltd. The positive and negative electrode are used bar tubular and the barbed electrode respectively. In addition, this ESP also has tubular auxiliary electrode. The raping system is a floating structure. The characteristics of this ESP are as follows: (1) higher migration velocity of the parcitle; (2) colleting positive particles; (3) the resistivity of the collection particles follow the the range of 10^3 Ω·cm—5×10^{11} Ω·cm; (4) has wider operation conditions; (5) larger specific collection area and high efficiency.

Application: The emission concentration of particles in the glass boiler and sintered ESP are 5 mg/m³ and 30 mg/m³ respectively.

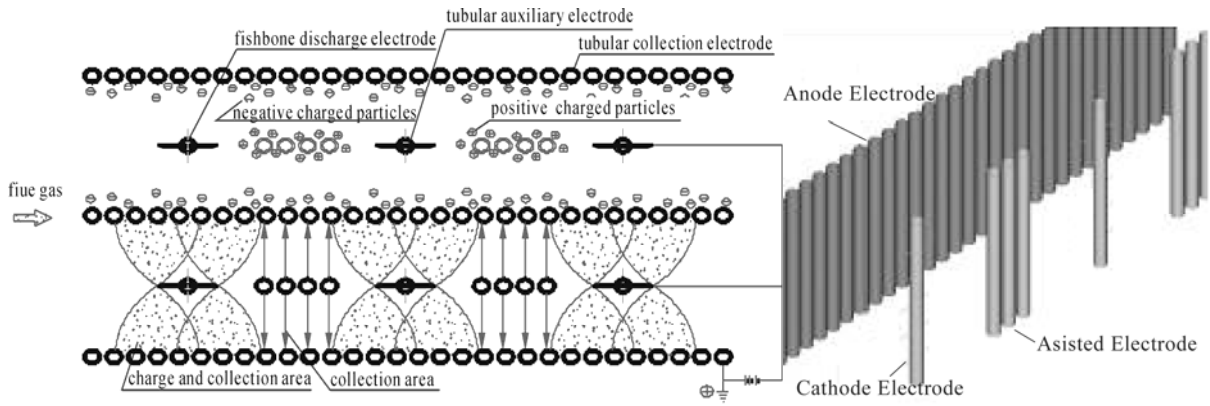


Fig. 2 Schematic Diagram of Tubular ESP

2.1.3 Cylinder ESP

Cylinder ESP was developed by Xi'an heavy Machinery institute, Xi'an Xikuang environmental protection Company and Xuanhua metallurgic environmental protection Company. This ESP is a critic apparatus in the convertor flue gas purification. The main component of the convertor flue gas is coal gas which has the risk of explosion. In order to prevent the coal gas and the atmosphere mixing in the ESP chamber, it is the best way to pass through the ESP as laminar flow without circumfluence. Consequently, the ESP was designed to cylinder.

The structure of the cylinder ESP is the same as the horizontal ESP, the inlet and outlet of are taper shape. The pressure impulsion of the ESP chamber 0.3 MP, and the emission concentration is 0.2 mg/Nm^3 greatly less than 10 mg/Nm^3.

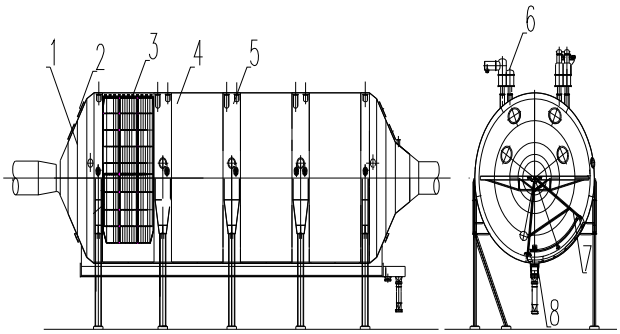


Fig. 3 Schematic Diagram of Cylinder ESP
1. horn shape inlet 2. explosion safe valve 3. electrode 4. ESP shield 5. tach 6. heat preservation box 7. dust scratch 8. dust transport engine

2.1.4 Roof ESP

The roof ESP is a light type build on the roof of the workshop, and mainly used in stove second flue gas purification. The second flue gas has characteristics of large volume of gas, small particle mean diameter, stochastic diffusion, fluctuation of concentration and temperature.

The characteristics of roof ESP developed by Beijing metallurgy construction institute and Wuhan security environmental protection institute are as follows: ①build on the roof of the workshop, no need of the land area; ②operate stably; ③ high efficiency with the wet rapping ④ low energy consume (flue gas float through the electric field itself by the flotage); ⑤low maintenance costs ⑥low invest costs.

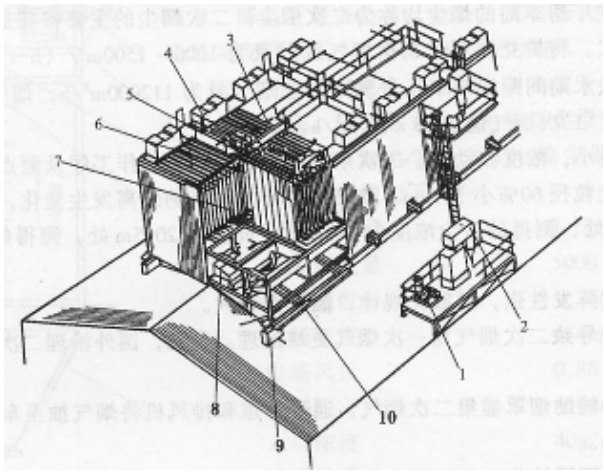


Fig. 4 Schematic Diagram of Roof ESP
1. fan for the insulator 2. high voltage power 3. water supply device 4. insulate box 5. water nozzle 6. collection plate 7. discharge electrode 8. water collect flume

2.1.5 Five-fields ESP

The five-fields ESP is developed by the Xi`an Yuqing Science & Technology Company. The schematic diagram of this ESP was shown in Fig. 5 and the characteristics as follows: (1) gas distribution and particle collection are ongoing at the same time in the pre-charge area; (2) collect the positive and negative particle; (3) charge repeating (especially in the high concentration particles area); (4) increase the collection efficiency of fine and light particles; (5) decreasing the reentrainment of light and fine particle; (6) the five fields can be combined flexible; (7) especially suitable for the old ESP. The results of the rebuilt project of sintered two-field ESP show that the emission concentration is less than 40 mg/m³.

2.1.6 High concentration dust removal with ESP

The inlet concentration is 700 g/Nm^3–1200 g/Nm^3 and the working pressure is –800～–1500 Pa of the ESP with DFGD in the cement production process.

The problems of treating high concentration dust removal are as following such as fixing equipment of pre-dust removal, air distribution and guide device reasonable, matching electrical apparatus parameters for electric field and the corona blocking, the development of new de-dust, the structure strength and the air leakage.

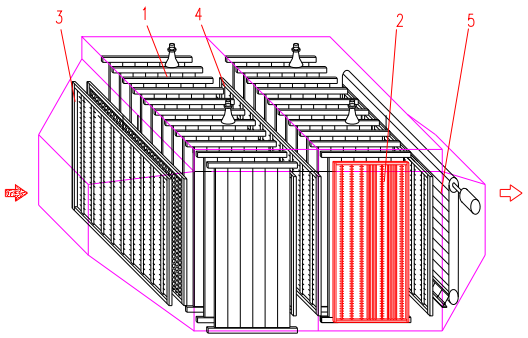


Fig. 5 Schematic Diagram of Five-field ESP

1. positive electrode 2. auxiliary electrode 3. gas distribution and collection electrode 4. charge repeating 5. rotate collection electrode

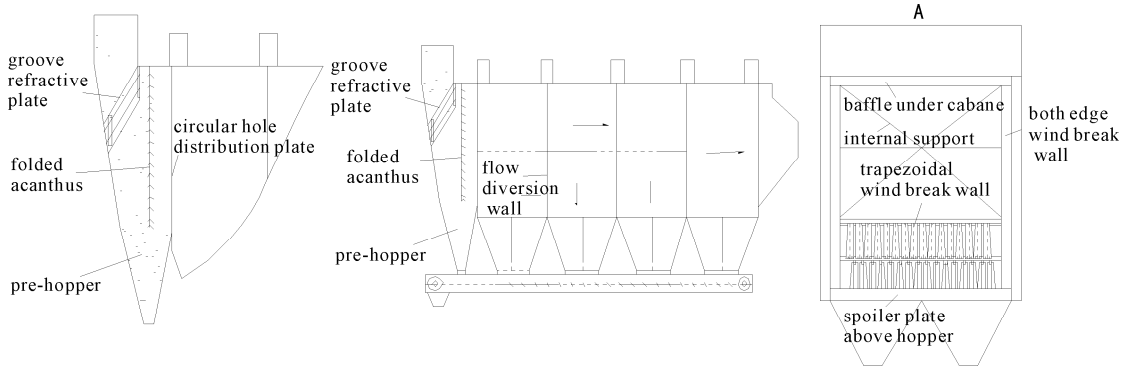


Fig. 6 schematic of ration dust removal with ESP

2.1.7 Application of ESP in machines and electricity with multimode and double-zone

The charge area and the Dedust area are independent in the ESP of machines and electricity with multimode and double-zone exploited by FUjian Longking Environment Corporation

The de-dust efficiency of BES102-4 in 2×130 T/n was up to 99.93% and the exit concentration was 27.4 mg/Nm^3.

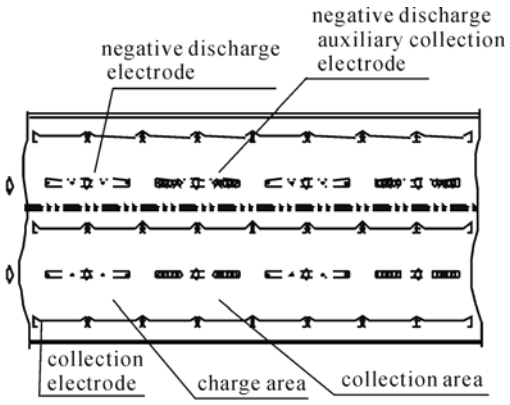


Fig. 7 ESP with Multimode and Double-zone

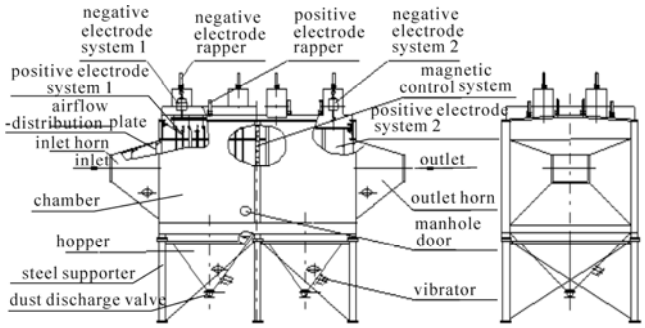


Fig. 8 Electromagnetism ESP

2.1.8 Electromagnetism ESP

The trajectory of charged particle was changed in magnetic field and the charged particle turned to collect plate and separated from flue in Electromagnetism ESP.

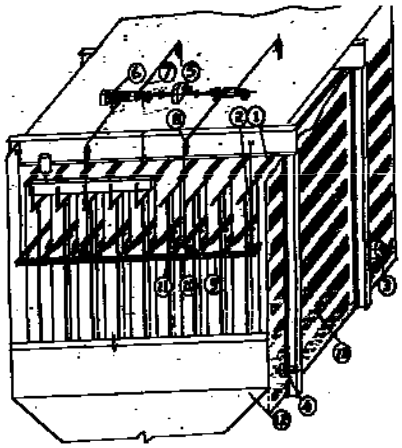
The Electromagnetism ESP developed by Qinghua tong fang Environment Company has high efficiency and lower consumption.

The inlet concentration is 39 g/m^3 and the outlet concentration was 48mg/m^3 in CKⅡ-45 with 40T/n Electromagnetism ESP.

2.1.9 Steel brush ESP

It is difficult to removal the glutinous, small bulk density dust, the steel brush was moved to clean the ash in the plate and wires.

There were several tens steel brush ESP developed by Angang design institute, and their drive speed can up to 50%-100%.



1 anode plate, 2 cathode wires,3 cathode rapping deceleration motor, 4 anode rapping deceleration motor, 5 brush bracket hoister, 6 controller, 7 wire rope, 8 trail rope, 9 brush bracket, 10 anode steel brush, 11 cathode steel brush, 12 dust hopper, 13 ESP shell

Fig. 9 Schematic of Steel Brush ESP

2.1.10 P-FF hybrid precipitator

Although the ESP and FF precipitator also have mature technique, they also have the disadvantages. The ESP has the characters such as lower resistance and maintenance; treating high temperature flue and firm structure, but it was difficult in high resistance. The efficiency of FF precipitator can be up to 99% used the appropriate filter material, while the disadvantages are the high resistance; high power consumption and high maintenance. The ESP-FF precipitator has the both advantages and no disadvantage of ESP and FF precipitator.

The ESP is the first precipitator; it can collect the 80% dust then decrease the de-dust pressure of FF precipitator and the abrasion of filter material. The charge effect of the former electric filed can enhance the characters of breathable and ash removal, it decreased the resistance and filter areas, it also increased the lifetime of filer bag and pulse valve then decrease the cost of maintenance.

The ESP-FF precipitator had the noticeable de-dust effect in the transformation program since the first one operated in Fujian Longjing. The ESP-FF precipitator is the best choice in the condition of high resistance.

The wet-ESP had also been developed expect above ten ESP technology as well as flue adjustment. The move plate ESP and INDIGO coagulation developed with foreign country also got success, plenty of develop working had done in the matching of plate and wire such as the corona wire used to decrease electric blind area, the fishbone needle and field specific resistance tester.

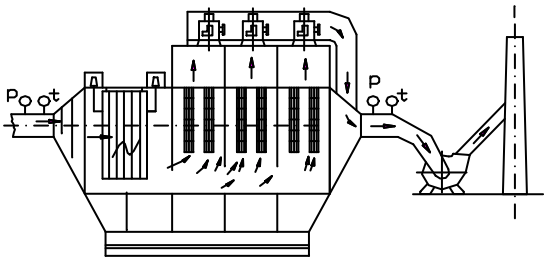


Fig. 10 ESP-FF hybrid precipitator

2.2 Power Source Technology

Dedust process in ESP is based on the principle of electrical physics. ESP has developed for more than 100 years with few technical breakthrough. But the state of art of power source technology may bring an important renovation to ESP.

ESP power source has developed for several generation. The performance of domestic conventional power source is similar to products from oversea.

To realize the goal of energy saving and emission reduction, Chinese researchers made an effort to do lot of friable work. Pulse power source and wised dynamic optimized control system have been developed according to the regulation between dust collection and electrical parameters. Based on this, emission can be reduced by more than 30% and energy can be saved by more than 70%.

These years, conventional power sources have been improved in China. Meanwhile, research and development of new kind power source are ongoing.

2.2.1 High Frequency High Voltage Rectifier

Up to now, Longking Environmental Protection Corp., Wuhan Guoce high tech Corp., Zhejiang Jiahuan Corp., Longyan Longmen Corp., have developed high frequency high voltage rectifier respectively.

Take Longking Environmental Protection Corp. as an example, its SIR power source adopts AC-DC-AC technology. Soft switch technology is used for protecting the inverse switch. Different resonance matching parameters are used for different sepecification of power source.

Longking has also developed a high power convertor, which give priority to full-bridge resonance part parallel resonance. The mixed topological structure can satisfy the requirements of continuable spark discharge and impact, and large scale load variety.

The problems of high power convertor and high frequency high voltage have been solved by nano-crystalline high-frequency high voltage transformer and self-developed large current high frequency high voltage silicon rectifier stack. The developed high frequency high voltage rectifier has passed the tests of bad environment and complex operating condition.

There are two kinds of power supply for control system, one is DC supply, the other is intermittent supply. And the control system has good control and protection functions: integration of high voltage and low voltage, rapping control program, power off rapping and back-corona auto-detecting and control, remoting control function.

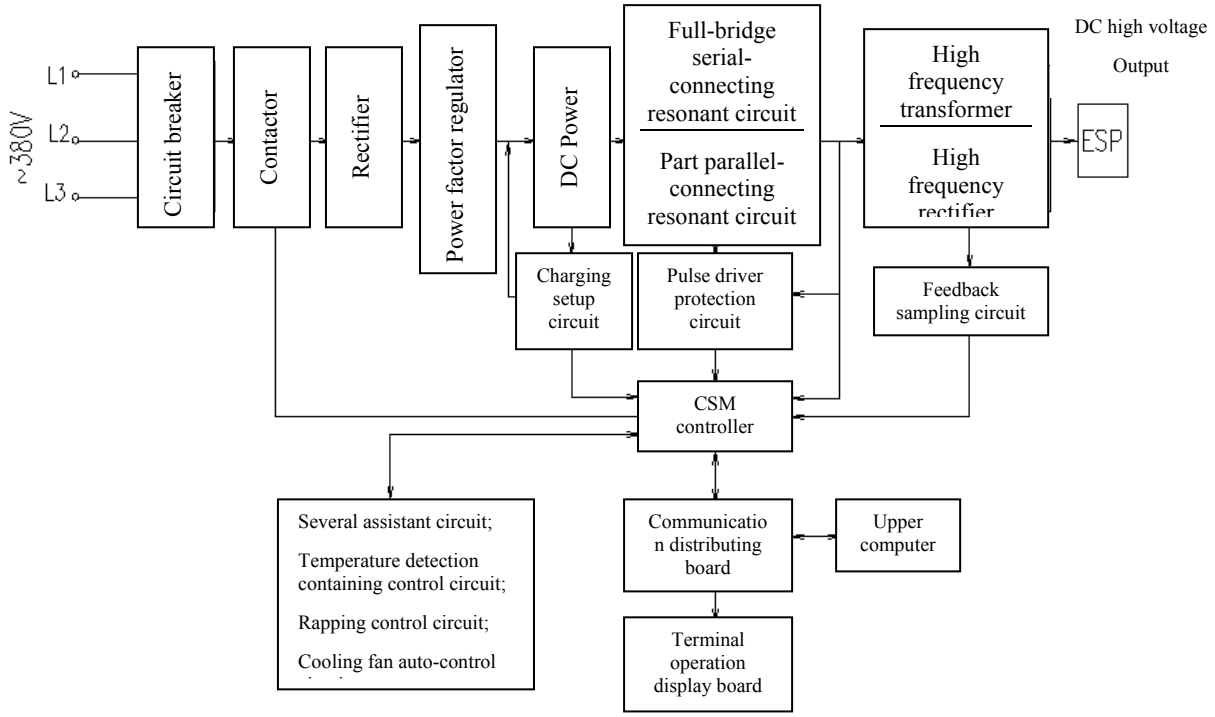


Fig. 11 Schematic of high frequency power source

2.2.2 Three phases silicon-rectification power source

Xiamen Lvyang Corp. and Jinhua Zhonghe Corp. have developed three phases silicon rectification power source, which using full wave rectification. Electricity, from electric grid Y308^{V}/50HZ enter the rectification, then stepped up by three phases transformer. After second rectification, the three phases high voltage will be added together on the discharging electrode of ESP.

The three phases silicon-rectification power source is good as single phase power source at the aspects of control and management function, spark control, and network monitoring. The two are compatible with each other. Compared with the latter, three phases silicon-rectification power source has other characteristics as follows:

(1) High conversion efficiency. The power factor is larger than 95, results in the small electric grid loss.

(2) High voltage output. Secondary voltage from three phases silicon-rectification power source is high. So the charge ability of dust and collection efficiency can be improved.

(3) Prominent energy saving if super high power setup is used. Primary current output of Single phase power source 2.0/72 kV is 541 A, but 230 A for three phases power source.

After using three phases power source in a aluminum production factory, its dust emission concentration is decreased from 600 mg/Nm^3 to 57 mg/Nm^3 and 37 mg/Nm^3.

In the electric reconstruction of 60 kW unit in a power station. Three phases power source was used on the first field, and intermittent power supply for others. The emission concentration was decreased from 130 mg/Nm^3 to 50 mg/Nm^3. Energy was saved by 60%.

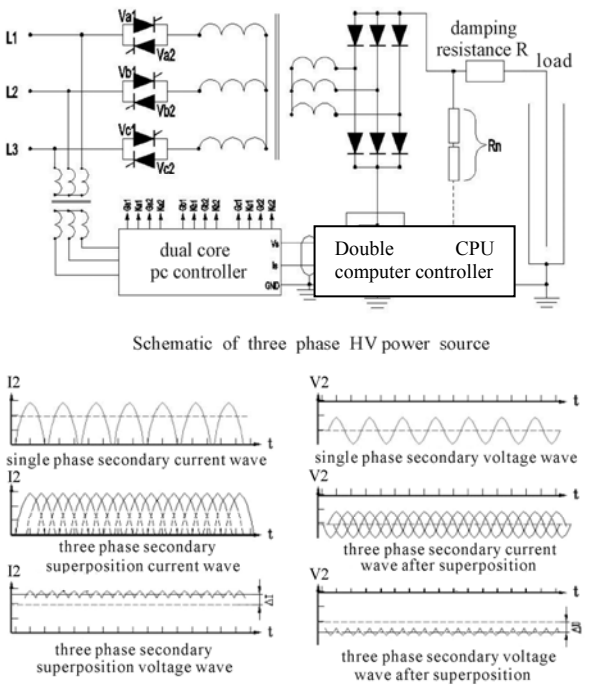


Fig. 12 Schematic of three-phases high voltage control

2.2.3 Three phases intermediate frequency DC high voltage power source

Intermediate frequency power source has the characteristics of both SCR power source and high frequency power source: low switch wastage, high power, small volume, good performance and technical environment. Large quantity

of this kind of power source can be produced with low cost in a short time and replace the SCR power source. Zhejiang Jiahuan Corp. and Wuhan University hve developed a kind of intermdiate frequency power source jointly:

(1) Operated under AC-DC-AC-DC, three phases high frequency adverse transform, intermediate 400Hz rectification. The work efficiency is improved obviously. Volume and weight of the power source is decreased, and output wave is more flat.

(2) Using IGBT module as switch, and double CPU as the core of control system,(TMS320F2812 from TI Corp. is used in operating control system, and ARM controller is used for monitoring). Several power sources constitute a control network and communicate with CAN or RS485.

(3) 0.21 mm–0.27 mm silicon steel is used as the core of transformer. Normal electrical wire and silicon stack are used as string wire and rectifying bridge. □/*Y* three phases winding and three phases rectfication. The volume and weight are much smaller than SCR power sources.

(4) Illegible PI (proportion integration) control method is used in stable voltage and current control system, and realize astatic control of voltage/current. SVPWM adverse transform technology is used for current transformation control, and realize three phases symmetry intermediate frequency AM and FM. In that way, switch wastage is small and DC current utilization can be improved. The output can be Stable DC wave and intermittent wave.

(5) Excellent protection function makes power source reliable.

(6) Control cabinet and transformer can either be separated or integrated.

The primary tests showing high dust removal efficiency and energy saving of power source. The practicality needs further verifying.

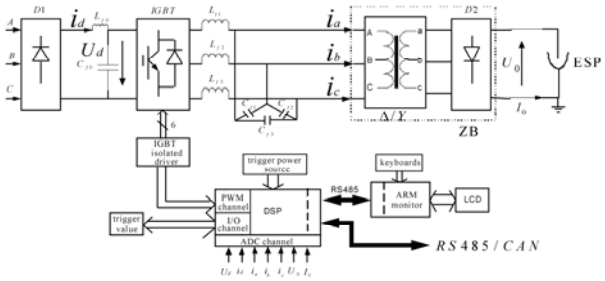


Fig. 13 Mechanism of Three Phase Medium Frequency Power Source

2.2.4 LC HVDC current power source

Shanghai Power Equipment for Laser Co., Ltd develops a HVDC Current Power Source. The mechanism of power source is rectifying line frequency of single phase output with L-C control cabinet and then converting to high voltage to load through transformer.

As indicated in Fig. 13. The condition of constant voltage, constant current and optimal discharge sparkle ratio is control by L-C circuit. Voltage is a random parameter. Current is set according to requirement and unaffected with electric field.

Thus, automatic tracking of high voltage can be realized. The above characteristics are benefit to obtain high operation voltage, enhance corona power and apply in complicated working condition.

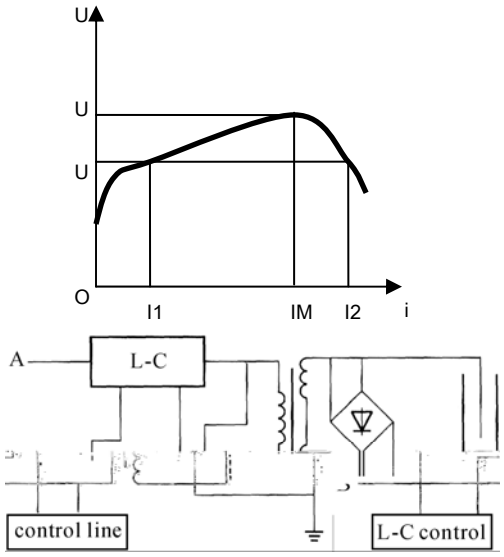


Fig. 14 Mechanism of HVDC Current Power Source

2.2.5 Development of plasma source

Plasma dedust and DeNOx/SOx is a promising technology which needs high frequency , sharp rising, and narrow pulsed high voltage supply. However, the previous pulsed power source can not meet the demand of dedust and DeNOx/SOx industry application.

AC/DC power source is an innovation streamer corona generator which is developed with several years of exploration and experience accumulation. This newly technique is realized by modulating a high voltage DC on high frequency AC and turning the glow corona to high efficient streamer corona.

The AC/DC system is consisted of high voltage DC, high voltage AC and AC/DC coupling circuit. AC and DC are all worked with resonant means through three-step process. In the first step, line frequency input is rectified with three-phase full-bridge controllable circuit. During the second step, the output from first step is filtered with a LC circuit. Then the filtered current is inverted into high frequency AC with a single-phase full-bridge inverter circuit which is composed of IPM and converted into high voltage with a transformer. The DC output is connected with a full-bridge rectifier.

The largest industrial application of AC/DC streamer discharge system for abating NO_x/SO_x (50 WM unit) is developed by Guangdong jiete Technology Co., Ltd and Guangdong Jiade Environmental Protection Co., Ltd.

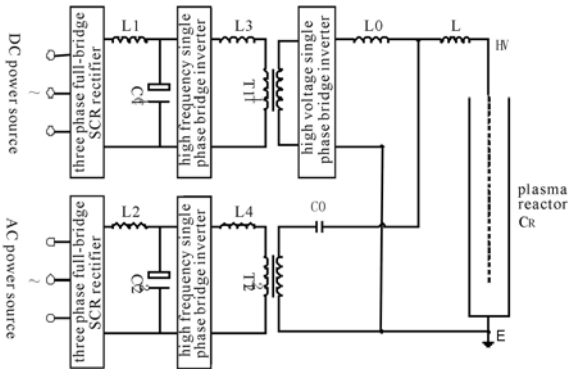


Fig. 15 Schematic of AC/DC Power Source

2.2.6 High frequency inverse DC (rectangle characteristic) power supply

Shijiazhuang Tuowei technology Co., Ltd develops a high frequency inverse DC power supply. Its rectangle VA characteristic can meet the following demands of high voltage ESP:

(1) Unaffected by long term short circuit and open circuit operation.

(2) The dust concentration can be automatically tracked when operation point is on vertical line of rectangle.

(3) Saving energy.

The rectangle VA characteristic is produced by double-closed-loop error. By regulating Ui value, the horizontal line of rectangle can be changed, thus setting safety operation voltage Uom. By regulating Ui Ii, the vertical line of rectangle can be changed, thus tracking operation point.

Almost a hundred dedust projects indicating the F type power source has stable running, high reliance and excellent energy saving properties. According to running datum of Shougang group and Shuangliang group, F type power source can save about 90% and 40% of energy and steel respectively compared with traditional optimal discharge sparkle ratio dedust system.

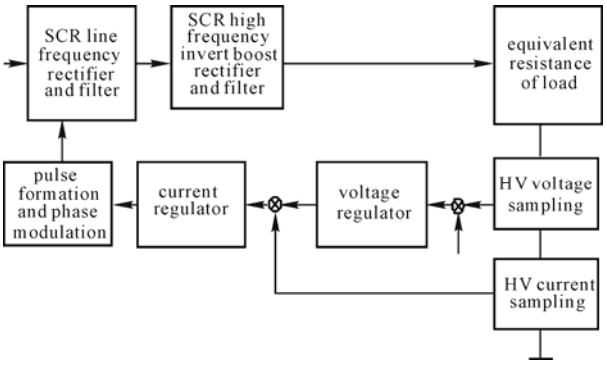


Fig. 16 Mechanism of High frequency inverse DC power source

Besides above mentioned, pulsed power supply has also been developed. Almost no breakthrough progress was made in last 30 years for single phase power source. However, various power supply modes have been innovated to meet the requirement of domestic market, such as highest mean voltage control, optimal discharge sparkle ratio control, critical sparkle tracking and low voltage control of PLC and DCS et al.. The collected datum transportation are also developed as field bus, ethernet network and OPC ports et al.

2.3 Associated Equipment and Technology

Excellent ESP equipment, not only needs a good body and superior electricity-supply technology, but also needs fine accessories. With the development of ESP technology, the accessories are also making progress.

There are more than 30 corporations in China to make accessories related to ESP industry, including electrode plate, electrode wire, insulation, sound wave dust-removal, level indicator, isolation switch, speed reducer gear, cinder valve, bearing ect. The following part will highlight two accessories, insulator – Longtai 95 ceramics, and SQ series sound wave dust-removal.

2.3.1 Tailong 95 ceramics

Tailong 95 ceramics are produced by the Nanjing Tailong Special Ceramics Company. α-Al_2O_3 (purity of 95%) is formed by uniform static pressure technique and then calcinated under 1600 ℃-1700 ℃. The products have strong mechanistic strength and resistance against high temperature and drastic vibration, 4-6 times higher than the normal electric ceramics. Their volume have been greatly reduced under the same condition. The main specialty of the product is of high resistance at high temperature, 10^9 Ω·cm under 400 ℃, but for normal electric ceramics, its volume resistivity will drastically reduce to 10^8 Ω·cm under 150℃– 200 ℃. Tailong 95 ceramics' excellent electromechanical performance under high temperature can maintain insulation requirement of all kinds of ESP. Their performance index has achieved or exceeded that of foreign products, but 1/2-2/3 lower price. So far they have been widely used in many domestic ESP equipments, some have been exported to Australia, America, Korea.

2.3.2 SQ series sound wave dust removal

The products are manufactured by Liaoning Zhongxin Co., Ltd. Their sound wave is produced by vibration filmstrips and the drive force is compressed air. The working pressure has a wide span and sound wave level index is also very high.

Table 2 SQ main technical parameters and a compare with other products

Type	Zhongxin Co., Ltd.	Foreign product	Domestic product
Frequency Hz	75-280	220	30-70
Sound pressure db	≥145	143-145	135-145
Sound resource Mpa	0.3-0.7	0.4-0.55	0.3-0.6
Air consumption	1.5-2.95	12-2.4	≥1.5

m^3/min			

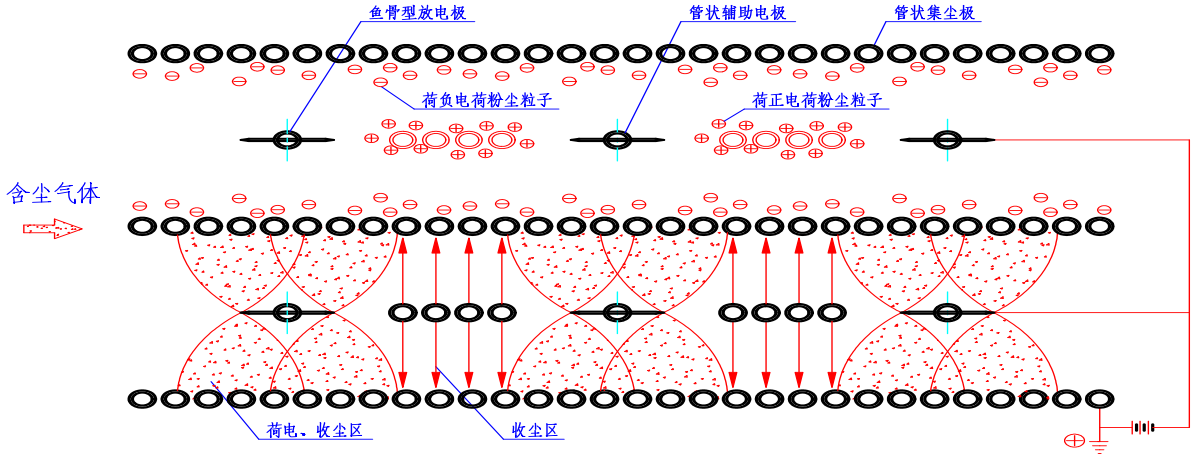
The products have been widely used in the steel industry, electricity industry and many other fields. They have many advantages, wide working space, good dedust efficiency, easy fixture, and low price. After application of the sound wave dust-cleaner, the dust emission concentration has been greatly reduced, from 247 mg/Nm^3 and 235 mg/Nm^3 to 58 mg/Nm^3 and 46 mg/Nm^3, respectively.

3 OUTLOOKS

Along with the acceleration of the process of urbanization and industrialization, energy industry and material industry need faster development. According to the 11th Five-year Plan, 165 million kilowatts are arranged during this period. Total electrical install capacity will achieve 650 million kilowatts till 2010, and coal-fire power will be 87 million kilowatts. During 11th Five-year Plan, cerement will increase 400 million ton. So the environmental protecting industry has a wide developing space. Serious air pollution control should be emphasized. On one hand, coal takes more than 70% in our energy structure, in the other hand, our extensive development mode needs a higher energy consumption. Coal-smoke air control provides a good chance to ESP to be widely used.

In order to improve equipment and energy utilization ratio, power plant and unit capacity is developing to 600000 kW and 1 million kW super-critical units. Cerement industry is also developing to 5000 ton/day, 10000 ton/day, and 12000 ton/day. All other industry equipments are also becoming macro-scale. Undoubtedly, ESP equipments are the main dedust apparatus for the macro-scale devices.

As the emission standard is improving, original ESP equipments need to be rebuilt. Of course, this is a heavy duty and there is much work for us to do in the field of ESP.



含尘气体：flue gas

鱼骨型放电极：fishbone discharge electrode

管状辅助电极：tubular auxiliary electrode

管状集尘极：tubular collection electrode

荷负电荷粉尘粒子：negative charged particles

荷正电荷粉尘粒子：positive charged particles

荷电、收尘区：charge and collection area

收尘区：collection area

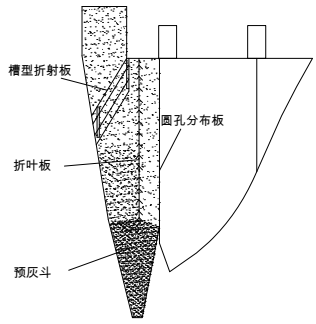


图3 分布板的布置图

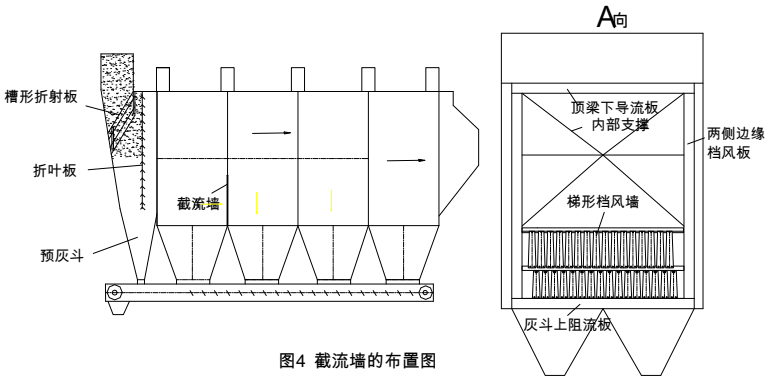


图4 截流墙的布置图

分布板的布置图：arrangement plan of distribution plate

槽型折射板: groove refractive plate

折叶板：folded acanthus

圆孔分布板：circular hole distribution plate

预灰斗：pre-hopper

截流墙：flow diversion wall

截流墙分布图：distribution graph of flow diversion wall

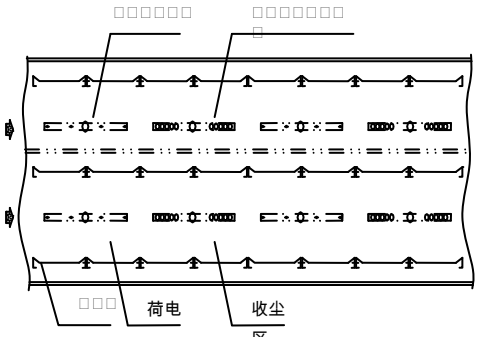
顶架下导流板：baffle under cabane

内部支撑：internal support

梯形挡风墙：trapezoidal wind break wall

两侧边缘挡风板：both edge wind break wall

灰斗上阻流板：spoiler plate above hopper



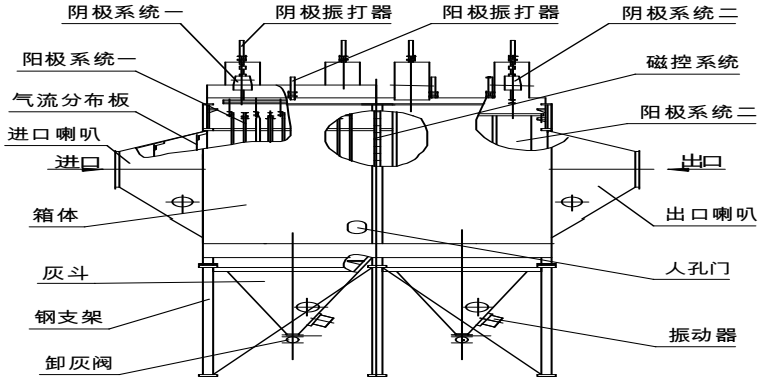
阴极放电电极：negative discharge electrode

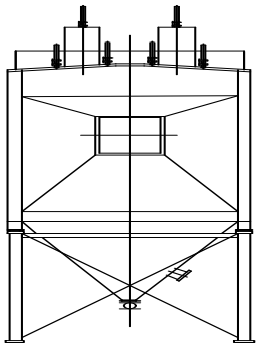
阴极辅助收尘电极：negative auxiliary collection electrode

收尘极：collection electrode

荷电区：charge area

收尘区：collection area





阴极系统一：negative electrode system 1

阳极系统一：positive electrode system 1

气流分布板：airflow-distribution plate

进口喇叭：inlet horn

进口：inlet

箱体：chamber

灰斗：hopper

钢支架：steel supporter

卸灰阀：dust discharge valve

阴极振打器：negative electrode rapper

阳极振打器：positive electrode rapper

阴极系统二：negative electrode system 2

阳极系统二：positive electrode system 2

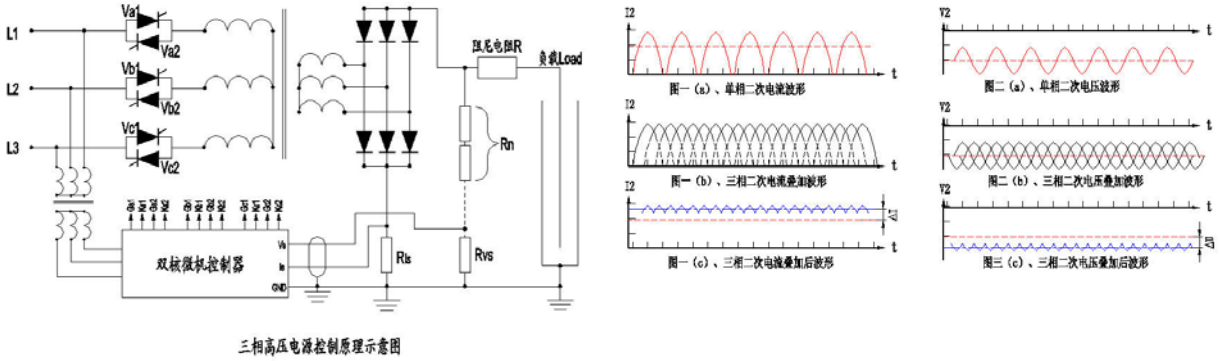
磁控系统：magnetic control system

出口：outlet

出口喇叭：outlet horn

人孔门：manhole door

振动器：vibrator



三相高压电源控制原理示意图

双核微机控制器：dual core pc controller

阻尼电阻 R：damping resistance R

负载：load

三相高压电源控制原理示意图：Schematic of three phase HV power source

图一（a）、单相二次电流波形：single phase secondary current wave

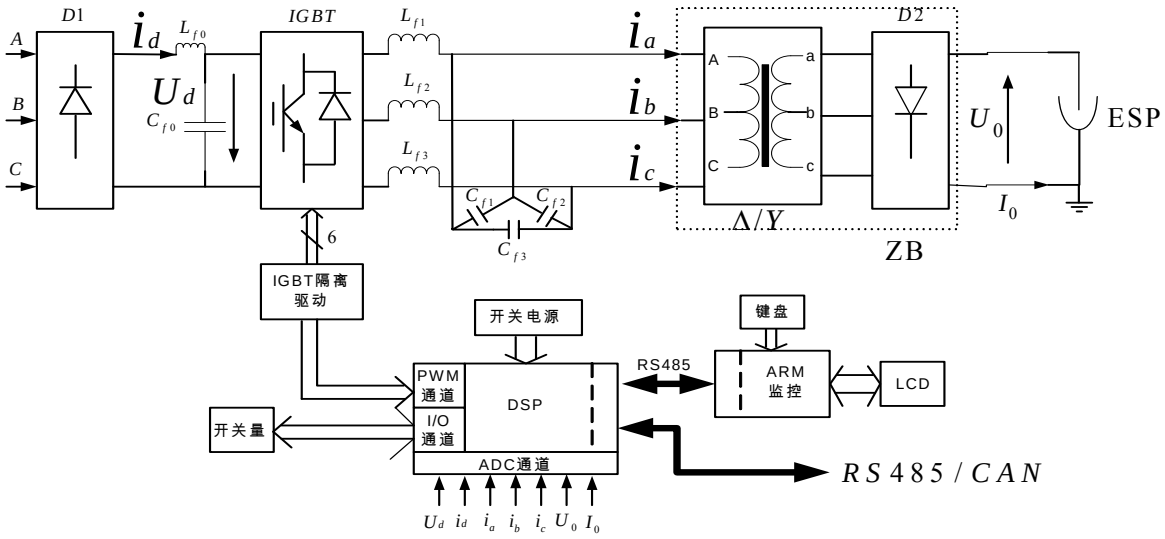
图一（b）、三相二次电流叠加波形：three phase secondary superposition current wave

图一（c）、三相二次电流叠加后波形：three phase secondary current wave after superposition

图二（a）、单相二次电压波形：single phase secondary voltage wave

图二（b）、三相二次电压叠加波形：three phase secondary superposition voltage wave

图三（c）、三相二次电压叠加后波形 three phase secondary voltage wave after superposition



IGBT 隔离驱动：IGBT isolated driver

开关量：trigger value

开关电源：trigger power source

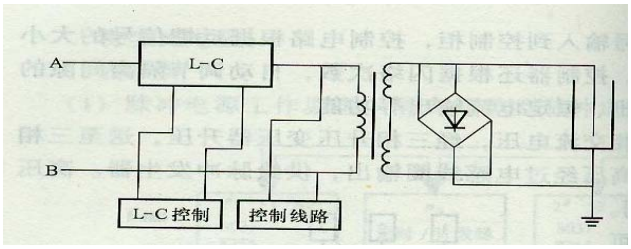
PWM 通道：PWM channel

I/O 通道：I/O channel

ADC 通道：ADC channel

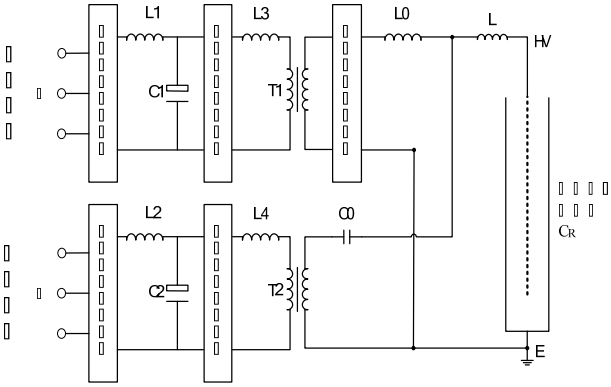
键盘：keyboards

ARM 监控：ARM monitor



L-C 控制：L-C control

控制线路：control line



直流电源：DC power source

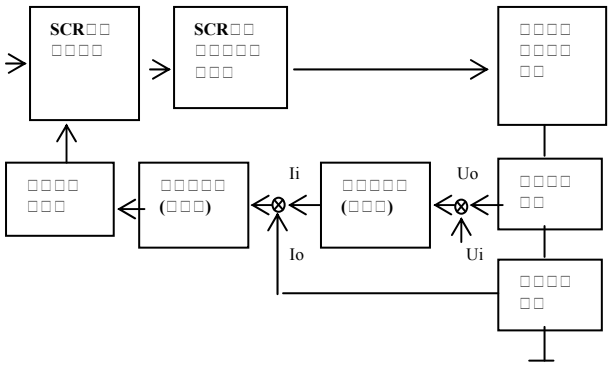
交流电源：AC power source

三相全桥可控整流：three phase full-bridge SCR rectifier

高频单相桥式逆变：high frequency single phase bridge inverter

高压单相桥式整流：high voltage single phase bridge inverter

等离子体反应器：plasma reactor



SCR□□□□□□：SCR line frequency rectifier and filter

SCR□□□□□□□□□□：SCR high frequency invert boost rectifier and filter

□□□□□□□□□□：equivalent resistance of load

□□□□□□□：pulse formation and phase modulation
□□□□□(□□□)：current regulator
□□□□□(□□□)：voltage regulator
□□□□□□：HV voltage sampling
□□□□□□：HV current sampling