Development of Energy Saving and Efficiency Enhancing Electrostatic Precipitator Power Supply Control Equipment

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Abstract: Energy-saving and efficiency enhancing are more and more important to the electrostatic precipitator (EP). This article introduces the structure of hardware platform and the connotative meaning of combination of high voltage (H.V) control and low voltage (L.V) control, presents the schematic diagram of multi-processors system structure and explains the advantages of hardware platform. The article also analyzes the power consumption during the EP's running process and introduces the two key technologies of achieving energy-saving and efficiency enhancing effect: one is using pulse power supply to reduce the non-effective and adversely effective electric power, lower the power consumption and improve the efficiency; the other is achieving dynamic optimization control by the method of analyzing the critical electricity parameters, it make the equipment run in the optimal state of energy-saving and efficiency enhancing. As is proved in practice, the equipment can lower the EP's working power consumption obviously, reduce the dust emitting and eliminate or weaken the back corona. This equipment has important actual meaning and high popularizing value.

Keywords: electrostatic precipitator, multi-processors, energy saving and efficiency enhancing, power supply control, back corona

1 FOREWORD

Electric precipitator is now the most widely used de-dust equipment with the advantages of high collection efficiency, dealing with high gas flow rate and low running and maintenance cost. In our electricity industry, the coal-fired power plants, whether new or conversion and extension, or old, they almost use the EP to clean the waste gas. The installed capacity of thermal power using EP is more than 90% of the general installed capacity of thermal power. But with the improving requirements in environmental protection, the EP in coal-fired power plant is faced with new challenge and opportunity. Firstly, "*GB13223-2003 Emission Standard of Air Pollutants for Thermal Power Plants*" has been put into practice on Jan 1st, 2004. Whether new or old power plant, the new national standard is much strict with the dust concentration than before. Secondly, the gas desulphurization technical process in many coal-fired power plants require strict limit on the dust concentration in gas, so the collection efficiency of EP shall be improved. Thirdly, the fuel used in our coal-fired power plants is mostly low-rank coal with high ash share and low sulfur. The variable coal rank is also a problem. China's the Eleventh Five-year Plan presents clearly that "build a resource-conserving, environment-friendly society" and encourages innovation. How to develop technical innovation, solve the difficult problems during the developing process in EP technology by exploiting EP's potential further, change the challenge into the opportunity become the urgent problems to be concerned and solved in the whole industry.

EP's power and control unit is important to adapt to the running conditions and improve the
overall capability of EP. So, it has great technical and economic significance to develop new EP's power control technology by ameliorating the energization technology, to realize the effects of energy-saving and high efficiency of EP by fully exploiting the potential of the existing EP systems.

2 HARDWARE DESIGN

EP's energization control unit is a kind of automatic control device and its core component is micro computer. During the EP's running process, we need a good real-time capability of the control and processing mass of data. For ensuring what control algorithm requests of calculating capability and satisfying the requests of system control and protection time, a high capability hardware platform is the base of improving EP's energization control unit.

2.1 Multi-processor Design

At present, because of the economic factor and the limitation of the computer and electron technique, most EP's energization control units, during the early developing procedure, adopt the design conception that on the premise of satisfying the necessary functions, reduce the margin of all sorts of resources as few as possible to make the cost down. We call this design conception "Compact Structure". So that is why most energization control units use single-processor.

We found the design of single-processor has its congenital deficiency. Firstly, the calculating capability of single processor is limited, but the working task is heavy, such as detecting the running conditions of electric field, control to the keyboard, data displaying, communication and others. Once conflict occurs, maybe it will result in wrong or missing spark capture, and then influence on the real-time capability of control, lead to the bad control performance and finally influence on the collection efficiency. Secondly, the current EP's energization control unit is a kind of intelligent

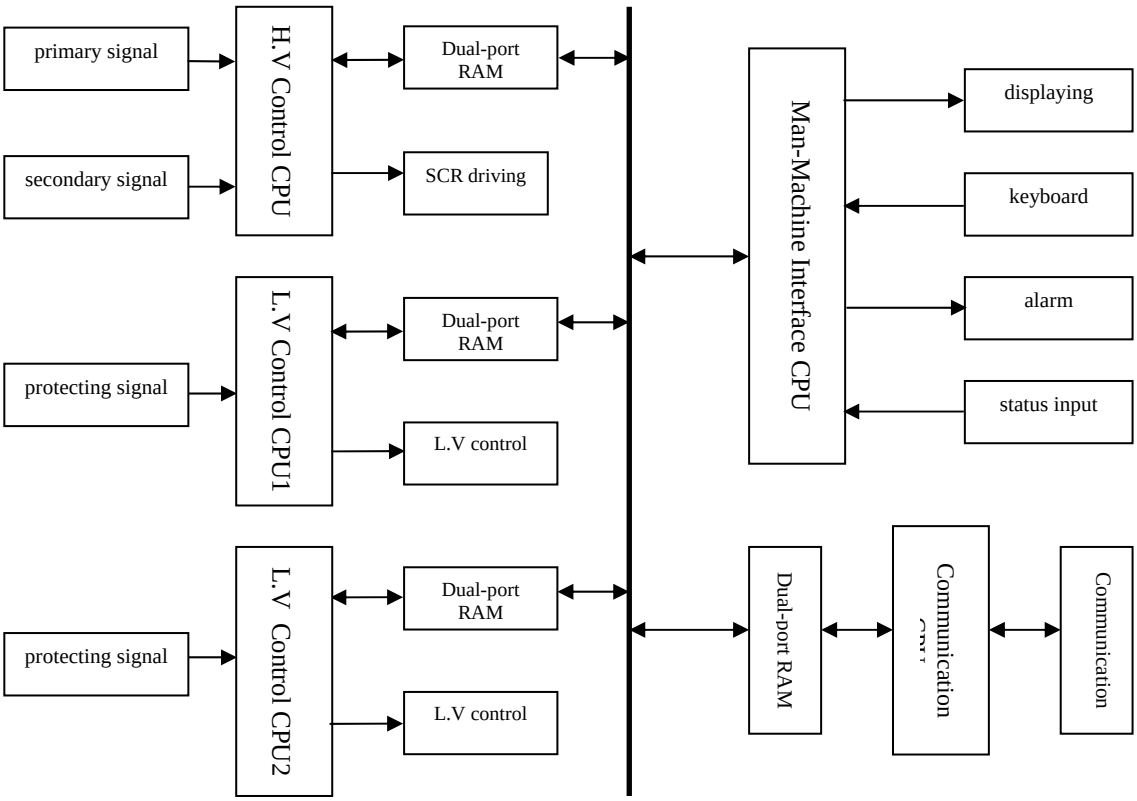

Fig. 1 The schematic diagram of system structure

product with micro computer as the core. The software influences the product capability greatly. As the single processor has its limitation, many advanced software functions and control algorithms can not be realized, the general capability of the product is limited, also the upgrade of the software is restricted. The multi-processor design and the construction of the high capability hardware platform can solve the limitation problems that single-processor design result in and can improve the general capability of product and the upgrading ability of software obviously.

The schematic diagram of system structure is shown as Fig. 1. The basic conception is as follows: According to the control functions of the device, the whole controller is divided into several different functional modules; every functional module uses one processor to complete the corresponding control function; each processor exchanges data by Dual-Port RAM; Man-Machine Interface CPU centrally manages each functional module.

Multi-processor system is consisting of several different computer systems. As each CPU system is independent mutually, the data exchange between each CPU is a very important problem. The serial communication can not adapt to the condition which require a high real-time capability of control because of its low communication speed and high consumption of software resources. So we use dual-port RAM share technology: each CPU uses respective dual-port RAM as the interface of system bus; Man-Machine Interface CPU handles data exchanges between different CPU systems fleetly. It can greatly improve the real-time capability of system, save the system resources, and make the most of multi-CPU control system's advantages.

2.2 Integrate H.V Control and L.V Control

At the present time, most EP's energization control systems always adopt the design concept that separates the H.V energization with the L.V devices control. It separates the H.V DC energization with the L.V devices control in a single electric field, respectively using independent control cabinet. This design concept dissevers the connection between H.V and L.V equipments, restricts the advancement of EP's capability.

We adapt the design concept of "integrate H.V control with L.V control". "integrate H.V control with L.V control" means that design the control unit according to a single electric field , integrating the H.V energization control and L.V devices control of one electric field in one control unit. On the one hand, this design concept can improve the integration level, save the floor area in control room and reduce the project cost. On the other hand, the L.V control is changed centralized control into distributed control of every electric field, this can avoid the control invalidation of a whole EP's L.V devices when L.V control device is damaged, improve the system running reliability. Additionally, it can realize the voltage reduction rapping control. By improving the vibration cleaning effect, the de-dusting efficiency and the EP's adaptability to the special, complicated working condition is improved effectively.

3 ENERGY-SAVING AND EFFICIENCY-ENHANCING PULSE ENERGIZATION MODE

For EP's H.V energization control system, in order to improve EP's de-dusting efficiency as high as possible and reduce the dust concentration as low as possible, the control system is always working in spark adjustment mode to make the running voltage U2 closed to the sparkover voltage and to make the secondary current I2 as high as possible. We call it "big power and high energy consumption" working mode temporarily. The EPs of China's coal-fired power plants are almost all running in this working mode.

Theoretical analyze indicates that, in ideal conditions, the EP which dealing with the gas flow rate of 8 $m^3/h \times 105$ m^3/h only needs several hundred watt power if it has a high de-dusting efficiency. This is a very small energy. Although in actual conditions, the EP's running power consumption is a little higher than the theoretical value because of the dust re-entrainment, the un-uniformity of gas distribution and EP's power supply characteristics, the power consumption should be in a reasonable range. But in the actual applications, for realizing the design de-dusting efficiency, the electric power consumption can be high to several hundred kilowatts, and that is greatly higher than the theoretical analyzing value. The primary reason is the very low utilization rate of electric power in spark adjustment working mode.

During the EP's running process, the power consumption used in dust collection includes three kinds. The first is called "effective" power that is used to charge and capture the dust; the second is called "adversely effective" power that destroys charging and capturing the dust, such as back corona and dust re-entrainment; the third is called "non-effective" power that is neither beneficial nor harmful, such as the charge which is not used to charge and capture the dust in corona discharge process, also we call it "wasted" power. The three kinds of power all exist. Actually in total power consumption, most are adversely effective power and non-effective power, few is effective power. If using advanced methods to improve the ratio of effective power, to depress the ratio of adversely effective power and non-effective power, it's certain to improve EP's de-dusting efficiency and reduce the power consumption.

In recent years, we researched the EP's energy-saving and efficiency-enhancing deeply based on the world's advanced technology. We developed pulse power supply with functions of energy-saving and efficiency-enhancing in research of the novel EP's power and control unit DKZ-2B. This energization mode well utilizes the inductance characteristic of T/R and the capacitance characteristic of EP's electric field. It rationally controls the amplitude and the cycle of the output pulse in given scope, outputs the appropriate energization wave shape.

The pulse energization improves the power efficiency and achieves good effect.

4 INTELLIGENT DYNAMIC OPTIMIZED CONTROL

During the EP's running process, by reason of the changes of boiler load and coal rank, the running conditions is always dynamic. The energization parameter of EP should be altered synchronously with the different running conditions so that the EP can be always on the most optimized status. After theoretical analyze and many industrial applications, we found the regularity between the EP's running conditions and the electric parameter. On this basis, we developed the intelligent dynamic optimized control function. The core is that when the EP works, according to the variable properties of the gas and the dust, analyze and judge the wave shape of voltage, current and the characteristic of U-I, automatically select the working mode, conduction angle and energization wave shape based on the mathematic model, therefore the voltage and current supplied to the EP's collection electric field are always on the best status. The intelligent dynamic optimized control is good for charging and capturing dust to improve the de-dusting efficiency, reduce the dust emission and the energy consumption.

5 APPLICATIONS

Figs. 2 and 3 enumerate partial industrial applications. We can see the evident effect.

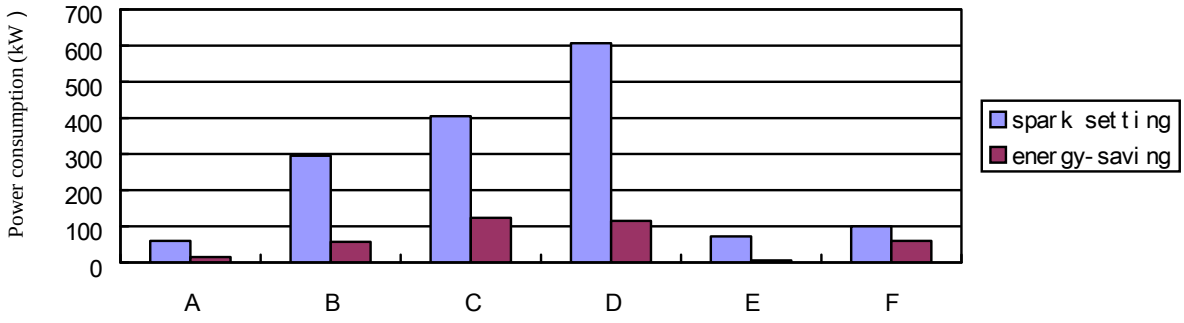

Fig. 2 The comparison of the power consumption between in spark setting power supply mode and in energy-saving and efficiency-enhancing power supply mode

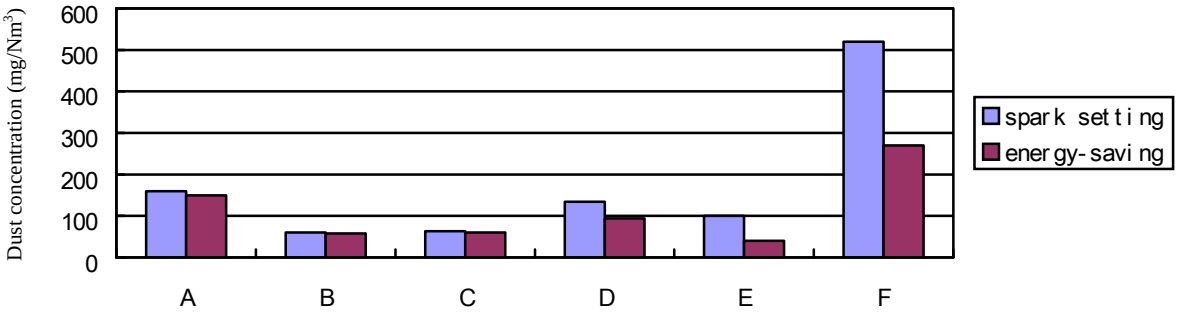

Fig. 3 The comparison of EP's outlet dust concentration between in spark setting power supply mode and in energy-saving and efficiency enhancing power supply mode

In Fig. 2, the power consumption on energy-saving and efficiency enhancing power supply mode is lower than that on spark setting power supply mode. The average decrease is more than 70%.

In Fig. 2, on energy-saving and efficiency enhancing power supply mode, the EP's outlet dust concentration reduced with different degrees, the highest decrease is more than 50%.

6 CONCLUSIONS

(1) EP's energization control unit is the automatic control device and its core component is micro computer. A high capability hardware platform is the base of improving the whole control capability. The design of multi-processor and combining H.V control with L.V control improves the general capability of the hardware platform.

(2) The required dust-cleaning energy of EP is very small in theory. The actual power consumption is big when EP runs. The primary reason is low utilization rate of electric power. Pulse energization can raise the utilization rate of electric power obviously and has the effect of energy-saving and efficiency enhancing.

(3) The new-generation power and control unit of EP DKZ-2B(50 Hz) has many advantages such as energy-saving and efficiency enhancing, intelligent optimized control, optimized rapping, weakening and overcoming back corona. The device achieved obvious effect in industrial applications: The decrease of outlet dust concentration is more than 50% in some power plants; the average saving power consumption is more than 70%.

(4) The EP's running conditions in coal-fired power plants should be changed from "big power and high energy consumption" to "energy-saving and efficiency enhancing".

The successful development of DKZ-2B has important practical significance and the equipment deserves popularized widely.

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