Research for a New Type Plant-wide DCS Integrated Main and Auxiliary Control Network

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Abstract—**For the development of distributed control system (DCS), a new plant-wide DCS main and auxiliary control integration network was introduced, that means the whole plant is equipped with Unit Plant DCS. Unit Plant DCS public network and the whole plant auxiliary plant control network Combine into a new structure of the plant-wide DCS public network. It is proved feasible through the simulation experiment data and actual operation, and also provides the reference for the development of plant-wide DCS main and auxiliary control integration.**

Keywords-plant-wide DCS main and auxiliary control integration; new type network; DCS.

I. INTRODUCTION

Distributed control system (DCS), as a technically mature and reliable control system, has been widely used in the domestic power plant unit and important auxiliary system control. With the continuous reduction in price, the DCS control range has been extended to the general use of the water, coal, ash and other auxiliary workshop controlled by PLC (Programmable Logic Controller) , and plant-wide DCS control integration gradually become a trend. At present, the network structure of the power plant's main and auxiliary control is still a traditional mode. The mode is that each unit is used to configure Unit DCS plant according to the furnace, mechanical and electrical integration, and two units of public system set up DCS control network which connects control system of each unit through the communication interface; Auxiliary workshop (water, coal and ash) system establishes auxiliary network, like the main control network, to associate with the Supervisory Information System (SIS) in whole plant. There is also a new network structure that the whole plant has unit DCS and DCS public network, which hangs all auxiliary workshop control system on the public network. The paper is the analysis of the feasibility of this kind of network structure and its application in practical production.

II. NETWORK STRUCTURE ANALYSIS AND SIMULATION

A. New Network Structure

In order to explore the feasibility of the whole plant DCS main and auxiliary integration network control in large unit (4 × 1000MW, 6 × 1000MW), this experiment uses Guodian Zhishen EDPF-NT + control system and organizes a 1:1 model test, focusing on the following aspects of the problem after the whole plant auxiliary control network integration:

Information transfer and control;

The network traffic of each node;

Information processing capacity and location in operation director station;

The configuration, data information and communication traffic in Historical Storage and Retrieval Station;

In order to make the conclusion more extensive, the simulation experiment takes 6 x 1000MW power plant main and auxiliary integration network as the test model, data for all domains are from actual configuration projects with the same scale, only the public portion of the plant is designed according to the size of two auxiliary control units because there is no actual project. Overall, the public measuring point data in plant is too large, more than about 20% ~ 30%. The 6 x 1000MW power plant main and auxiliary integration network topology designed by the experiment is shown in figure 1:

The characteristics of the topology model is**:**

1) Each unit sets up a control field, including boiler control and its auxiliary parts (such as blowing SPC, in situ ignition, furnace tube leakage, etc.), steam turbine, small steam turbine control and auxiliary control part (e.g., DEH/MEH, TSI/MTSI, ETS/METS, etc.)

2) Every two units built in the same period establish a unit public domain, including these subdomains: the public electric parts of the two units , instrument and maintenance of air compressor control parts, desulphurization control part, circulating water pump house control; Boiler make-up water treatment control part, circulating water and ash control unit, condensate polishing treatment section, ash removal at ash field and so on (the part of coal is treated as the factory public; the part of desulfurization which belongs to the unit system domain is treated as the unit plant domain, while the other part of desulfurization which belongs to the public system is put into two units public part)

3) There's a public domain of the factory, it includes the following subdomains: Whole plant electrical control part, Water sources and water supply system control section, Coal yard and coal handling system control section, and Ash removal public system control part, etc.

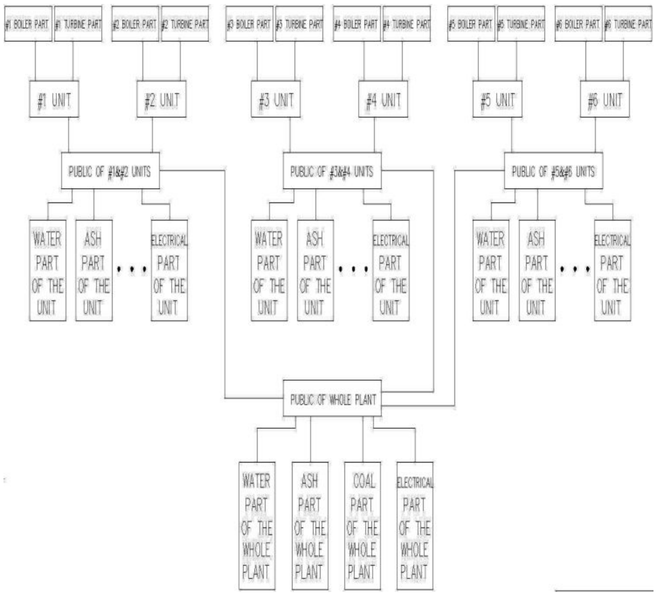

Figure-1 The topology of 6×1000MW plant-wide DCS main and auxiliary control integration

Traditionally, the power unit DCS public network and the auxiliary workshop control network are set as two separate networks, but this network structure is different. It treats the two networks as a whole plant DCS public network. According to the similar project estimate, every domain I/O point is set as Table-1:

TABLE-1 MEASURING POINTS TABLE OF EVERY DOMAIN

1. Unit Plan	101693 points
2. Public Electric Parts of Unit Plan	8190 points
3. Water System of Unit Plant	26553 points
4. Coal System of Unit Plant	9529 points
5. Ash System of Unit Plant	78969 points
6. Desulfurization system of Unit Plant	21037 points
7. Public Electric Parts of Whole Factory	50360 points
8. Water System of Whole Factory	26553 points
9. Coal System of Whole Factory	9529 points
10. Ash System of Whole Factory	26553 points
Total:	1207320 points

B. Data Simulation

1 unit uses the hardware devices of a million units laboratory, which has totally 33 controllers, and the other domains projects use Guodian Zhishen EDPF-NT + professional communication simulation software DDS, which can load all the controller databases in this domain and send data on time like the controller.

EDPF - NT + system adopts the network control and management technology to take control of the information flow ,that is: the information of each unit is independent of each other, doesn't enter into other units; Public information of every two units is independent, doesn't enter into the other two units' public area and other units. Communication mechanism of EDPF - NT + system also implements the two mechanisms: data multicast and publish-subscription, the default configuration is: real-time data multicast at periodic points and publish-subscription at non-periodic points. The characteristic is it's fast to open the process monitoring picture for the first time, less than 1 second. And when open the SAMA diagram, it's slower for the first time, less than 2 seconds, because the real-time data at non-periodic points need to be subscribed from the controller.

C. The Experimental Results

a) The test results under mixed communication mode

EDPF-NT+ system takes the network control and management technology to achieve the information flow control, for example, the # 1 unit MMI only receives the information from domain 101, public domain (and affiliated) 107, # 1 and # 2 unit public domain 121, 122, 123, 124, 125. All irrelevant information, such as other units and utilities will be effectively separated. After the power plant's main and auxiliary control network integration, the communication information of # 1 unit is shown in figure-2:

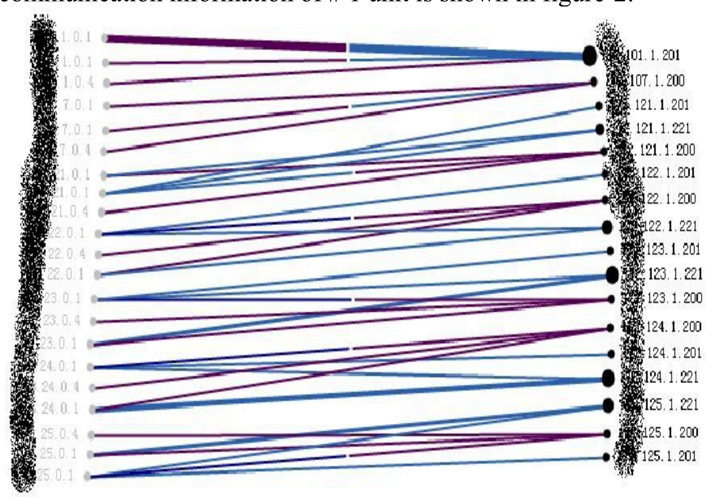

Figure-2 # 1 unit communication information figure after main and auxiliary control network integration

In order to monitor the information flow in the system, there're 11 network nodes (node position is shown in Figure -1) in the network topology model for monitoring in this experiment, and finally it is concluded that all nodes of the network traffic is shown in table-2:

TABLE-2 EVERY NODE OF THE NETWORK TRAFFIC

Sequence No.		Owner	Network Load%	Comment
1	Node 1	#1 Unit	8.68	
2	Node 2	#3 Unit	8.68	
3	Node 3	#5 Unit	8.68	
4	Node 4	#1 #2 Units Public	13.76	
5	Node 5	#3 #4 Units Public	13.76	
6	Node 6	#5 #6 Units Public	13.76	
7	Node 7	#1 #2 Other Public	1.2	Ash
8	Node 8	#3 #4 Other Public	1.6	Polishing
9	Node 9	#5 #6 Other Public	1.3	Desulfurization
10	Node 10	Whole Plant Utilities	50.97	
11	Node 11	Whole Plant Other Utilities	1.6	Water

As can be seen from the table, when EDPF-NT + system uses a mixed communication mode, since the historical stations are scattered in various domains and there is no need to contact each other, the information processing of every unit's nodes and every two units' public nodes is less than 30%, within reasonable limits, if the number of domains (multiple units) and domain information (large units) increases, the network overhead increases, in the circumstances of the 6 × 1000MW ultra-large-scale network, the information processing of node 10 is very large, the reasonable range is much larger than 30%, the most reasonable position of operation director station is to be connected to the public switch in the whole plant, but large information flow causes the slow response of operation director station.

b) the test results under publish-subscribe mode

When EDPF-NT+ system takes publish-subscribe communication mechanism, network traffic will change based on the subscription points. After testing, operation director station is connected to the whole factory public switch, the information processing is less than 10%, which is in a reasonable range. Refer to the principle of publish-subscribe mechanism, according to EDPF-NT+ system data report management method, theoretical calculations for amount of data can be used after taking all the subscribers in the mechanism and in the most extreme cases. For example, as shown in figure -1, 6 x 1000 mw power plant's main and auxiliary control integration, Unit is divided into six domains, each domain DPU site number is 100; The public of unit is divided into 15 domains, and each domain of DPU site number is 20; The public of the whole plant is divided into four domains, the number of sites for every domain is 20 DPU.

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Inquiry screen is calculated by the big screen pointing out four pictures, and every picture applies for data to all the domains DPU (including minority cross-domain), refer to the provisions of subscription mechanism, every DPU which is applied for data must send the data in two minutes to the application machine. Taking the most extreme case of data into account, four pictures can be switched per minute based on the operation and capabilities of people, and in this case, the applied data is double from the source DPU. DPU data management of EDPF-NT+ system puts 100 measuring points into a package to send, so it can include all of the applied data by application machine, that is, a package, the maximum size is 1200 bytes, therefore, amount of communication data generated from DPU: 4 × 2 × 1200 bytes = 9.6Kbytes, through the above calculation, we can draw even in the most extreme case, the amount of communication data connected to the whole plant switch operation director station is: 980 × 9.6Kbyte = 9.1875Mbyte, which means the network load is 9.2%.

Described above is an extreme case, only to test the system and network performance after 6 × 1000MW main and auxiliary control integration, which does not exist in the actual production, because a screen content is limited, it is impossible that operation director station simultaneously sends the subscription request to all controllers in a domain, a reasonable estimate for network load is of 1% to 2%.

Above all, for large-scale power plant, the unit DCS public network and the corresponding auxiliary workshop merge into a whole plant DCS public network, the control system can take the publish-subscribe communication mechanism to meet the needs of actual production.

III. THE PRACTICAL APPLICATION OF NEW MAIN AND AUXILIARY CONTROL INTEGRATION NETWORK STRUCTURE

The first phase of development of Xingyang power plant is two 600MW supercritical coal-fired condensing steam turbine units, the whole plant uses hierarchical and level-to-level management on network control and management system. The boiler-turbine in this phase is unit system, using stove, machine, electricity centralized control mode. Every unit configures the distributed control system (DCS) network based on stove, machine, electricity integration, the closely related program controller and auxiliary control device(electric protective device, ASS, AVR, etc) are also hung on the unit plan network. Two unit plants also have public system control network, it connects to the communication bus of each unit through bridges. It can monitor the public system device at every unit's DCS operation station; it also has the lock control. The network is the whole plant DCS hardware integration network structure, the whole plant has DCS unit and DCS public network, water, coal, ash auxiliary workshops are also connected to the public network except fuel oil pump house, circulating water pump house, Instrument air compressor part. This network structure gives up traditional auxiliary network and realizes the integration of main and auxiliary control integration. The first phase of development of Guodian Xingyang power plant's two 600MW supercritical units DCS system network structure is shown in chart-3:

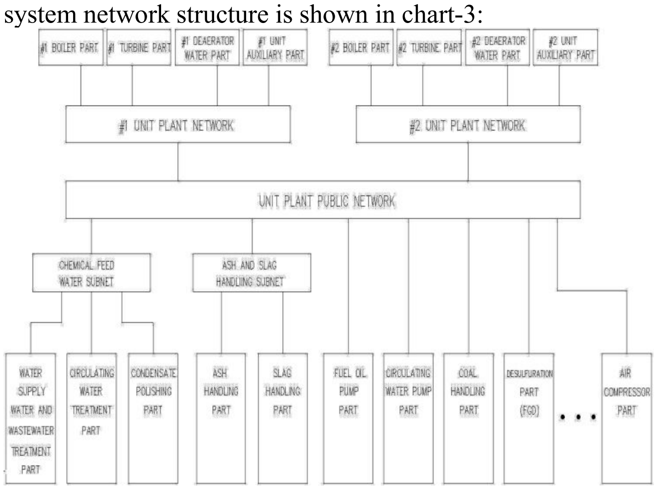

Figure-3 Guodian Xingyang power plant first phase 2 x 600 mw supercritical unit DCS system network structure

During the performance testing, all the network nodes data is smooth, network load is mainly between 3.3% and 5.9%, and only the network load of public network nodes on the main switch occasionally reaches 7.2%, but still within the reasonable scope. Two 600MW supercritical units in the first phase of development of Xingyang power plant pass 168h full load operation since November 2010, after normal power generation, DCS network is secure and stable, whose control systems fully meet production needs, and no failure has occurred because of the control system and the network structure of the furnace, such as shutdown, jumping machine, etc.

IV. Conclusions and Expectation

With the continuous reduction in price, the control of DCS integration in power plant has been accepted by more and more design institutes and power plants, and compared to controlled by PLC auxiliary plant (water, coal, ash), the control of the whole plant DCS integration can be done seamlessly on hardware device, eliminating the need for interaction between the PLC and DCS compatibility issues. Compared to the traditional plant main and auxiliary control DCS, the structure of the new network structure is more clear and the less-layer network, and with the development of the controller and the operation speed increased, the advantages of such a network will become more evident. The experiments and practices prove, unit DCS public part and the whole plant auxiliary workshop parts merge into a whole plant DCS public network can meet the control requirements of actual production. Analysis For this new main and auxiliary controls DCS integrated network structure can be classified as an attempt on the whole plant DCS integration development and research

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