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Design and Optimization of Thermal Instruments: Comparing Traditional and Modern Technologies

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Abstract: The overall construction operation of thermal instruments in the power plant includes the installation of surface meters, program control instruments, instrument pipelines and connecting cables. In the installation process, it is necessary to ensure the aesthetics and reliability of the thermal instrument installation, which will directly affect the normal operation of the equipment. At the installation site, it is necessary to make various connections between control rooms, instruments, instruments and control rooms, and instruments and pipelines. In order to ensure the safe and stable operation of thermal instruments, it is necessary to do a good job in the installation of thermal instruments in power plants, master the technical points of thermal instrument installation, and lay a good foundation for the safe and stable operation of thermal systems in power plants. Based on this, this paper compares traditional and modern technologies, and mainly designs and optimizes the thermal instruments in thermal power plants.

1. Introduction

With the technical progress, the functionality of thermal instruments has been greatly improved, and the acquisition of thermal parameters is more accurate and efficient, especially the application of thermal automation technology, which improves the intelligent management and control level of industrial production. If boilers, deaerators, demineralized water tanks and other related equipment in thermal power plants are stored in the open air, the related thermal automation equipment will also be set in the open air.

As far as the current development situation is concerned, the realization of the safety performance and economic benefits of the generator set largely depends on the thermal control system, which is a key factor to ensure the safety of the control unit by adjusting and installing some relatively complicated software. This paper compares traditional and modern technologies, and mainly designs and optimizes thermal instruments in thermal power plants [1].

2. Application of thermal instrument in power plant

The overall construction operation of thermal instruments in the power plant includes the installation of surface meters, program control instruments, instrument pipelines and connecting cables. Simply speaking, it is to form a loop system with unrelated components according to the original design requirements, and complete the task of detection or adjustment. Traditional thermal instruments in power plants are mainly used in the following aspects: liquid level control, temperature, pressure and delivery flow. With the development of automatic control system, the automation of thermal instruments in power plants has been widely used, and the automation technology has greatly improved the working efficiency of thermal instruments. In power plants, the installation of thermal instruments and devices is a very important link. Optimizing thermal instruments and devices can greatly improve the working efficiency and economic benefits of power plants.

In the process of thermal instrument installation in power plant, the specific installation contents mainly include thermal instrument management, control device, source taking parts, measuring instruments, electrical wiring, control panel and so on. In the installation process, it is necessary to ensure the aesthetics and reliability of thermal instrument installation, which will directly affect whether the equipment can operate normally [2-3]. At the installation site, it is necessary to make various connections between control rooms, instruments, instruments and control rooms, and instruments and pipelines. Moreover, during the installation of thermal instruments, it is necessary to consider the relationship between thermal instruments and pipelines, equipment, civil engineering, electricity, heat preservation, anti-corrosion and other professions, and maintain close cooperation to ensure the smooth installation of thermal instruments. Liquid medium has many applications in industrial production, and in order to effectively monitor liquid level changes, it is usually necessary to use liquid level sensing devices to ensure the accuracy of thermal measurement.

3. Design of thermal instrument

With the progress of modern electronic technology, thermal instruments have made great progress and played an important role in industrial production and technical development, especially in the measurement and application of physical quantities such as pressure, temperature and flow in industrial production [4]. Judging from the current domestic situation, most of the thermal instruments in many industrial production are calibrated by adjusting potentiometers, which stabilize the calibrated instruments at a specific temperature and humidity, input standard signals from small to large according to certain standards, and then input standard signals from large to small after entering the full scale. It is necessary to manually read and record the displayed values of the instruments, and adjust the instruments according to error analysis to obtain error limits and correction values. This traditional calibration method is complicated and has limited efficiency, and this calibration method of adjusting potentiometer is not ideal in industrial field application to some extent.

The electro-hydraulic regulating and tripping protection system is a powerful guarantee for the safe and stable operation of the turbine, and both are provided by the main engine factory. If the main engine factory is not familiar with the control system that realizes this function, it will bury hidden dangers for the safe operation of the generator set in the future [5]. The electro-hydraulic regulation and trip protection system of steam turbine is provided by the steam turbine factory in complete sets, the electro-hydraulic regulation and trip protection system of steam turbine is provided by the steam turbine factory, using PLC, and the related signals are connected to DCS by hard wiring. This scheme effectively reduces the project investment cost on the premise of ensuring the safe and reliable operation of the system. The intelligent equipment management system server is set in the central control room, and is connected with the corresponding DCS local area network or HART protocol receiver and the information management network. The DCS power cabinet adopts two-way incoming wires, and the control cabinet is powered by two incoming wires respectively, while the man-machine interface system such as the engineer station is powered by the switched power switching device arranged in the DCS power cabinet [6-7]. Thermal instruments can basically achieve automatic, accurate and intelligent control, and the acquisition of thermal parameters is more efficient and reliable. Not only can they provide timely and accurate feedback on equipment and process anomalies, but they also have adaptive functions, so that the working conditions are in a controllable range. In the safe, economical and high-quality production, the application of thermal instrumentation automation plays a key role and should be paid attention to.

In this project, an electric door distribution cabinet is set up, and the power supply takes different sections of the auxiliary power, and a double power supply switching device is set in the cabinet. After switching, the power supply provides power for the on-site electric door. Both AI/AO signals and DI/DO signals use redundant channel cards and supporting terminal boards, while simple status indication and DAS signals use non-redundant cards and supporting terminal boards. The pressure transmitter, mass flowmeter, radar level gauge, magnetic flap level gauge, zirconia, valve positioner and actuator are all intelligent products based on HART protocol [8]. In view of the shortcomings of metal hose, the connection of metal hose is abandoned, and the connection mode of steel wire armored cable and steel wire armored stainless steel cable sealing head is selected. The branch cable between local instrument and local junction box is selected as steel wire armored multi-strand copper core polyethylene insulated PVC sheathed flame retardant copper wire braided shielded computer cable.

4. Optimization of thermal instruments

4.1 Optimization of electric heat tracing system

Electric heat tracing is to install a semiconductor polymer material which plays a heating role between the insulation layer and the traced pipeline, and make use of electric heating energy to make up for the heat lost in the sampling process of the instrument sampling pipeline, so as to keep the temperature of the medium in the instrument sampling pipeline in the most reasonable range. Because the conductive chemical polymer material is automatically adjusted by the ambient temperature, the temperature of the medium in the instrument sampling pipeline will fluctuate in the most reasonable range [9].

Through the principle of thermal expansion and contraction, we can know that if the temperature of the environment where the heating cable is located is low, the chemical polymer materials used for conducting electricity will shrink, and then a current will be formed that can make the heating cable start to generate heat. On the contrary, if the temperature of the environment where the heat tracing cable is located is high, the polymer material will swell, and at the same time, it will block the gathering of carbon particles and the formation of loops. In addition, when setting the anti-freezing device, it is necessary to pay attention to the combination of steam heat tracing and electric heat tracing. The electric heat tracing is one of the most stable heat sources, which takes electric heating elements as the most basic heat source and plays a good role in the production and operation of thermal power plants.

Electric heating cables can be laid by parallel method and winding method. If the calculated heat loss per unit length is less than the rated heating value per unit length of electric heating cable, generally, the parallel method is adopted, that is, aluminum tape is used to directly attach the heating cable to the pipeline, and heat-resistant tape is used to wrap the electric heating cable radially every 0.5 m; The power supply of electric heat tracing power cabinet comes from two paths of 380 V AC power supplies, namely MCC A section and MCC B section of boiler operation layer, and then it is distributed to the power supply circuit of instrument incubator of main workshop through automatic power supply switching device, small bus in the panel and fuse.

4.2 Optimization of thermal instrument conduit valve

Although the steam parameters of ultra-supercritical units have far exceeded the specified pressure and temperature range, the content is no longer applicable, but the standard of the same material as the main pipeline is still applicable. At present, P92 pipes can be purchased in the market, but small-diameter pipes need to be ordered in advance. Compared with P92, TP316H stainless steel has higher carbon content and better decarburization resistance, so it is suitable for use at high temperature. In addition, although the water supply pressure is high, the temperature is not high, so stainless steel can also be used, and all instrument conduits in front of and behind the primary door can be made of TP316; Some projects choose 12Cr1MoV material. What kind of material is good to use, and the advantages and disadvantages should be considered comprehensively according to the actual situation to choose [10].

The wall thickness of instrument conduit is calculated according to ASME B31.1 wall thickness calculation formula. The formula is as follows:

$$t_m = \frac{PD_0}{2(SE + Py)} + A \tag{1}$$

Where: t_m is the calculated wall thickness (mm), P is the designed internal pressure gauge pressure (MPa), D_0 is the outside diameter of the pipeline (mm), and SE is the maximum allowable stress of the material determined by the pressure and weld joint coefficient (or casting quality coefficient) at the design temperature. y is the coefficient.

Wall thickness after considering negative deviation of pipeline:

$$\begin{aligned} t_m &= t_m + c \\ c &= \alpha t_m \end{aligned} \tag{2}$$

Where: α is the negative deviation coefficient of pipe wall thickness, and when the negative deviation specified in the product technical specification is 10%, α is 0.11.

The specification of instrument tube, taking the instrument tube of the main steam pipeline as an example, the wall thickness calculation formula shows that the wall thickness of the conduit in front of the primary door is 7.3mm, and the specification of the conduit we choose is Φ 33*8, and the wall thickness of the conduit behind the primary door is 3.6mm, and the specification of the conduit we choose is Φ 18* 5. The same method can be used to calculate the instrument pipe specifications of hot reheat steam system and water supply system, and the results are shown in Table 1.

Table 1: Instrument conduit specification

location	type	material	specifications
steam main	Primary portal catheter	P92	Φ33*8
	Primary portal catheter	TP316H	Φ18*5
Hot reheat steam pipeline	Primary portal catheter	P92	Φ25*5
	Primary portal catheter	TP316H	Φ15*5
water supply pipe	Primary portal catheter	WB36	Φ25*5
	Primary portal catheter	TP316	Φ18*5

There are two different opinions on the selection of instrument valves in China: ordinary instrument valves and process valves. In China, the design of instrument primary valve belongs to thermal engineering specialty, so the instrument primary valve in China is mostly familiar with thermal engineering specialty. The selection of valve size mainly depends on the consideration of valve circulation performance, and the valve size should be 10 mm ~ 20 mm. With the increase of the diameter, the weight of the valve itself also increases sharply, which leads to the increase of the valve cost and the stress of the pressure tap weld. Therefore, the selection of valve size should be based on the principle of sufficiency, and the valve with smaller size should be selected as far as possible.

4.3 Optimization of thermal instrument installation

The operating system of thermal control is very extensive and comprehensive, and its location is relatively scattered during installation. Its main features are wide coverage and tight working time. In the process of installation and operation, every operating system in the power plant is involved. In the specific construction stage, the objects and media that need to be faced are different, so the corresponding specific requirements in the work are also different. For the above reasons, the thermal control installation work must be meticulous, the arrangement of construction period must be reasonable, and the communication work must be done well during the operation. Only in this way can the actual operation work be completed well.

The optimization of thermal instrument installation in power plant can be summarized as follows: first, check and verify the quantity and quality of equipment on the construction site before construction operation to prevent the problem of equipment quantity discrepancy during construction; Second, when installing the instrument panel cabinets in the control room, the DSC application operating system system should be included, and the installation of various other instruments should not be ignored; Third, through the cooperation between various operating systems in the field, the source installation is completed at one time; Fourth, when installing field instruments, avoid places where corrosion and magnetic field sources interfere.

In order to meet the requirements of measurement, power supply and signal transmission, it is necessary to install all kinds of pipelines and wiring reasonably when installing thermal instruments. When it comes to the laying of thermal instrument pipelines and wiring, it is necessary to consider the convenience of maintenance and inspection, rationally plan the pipeline layout and optimize its final presentation effect. Moreover, it is necessary to improve the technical level of instrument wiring to make the wiring of thermal instruments more reliable and safe. Attention should be paid to the linkage trial operation of thermal system, and remote and local operation should be replaced, and instruments such as pressure and control should be put into use as required to comprehensively test the instrument system, laying a foundation for the realization of automatic control function.

5. Conclusions

As far as the current development situation is concerned, the realization of the safety performance and economic benefits of the generator set largely depends on the thermal control system, which is a key factor to ensure the safety of the control unit by adjusting and installing some relatively complicated software. The deep integration of automation technology and thermal instrumentation is not only the inevitable result of technological development, but also the need of modern industrial development. In order to ensure the safe and normal operation of the thermal system in power plant, it is necessary to do a good job in the installation of thermal instruments, which is a very complicated project. It is necessary to master the specific installation technical points in the specific construction process, and at the same time, the installers should constantly improve their own technical level and install in strict accordance with specific requirements, effectively ensuring the quality of thermal instrument installation, ensuring the scientific and reasonable installation, and laying a good foundation for the safe and stable operation of the thermal system in power plant.

References

[1] Qiao Hong, Zhang Quanzhuang,&Wu Rong. Modeling of thermal parameters based on improved smo algorithm [J]. Automation technology and application, 2010, (10), 4.

[2] Zhao Taogan, Zou Yun, Gao Chuanchao, & Feng Jiansen. Optimal design and thermal analysis of energy-saving and environmental protection porous brick based on ansys [J]. Silicate Bulletin, 2019, 38(6), 8.

[3] Hu Runyong, Huang Yu, Zhao Dou, Xiang Youhong, Liao Fangfang,&Yin Xiaolong, et al. Design of in-situ calibration device for measuring instruments in thermal and hydraulic tests [J]. China Test, 2022, 48(S01), 207-210.

[4] Wan Jingqiang, Qin Xiaojie, & Fang Yanjun. Design and Implementation of Instrument Metrology Verification Management System Based on B/S [J]. Automation and Instrument, 2011, 26(8), 5.

[5] Wang Fang. Design of remote monitoring system for high-speed wire rod based on wincc webnavigator [J]. Automation and instrumentation, 2016, (8), 3.

[6] Zeng Weidong, Wang Chunli, Yan Yuping, Ding Wei, Su Pengliang,&Li Yadu. Discussion on the Design of Fieldbus Control System for Large Thermal Power Units [J]. Thermal Power Generation, 2010, 39(3), 4.

[7] Xu Zhi, Jiang Daoqing,&Xu Huogen. Design improvement of axial offset control under MSHIM mechanism [J]. Automation and instrumentation, 2016, (1), 3.

[8] Zhang Yubi, Liu Haiding, Wang Dongzhe, & Zhao Yongtao. Process design and heat treatment of a nitrogen-containing cr-ni austenitic stainless steel [J]. Hot working process, 2016, 45(18), 6.

[9] Zhou Hong, Duan Yong,&Cui Yuheng. Design of a thermal instrument that can be quickly calibrated on site [J]. World Economic Yearbook of Chinese Businessmen Urban and Rural Construction, 2008, 000(008), 203-203.

[10] Wang Yi. Research on the causes of failure and maintenance countermeasures of thermal instruments [J]. Architectural Engineering Technology and Design, 2017, 000(036), 2762.