Analysis and treatment of jitter for 300MW steam turbine high-pressure control valve

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Abstract. The high-pressure control valve of Weifang power generation Co. LTD unit one turbine happens to jitter during operation, especially in the low opening action, the jitter is more frequent. This situation is serious for the safety and stability of generating unit. This paper analyzes the cause of the high-pressure control valve jitter and formulates effective reconstruction plans. After the reform of the high-pressure control valve, it can maintain stable and normal regulation to ensure the safety and stability of the generating unit.

1 Overview

The first stage unit steam turbine of Weifang power generation Co. LTD is a subcritical, intermediate reheat, two-cylinder, two-row steam, extraction and condensing heating steam turbine produced by Nanjing Steam turbine Works. The model is N330/C275-16.67/0.4/537/537. The main steam system adopts the "1-2" mode. The main steam enters the nozzle chamber arranged in the high-pressure inner cylinder through two main steam valves, four governing valves and four flexible steam guide pipes. The four guide pipes are symmetrically and vertically connected to the four inlet pipe interfaces of the high and middle pressure outer cylinder. In 2013, the high-pressure main steam valve group of Unit 1 of Weifang power generation Co. LTD was transformed by Dongfang Steam Turbine Factory. After the reform, there was shaking of the high-pressure control valve stem accompanied by the sound of metal grinding and shaking of LVDT connecting rod and falling off of the high-pressure control valve stem occurred in the operation of Unit 1.

2 Cause analysis of high-pressure control valve jitter

The control system works according to the electro-hydraulic principle. The control variables for the valve positions (strokes) are electric signals, which are converted into hydraulic forces by electro-hydraulic converters. Each turbine inlet control valve and intercept control valve has its own electro-hydraulic converter to control the valve stroke. The actual values of the valve strokes are acquired by measuring transducers (one per valve), that transmit electronic standardized signals to the electronic turbine controllers used for position control and indication[1].

The valve position controllers are designed to control the stroke of the control valves via the appropriate electro-hydraulic transducers. The output of the transducers is the hydraulic control variable, which is proportional to the electrical control signal and actuates the corresponding control valve servomotors. The electro hydraulic transducers are fed from safety system, i.e. when system is epressurized, the hydraulic outputs of the transducers become zero. Each transducer is mounted directly on the control servomotor[2].

The HP live steam control valves control the steam quantity that flows through the HP-turbine. They are of the single seat type. Each is operated by a hydraulic servomotor according to the “hydraulic fail safe” principle, i.e. hydraulic pressure to open-spring force to close. The electrical signal to the transducers is proportional to the HP live steam control valve stroke. The stroke feedback is derived from a position transducer mounted on the servomotor. The HP steam control valves open due to increasing electrical set value for the transducer. Steam flow is linearized within the turbine controller[2].

The jitter of the valve is basically due to the fact that the oil cylinder of the oil engine is constantly in the state of oil intake and oil return, which results in the failure of the dynamic balance of the oil engine and the oil circuit[3, 4]. The main reasons for the governing valve jitter are analyzed from the aspects of inlet mode, valve structure, control oil system and servo valve control loop combined with the field practice[5-7]:

1) The oily of EH oil is unqualified;
2) Improper setting of valve characteristic curve;
3) Servo valve coil deviation is large;
4) Fault exists in the servo clamp;
5) Interference exists in the control cable;
6) Control loose oxidation of cable terminal;
7) Steam excitation;

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8) Failure of LVDT feedback lever in place (including wear or break of LVDT, linear difference, poor installation position of LVDT, etc.);

9) EH oil pressure and tubing sloshing.

By Weifang power generation Co. LTD unit 1 tracking of abnormal situations of high pressure control valve for a long time, the scene of set of supporting structure and the arrangement and operation analysis, the main reason for the high-pressure control valve jitter is that the prestart valve and main valve disc structure design is not reasonable and rod lifting device design is unreasonable, high pressure steam after the main valve is divided into two road into the high-pressure control valve, the line is decorated "Y" pattern, causing the steam into the high pressure control valve stem tangential force, the valve stem tangential force produced by air impact jitter. In order to solve the vibration problem of high-pressure control valve stem of steam turbine, the prestart valve, valve stem and connector parts of high-pressure control valve of steam turbine are reformed.

3 Transformation plan of high pressure control valve

3.1. Modification of main valve core

Modify the connection form between the original prestart valve and the main valve core and cancel the 12 connecting claws and transform it into the connection form of "control valve prestart valve core compacting cock". As shown in Figure 1 and Figure 2.

Increase prestart valve inlet steam hole diameter from the original Φ50 mm to Φ80 mm, and the anticipated valve seat diameter Φ50 mm remains constant. Improve the prestart valve inlet steam quantity to make the prestart valve stability greatly enhanced. As shown in Figure 3 and Figure 4.

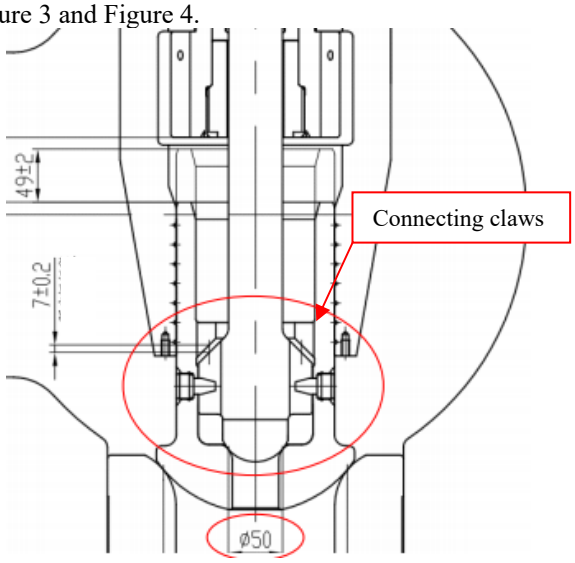

Figure 1. Schematic diagram of connection form before modification

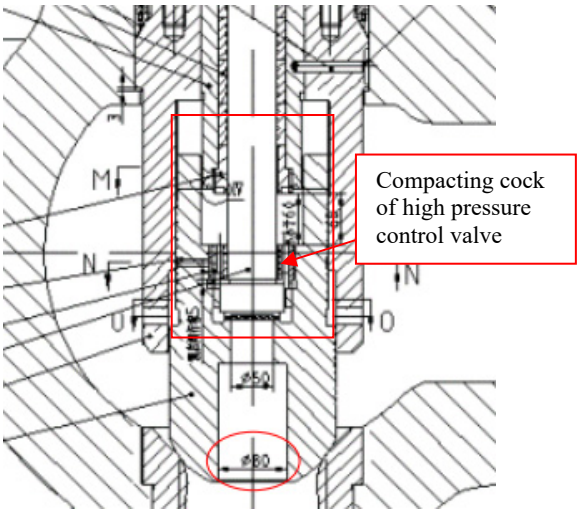

Figure 2. Schematic diagram of connection form after modification

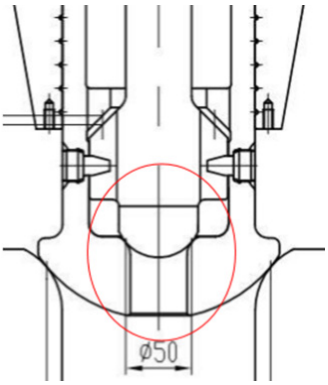

Figure 3. Schematic diagram of inlet steam hole diameter before modification

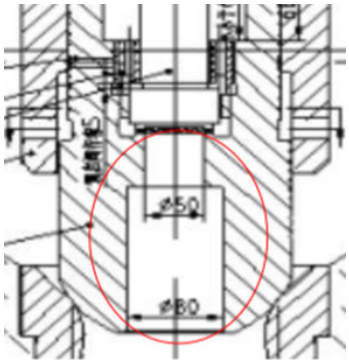

Figure 4. Schematic diagram of inlet steam hole diameter after modification

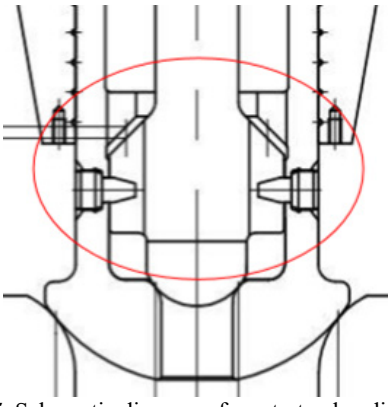

Figure 5. Schematic diagram of prestart valve disc before modification

The original prestart valve disc is round, and the positioning pin is used for anti-rotation positioning of the spool. After the modification, the inner wall of the prestart valve disc and the sleeve of the prestart valve disc all adopt the positive octagon form, so that the prestart valve disc has the function of positioning and anti-turning, and at the same time, all the positioning pins of the spool are cancelled, effectively preventing the problems such as rotation and vibration of the valve stem caused by the breakage of the positioning pins. As shown in Figure 5 and Figure 6.

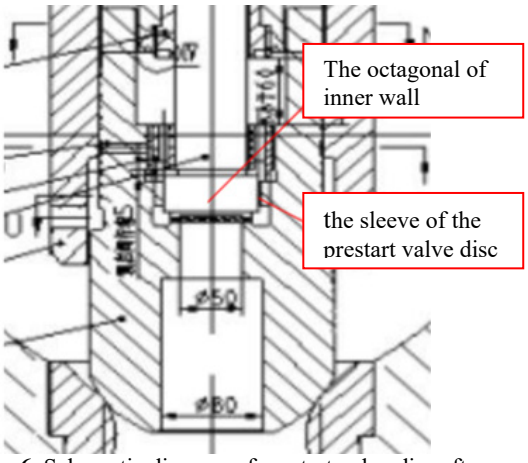

Figure 6. Schematic diagram of prestart valve disc after modification

3.2 Modification of stem crosshead connecting block

The original stem connection block adopts the crosshead connection form. At the moment when the valve is closed, the strong reaction force is applied to the thread connection surface, which causes the thread to be seriously deformed and causes the cross head pin to break during operation, the valve stem to fall off and the high pressure control valve to close abruptly. It is difficult to remove the cross head thread bite wire during maintenance. At the same time, the crosshead thread deformation will make the crosshead and stem connection not strong, causing stem vibration.

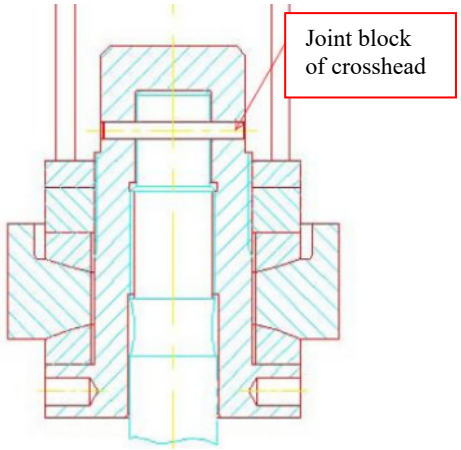

Figure 7. Schematic diagram of the crosshead connection block before reconstruction

After the modification of the crosshead connection form, the improved high-pressure control valve stem is lengthened, and the stem head thread reaches the top of the crosshead and is locked with double nuts. After modification, the impact problem of crosshead thread can be effectively avoided. As shown in Figure 7 and Figure 8.

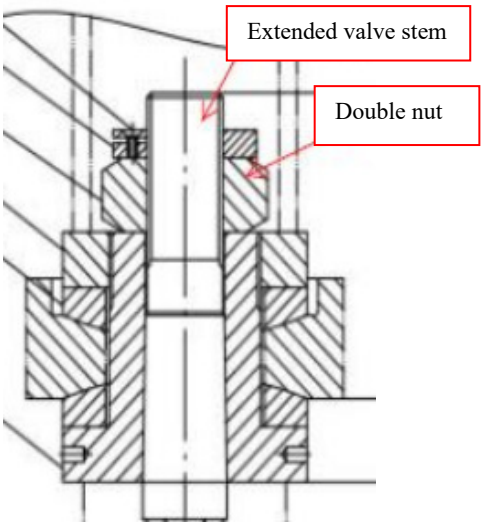

Figure 8. Schematic diagram of the crosshead connection block after reconstruction

3.3 Transformation of LVDT connecting rod

1) Change the installation position of LVDT rod. The original installation position of LVDT rod is at the connecting nut of valve stem and hydraulic servo-motor stem. After the modification, the LVDT bar is installed on the spring base of the operating seat of the hydraulic servo-motor, which can effectively improve the stability of the LVDT bar, reduce the vibration of LVDT and effectively protect the LVDT feedback bar.

2) Increase the LVDT intermediate guide stiffener in the middle of the original LVDT feedback lever to bear the force exerted by the valve stem and the hydraulic servo-motor, playing the guiding and positioning role at the same time. As shown in Figure 9 and Figure 10.

Figure 9. Equipment diagram of LVDT connecting rod before reconstruction

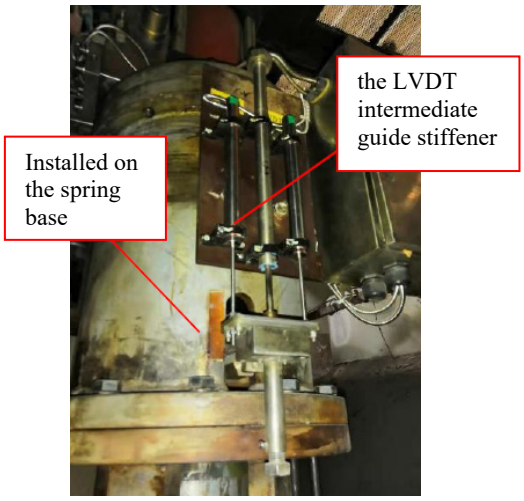

Figure 10. Equipment diagram of LVDT connecting rod after the reconstruction

4 Transformation effect and conclusion

The No. 1 unit steam turbine of Weifang power generation Co. LTD has been in operation after the transformation of the high-pressure control valve. At present, the high-pressure control valve of No. 1 turbine can remain stable during the operation of each load segment without high-pressure control valve shaking.

The main reasons for the jitter of the high-pressure control valve are the unreasonable design of the structure of the prestart valve and the main valve disc and the unreasonable design of the lifting device of the valve stem. The high pressure steam entering the high-pressure control valve generates tangential force on the valve stem, and the valve stem vibrates under the tangential force of the airflow impact. In order to solve this kind of problem, it is necessary to solve the root cause by eliminating the force and renovate the prestart valve, valve stem and connector of the high-pressure control valve.

Through the transformation, the problem of jitter of the high-pressure control valve is solved. The repair time and cost can be saved by modifying the valve stem structure without returning the valve to the factory for processing. At the same time, the problem of jitter of high-pressure control valve is solved thoroughly, avoiding many safety hazards such as load fluctuation caused by jitter of high-pressure control valve, reduction of regulating performance and vibration of control oil pipeline. It is feasible and effective to solve this kind of problem, and it has important reference significance to solve the similar problem of the same type of high-pressure control valve.

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