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International Workshop on Automobile, Power and Energy Engineering IP Start-up Control for 300MW Turbine Unit with Bypass System

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Abstract

Based on the analysis of characters of 300MW unit IP start-up, an approach with bypass system about turbine control has been explored in this paper. Control model for IP start-up is given. The pre-warm control of IP start-up and the start-up mode switching are discussed in detail. Control logic for main valve, valve exchanging and bypass system are properly designed. The opening curve of IP regulation valve is given. The schedule is successfully applied in the IP start-up of #8 turbine system, Shalingzi power plant, China. The actually operation results shows that the control logic is right and reasonable. It's available for the system requirements.

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Keywords: 300MW Turbine Unit; IP Start-up; Bypass Control;

1. Introduction

The installed gross capacity of Shalingzi power plant is 8×300MW, all the single-machine capacity is 300MW. Among them, the steam turbine of #1~#2 turbine system is the triplex steam turbine which is produced by DongFang Steam Turbine Works and the triplex steam turbine is composed of HP, IP and LP, the steam turbine of #3~#8 turbine system is the combined cylinder turbine composed of HP and IP which is produced by DongFang Steam Turbine Works who bring in and absorb the technology of the Western House US. October 31, 2006, Harbin University of Science and Technology, together with Shalingzi

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Power Plant, did the IP Start-up Control reform to this #8 turbine system, the reform achieve the cool state IP start-up system and the Grid Connection propitiously first time what was a useful attempt for eight 300MW turbine system of this plant achieving security, economic, rapid start-up and got successful and much valuable experience. To the end of 2010, the plant completed the IP Start-up Control reform for eight 300MW turbine units propitiously and got successful.

2. Features of the IP Start-up

The state of the turbine system start-up is sure according to the wall metal temperature of the HP, DEH can automatically determine the start-up state according to the actual situation:

- The cold start-up: <150 □
- The warm start-up: $150-300$ □
- The hot start-up: $300-400$ □
- The super heat start-up: ≥ 400 □

The IP start-up has some features as:

- The time of the IP start with cold is short, and the economic return is high. When the IP start-up with cold is used, steam can go through the IP with a low requirement of the steam condition, so with improving the steam condition, it can achieve the washing machine, constant speed test, Grid Connection with load, and it is also conducive to find out and handle the problem during the start-up on time, contract the time from the turbine system start-up to commercial operation. The HP and IP start-up together because the HP need a high steam condition, and at the same time, the time of start-up will be longer often due to the high pressure of the main steam and the reheat steam, the high and the Intermediate pressure valve with a low open-level when the machine being washing, the unstable vibration with a low open-level. When general turbine system use the cold start-up, the time and the economic returns of the IP start-up is shorter and higher than the HP and IP start-up together.
- The IP start-up can avoid several technical issues just like the cylinder expansion unsmooth when the turbine system start-up. When the steam turbine use the hot start-up, the temperature of the main steam and the reheat steam is not in accordance with metal easily, it is hard that avoiding a big negative differential expansion between the rotor and the cylinder in the way what is used the entering steam with high and intermediate pressure together. The reason is that the open level of the high-pressure valve is low and the throttling level is high, so the temperature drop sharply after the high-pressure valve working, the cooling effect is great for the high-pressure rotor. There are not above faults if using the IP start-up.
- The IP start-up can reduce the life-span consumption of the turbine system, because when the IP start-up, the temperature condition is low, the time of the IP cylinder pre-warm process time is long relatively, Being heated of the cylinder is evenly, the corresponding condition can also be improved, the heating to IP, HP, the steam turbine rotor and the cylinder is abundant, bring down the heat stress loss, prolong the life-span of the turbine system [1-3].

3. The status of the turbine system and the control system

The #8 turbine system, Shalingzi power plant, is N300-16.7/537/537-4 type (combined cylinder). It is subcritical pressure turbine, intermediate-reheat turbine, two-cylinder and two-exhausting turbine, extraction and condensing turbine. The Steam Turbine control use the high-pressure fire resistant oil Digital Electric Hydraulic Control System (DEH), it can achieve the coordinated control of the electric furnace. The bypass uses 40%BMCR capacity two-series-wound bypass and three- de-super-heating bypass systems. The high-pressure bypass steam is exported from the front of the high-pressure main fan

valve, discharged to the re-heater quencher pipe after the one-de-superheating-reducing. The low-pressure bypass steam is exported from the front of the intermediate united fan-valve, discharged to the condenser after the one and two-de-superheating-reducing. The high pressure bypass regulator valve, the high pressure spray regulator valve, the high pressure spray section valve are constitute the high-pressure bypass system. The low-pressure bypass regulator valve, the low-pressure spray regulator valve, the low-pressure spray section valve, three-spray section valve are constitute the low-pressure bypass system.

The #8 turbine system steam turbine speed control system of the plant use the INFI-90 high-pressure fire resistant oil Digital Electric Hydraulic Control System(DEH)of the ABB.USA, DCS is the MAX 1000 Plus system of MCS.USA [4], the bypass control system is unitized 300MW turbine system 40%BMCR bypass control system what is supplied by Harbin University of Science and Technology steam turbine bypass research institute, the three system is mutual independence, and they have not achieved network communications, part of the transmission signal communicate by hard-wired, achieve the cooperative control of the electric furnace. If the IP start-up will be used, these three control system should be part-transformed and the control mode should be corrected, it leadingly include: the selecting and cutting over of the way the turbine system start-up; changing of the way the cylinder and the valve pre-warm before start-up; cutting over of the valve control way; the opening curve regulation of IP regulation valve; the Interlocking control logic of fan valve; increasing the start-up control curve of the steam turbine IP in the bypass system and changing the automatic input way of the high and low pressure bypass [5]. There are some problems to resolve:

- The turbine system pre-warm. Before the steam turbine start-up, the HP pre-warm use this control tactics that do the cylinder of the HP pre-warm first, and then do the valve pre-warm, the time of the process is too long.
- The selection of the turbine system start-up way. There is only one way to start-up the steam turbine what is HP and IP start-up together, there are not two start-up ways to transform and allowable control logic.
- Control of the valve switching. The enabled condition of the valve switching is not complete, or some conditions do not suit the practical situation of the #8 turbine system, there are shortage of necessary conservation logic, for example: when the valve switching begin, extraction check valve start-up concatenate.
- The control of the fan valve. In order to keep the vacuum degree of the HP, control the temperature of the HP, we need increase the fan valve, at the same time of increasing the opening and closing control, we must increase the homologous catenation and alarm logic.
- Achieving the bypass control way. Since the #8 turbine system was on stream, bypass system was used in this way the HP and IP start-up together, for the requiring of the IP start-up, the high and low bypass system all need to increase the IP start-up control logic, so it was necessary to check and setting up the High and low side pressure control loop.

4. The plan of the IP start-up control

The #8 turbine system steam turbine, Shalingzi power plant, is the combined cylinder turbine composed of HP and IP which is introduced by DongFang Steam Turbine Works from Western House US, there is not a precedent of this kind of turbine system which use the cool state IP start-up in China, according to the design feature of the turbine system, investigate the control tactics, we provide following improved plan according to the control system which is used now.

- The HP pre-warm. The cylinder and the valve of the HP do the pre-warm at the same time. It is shown as in the Fig.1. (a). when the pre-warm begin, one aspect the HP is heating up by the inverted warm valve opening, the other aspect the high-pressure main fan valve open as the jaw opening 10% (the

servomotor of the #8 turbine system main fan valve use the servo valve control), do the valve pre-warm. When the metal temperature of the cylinder in the HP is higher than 150℃, the HP pre-warm process is completed, the inverted warm valve is closed automatically; when the metal temperature in the high-pressure main fan valve is higher than 150℃ or the metal temperature difference between the wall and the extern is less than 38℃, the valve pre-warm process completed, the high-pressure main fan valve is closed automatically [6].

- Selection of the turbine system start-up way. Increase the selection and control logic of the IP start-up way. The default start-up way of the turbine system (the turbine system hit gate, the system electrify again) is HP and IP start-up together, HIP/IP start-up can be clicked to change by the push button or the screen of the operator station, the condition of the IP start-up: the steam turbine is in cool state, all the valves are close, the bypass is automatic (include the high bypass and the low bypass). Selection of the start-up way will only be select before the steam turbine restoration, main fan valve opening (turbine system running), if the turbine system have run, the start-up way is allow to change for the start-up reliability.
- Valve changing logic. The low bypass close all, the CV valve close all, the dynamo grid connection, the IP start-up way, the temperature difference between the main steam and the cylinder metal of the HP is higher than 150℃, all the condition for valve changing is the high pressure discharge check valve leaving away from the off-position. The time of the valve changing what is set is one minute. After the valve changing is done, the control way of the high pressure control valve is single valve control. Just like Fig.1. (b).

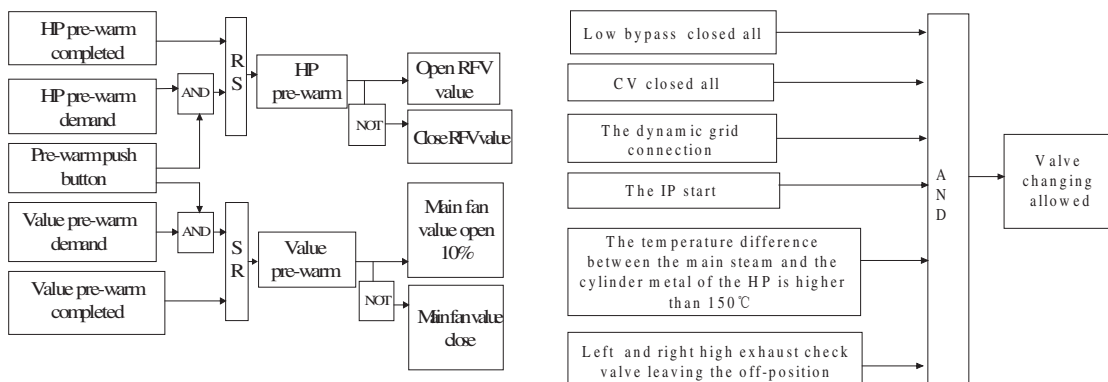


Fig. 1. (a) pre-warm control logic; (b) valves exchanging logic

- The opening curve regulation of IP regulation valve. As shown Fig.2.(a), regulate the opening curve of the IP regulation valve. Change the opening curve of the IP regulation valve according to the through flow characteristics of the turbine system IP regulation valve and the controls parameter of the DEH control system, so as to control the turbine system rotate speed or load reposefully, and prevent the turbine system vibration which is caused by the IP regulation valve swinging [7].
- The fan valve control. The control logic of the fan valve is shown as Fig.2. (b). The control function of the electric fan valve is achieved by DCS system, and is shown on the same screen together with the cylinder temperature of the steam turbine, the electric fan valve can do the function as opening, closing and intermediate stopping, and it can send information of the valve jaw opening back. Connect the electric fan valve when the valve is changed; stop the electric fan valve start-up when the turbine

system load is higher than 60MW; give an alarm when random metal temperature of the HP vent wall no matter above or below is higher than or equal to 380□ .

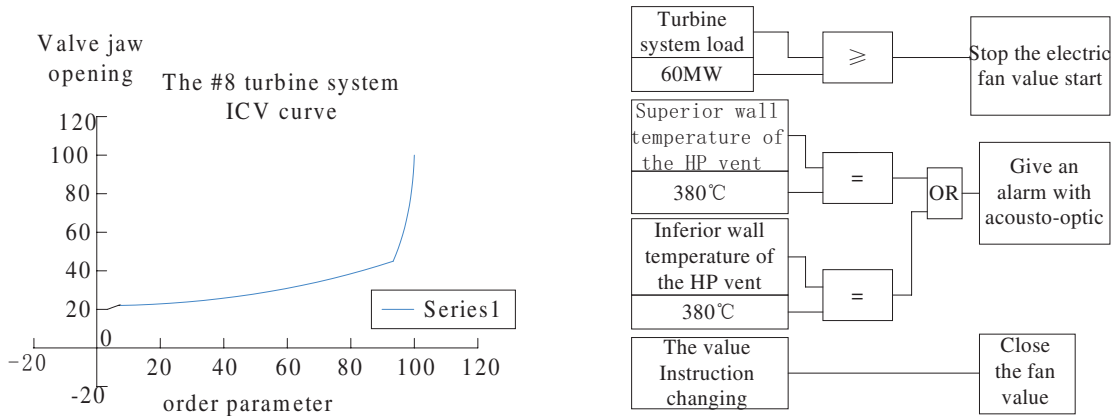


Fig. 2. (a) Opening curve regulation of IP; (b) valves exchanging logic

- The bypass input automatically. Increase the IP start-up logic to the bypass system PLC control logic, increase operation interface and parameter setup interface of the IP start-up to the host computer, do static gearing, dynamic test and the opening curve regulation of IP to the high and low bypass pressure automatic control loop. The opening curve is shown as Fig.3.

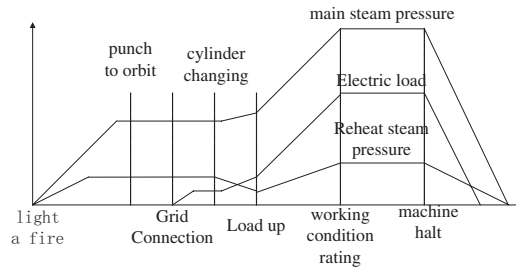


Fig. 3. the automatic curve of the IP start-up bypass

5. Conclusions

After the IP start-up control of the #8 turbine system, Shalingzi power plant, has been implemented, the turbine system use the IP start-up successfully first time, and has been tested by actual operation. The results show that this plan is a complete set of successful and a technical innovation. When the #8 turbine system had been successful, after nearly a year's work in 2006, the plant implemented this IP start-up control plan successively on other seven turbine system and all got the success.

From the energy point of view, implementing the turbine system IP start-up shorten the time of the turbine system start-up, reduce the fuel consumption, at the same time slow down the heat stress loss of the turbine system, it is great significance for extending the service life of the turbine system and improving the safety and reliability of the turbine system start-up and running. The operation and practice indicate, during the IP start-up, it is necessary to think about that whether the energy reserves is large

enough when the cylinder is been changing (valve changing), avoid the high bypass closing automatically during the cylinder changing, and when the HP valve is not open, make the HP not to perform work and the IP work lack of output, the load increase poignantly, the swing amplitude is too large, it easily cause the engine reverse power protection and shutting down, lead the IP start-up to be defeated. How to deal with this problem is the key point whether the start-up control plan gets a success or not. In the control plan of other seven turbine system, we must research seriously on the time of the bypass closing automatically and the match between the speed control and the load characteristics of the high pressure valve start-up, find out the corresponding relation and the method of coordination, match, resolve the problem that the load swing amplitude is too large during the cylinder changing (valve changing), achieve the changing without perturbation or with a little perturbation. This problem should be paid attention to and researched commonly by our vast power plant control system workers.

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