Inspection and treatment of four pipe supports and hangers of 350MW unit

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Abstract. Based on the on-site cold and hot state inspection of the four pipelines of a 350MW unit in Shandong, combined with the review and calculation of stress, design and installation data, operation and maintenance records and other data, this paper formulates a practical adjustment plan and construction scheme, implements comprehensive adjustment and treatment of the four pipeline supports and hangers, basically restores the normal working state of the supports and hangers and pipelines, and ensures the safe operation of the unit.

1 Introduction

After long-term operation, a large number of abnormalities, damages and failures often occur in the supports and hangers of steam and water pipes of utility boilers. The main causes are as follows:(1) the creep and stress relaxation of materials under long-term high-temperature operation make the stress of pipe system redistributed; (2) the installation of supports and hangers deviates from the original design or the original design is incomplete, resulting in significant changes in the load borne by supports and hangers; (3) deformation and corrosion of the external surface of supports and hangers during operation; (4) large impact load or violent vibration; (5) decline of spring performance after long-term operation, etc.[1-2]The above factors will change the stress of the pipe system and the bearing distribution of supports and hangers, increase the local deformation of the pipe section, increase the local stress of the pipe system and even exceed the basic allowable stress of the pipe. In addition, it will also cause a significant increase in the thrust and torque at the equipment interface connected with the pipe, resulting in damage and failure at the interface between the pipe and the equipment, so as to shorten the remaining service life of the pipe and seriously affect the safe and economic operation of the power plant. Therefore, it is very necessary to regularly check, check and adjust the supports and hangers of steam and water pipes of units in operation.

Taking a 350MW supercritical unit of a thermal power plant in Shandong as the engineering background, this paper carries out the inspection, calculation and adjustment of the supports and hangers of steam and water pipelines in operation, so as to realize the full cycle maintenance of the supports and hangers of steam and water pipelines after they are put into operation. The unit was put into operation in January 2019 and has operated for about 18000 hours so far. According to the working state requirements of supports and hangers, comprehensively inspect the supports and hangers under hot and cold conditions respectively; Recheck and calculate the stress of the four pipelines, and determine the supports and hangers to be adjusted through comparative analysis; Formulate and implement specific adjustment plans according to the requirements of relevant standards and regulations.

2 Function and working state requirements of supports and hangers

2.1 Constant spring hanger

It is used to bear the dead weight load of the pipeline, and its bearing capacity does not change with the change of the vertical displacement of the pipeline at the lifting point, that is, the load remains basically constant [3]. It is usually used where the vertical displacement of the pipeline is large or the transfer load needs to be limited. Working condition requirements: the hanger assembly is normal; The load displacement pointer is within the allowable range; No jamming, damage or abnormality of moving parts; The included angle between the hanger rod and the vertical line does not exceed the standard; The root bearing structure and auxiliary steel structure have no obvious deformation, and the main bearing weld has no macro cracks; The suspender and connecting accessories are not damaged or abnormal.

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2.2 Variable force spring support and hanger

It is used to bear the dead weight load of the pipeline, and its bearing capacity changes with the change of the vertical displacement of the pipeline at the pipeline support and lifting point [4]. It is usually used where the vertical displacement of the pipeline is not very large, and plays an important role in reducing the thrust or torque borne by the equipment. Working condition requirements: the hanger assembly is normal; The hanger spring has no excessive compression or load loss; The load displacement pointer is within the allowable range; The included angle between the hanger rod and the vertical line does not exceed the standard; The root bearing structure and auxiliary steel structure have no obvious deformation, and the main bearing weld has no macro cracks; The suspender and connecting accessories are not damaged or abnormal.

2.3 Rigid hanger

It is used to bear the dead weight load of the pipeline and restrict the vertical downward displacement of the pipe system at the lifting point, which plays an important role in reducing the flexibility of the small pipe system, enhancing the stability of the pipeline and controlling the vibration of the pipeline[5].Working condition requirements: the hanger has no loss of load; The suspender and connecting accessories are not damaged or abnormal; The included angle between the hanger rod and the vertical line does not exceed the standard; The root bearing structure and auxiliary steel structure have no obvious deformation, and the main bearing welds have no macro cracks.

2.4 Sliding support

It supports the pipeline on the sliding base plate to bear the gravity load of the pipeline and restrict the vertical downward displacement of the pipeline fulcrum without limiting the horizontal displacement. Working condition requirements: the working surface shall be flat without jamming and void; The sliding bottom plate of the pipe part does not exceed the limit; For the sliding support with PTFE plate, the sliding bottom plate of the pipe part shall be covered with PTFE plate under cold and hot conditions.

2.5 Limit device

A device used to restrict or partially limit the displacement in one or more directions at the pipe support and lifting point. It plays an important role in restraining the unreasonable displacement of pipeline and controlling the vibration of pipeline. Working condition requirements: the assembly is intact; The structure shall be free of obvious deformation and the weld shall be free of cracks; No damage or missing parts; It can limit the displacement in the predetermined direction.

2.6 Fixed support

It belongs to limit support device. The fixed support can limit the linear displacement and angular displacement of the pipeline support point in three directions, and can bear the dead weight load of the pipeline. It plays an important role in ensuring pipeline stability and preventing pipeline vibration. It is often used where no displacement is allowed on the pipeline. Working condition requirements: the fixed support shall be firm and reliable without looseness, the structural parts shall be free of obvious deformation, the welds shall be free of cracking, and the concrete buttress shall be free of damage.

2.7 Damper

It is used to protect the pipeline from accidental dynamic conditions. When the pipeline is under normal conditions, it can adapt to the slow movement of the pipeline caused by thermal expansion and cold contraction, and has little restrictive effect on the pipeline [5]. It is mainly used to bear steam hammer, water hammer, pipeline exhaust reaction and seismic load. It has no obvious control effect on low-frequency high amplitude or high-frequency low amplitude vibration. Working condition requirements: the damper shall be free of oil leakage and oil leakage; No missing parts; No abnormal deformation of bearing elements including nearby steel structures; The welds of pin seat assembly and pipe part shall be free of cracks; The position of damper piston shall meet the requirements.

3 Inspection of pipe supports and hangers

Check the hot state of supports and hangers before the unit is overhauled and shut down, confirm the support and hangers to be replaced, put forward the purchase list in time, and test the cold state of supports and hangers after the unit's outage pipes are cooled to normal temperature. By means of telescope, camera, vertical line and ruler, the supports and hangers of the four pipes of Unit 3 are inspected in detail in hot and cold states. The inspection results are as follows:

- The layout of each pipeline system is reasonable,
- The piping system has no obvious vibration,
- There are rigid supports and hangers in each pipeline system to stabilize the pipeline or devices to prevent the remote transfer of load,
- the hot state and cold state inspection of the four pipe supports and hangers are shown in Table 1.

Table 1. Statistical table of supports and hangers with problems in four pipelines (unit: Group).

Serial number	Pipe name	Total number of hangers	Problem	Number of questions / total
1	Main steam pipeline	24	12	50.0%
2	Reheat hot section pipeline	22	6	27.3%
3	Reheat cold section pipeline	22	5	22.7%
4	Main water supply pipeline (high temperature section)	21	1	4.8%
5	Total of four pipelines	89	24	27.0%

4 Recheck calculation of pipeline stress

The recheck calculation of pipeline stress is based on DL / T 5366 [6], DL / T 5054 [7] and ASME B31 1. According to the requirements of the specification and the design parameters of the pipeline, the layout of the pipe system and supports and hangers, the special pipe stress analysis software CAESAR II 2016 is used to verify the correctness of the configuration, load and displacement of the supports and hangers, as well as the deformation, stress distribution of the pipeline and the restraint reaction of the supporting structure for the three-dimensional thermal displacement of the supports and hangers, the thrust at the connecting end of its equipment and the maximum stress value of the pipe system under the design state, Determine the weakest link or key part of the pipe and evaluate the safe operation state of the support and hanger system.

The strength failure of pipeline is mainly caused by the fracture failure caused by primary stress and fatigue fracture failure caused by secondary stress. The stress caused by the internal pressure and continuous load borne by the pipeline, and the stress caused by seismic load, water impact and continuous action impact of safety valve belong to primary stress. The stress caused by thermal expansion, additional displacement, internal and external wall temperature difference and other displacement constraints of the pipeline belongs to secondary stress.

The primary stress shall meet the requirements of the following formula:

$$\sigma_L = \frac{PD_i^2}{D_0^2 - D_i^2} + 0.75\frac{iM_A}{W} \le 1.0[\sigma]^t$$

In equation: σ_L -- primary stress (MPA); P - design pressure (MPA);D_0 - Pipe outer diameter (mm); D_i - Tube inner diameter (mm); M_A - due to the combined moment of self-weight and other continuous external loads acting on the cross section of the tube, N.mm; W - Pipe Bending Section Factor (mm^3);$[\sigma]^T$ - Allowable stress (MPa) of steel at design temperature; i - Stress increase factor, and 0.75i should not be less than 1.

Secondary stresses shall meet the requirements of the following equation:

$$\sigma_E = \frac{iM_c}{W} \le f\left[1.2[\sigma]^{20} + 0.2[\sigma]^t + \left([\sigma]^t - \sigma_L\right)\right]$$

In equation: σ_E - Secondary stress (MPa); $[\sigma]^{20}$ - Allowable stress (MPa) of pipe base material at 20℃; M_C - The synthetic moment (N.mm) caused by thermal expansion calculated from the full compensation value and the elastic modulus of steel at 20℃; f - Reduction factor of stress range.

According to the above theoretical basis, the CAESAR software is used to model and calculate the four pipelines according to the actual situation. The calculation model is shown in Figure 1-Figure 4. After cold and hot calculation, the maximum values of primary and secondary stress calculation and the number of nodes are extracted. As shown in Table 2, the results show that the cold and hot calculation of the four pipelines meet the allowable stress requirements specified in the standard.

Table 2. Calculation results of pipe stress.

Pipe name	Stress classification	Calculated value (MPa)	Permissible value (MPa)	Location, node
Main steam pipeline	Primary stress	47.24	82.20	Upper elbow of spring hanger No. 13, 250
	Secondary stress	231.85	251.84	Right elbow of spring hanger No. 28, 530
Reheat hot section pipeline	Primary stress	52.17	83.49	No. 470 Constant Hanger Front Tee, 640
	Secondary stress	190.84	250.41	No. 355 Constant Hanger Lower Elbow, 420
Reheat cold section pipeline	Primary stress	69.21	119.83	No. 617 Constant Hanger Right Tee, 170
	Secondary stress	92.53	207.70	No. 607 Constant Hanger Right Elbow, 130
Main water supply pipeline (high temperature section)	Primary stress	83.40	120.66	Rigid Hanger No. 1024, 110
	Secondary stress	79.94	157.82	No.1022 Constant Hanger Upper Side Elbow, 260

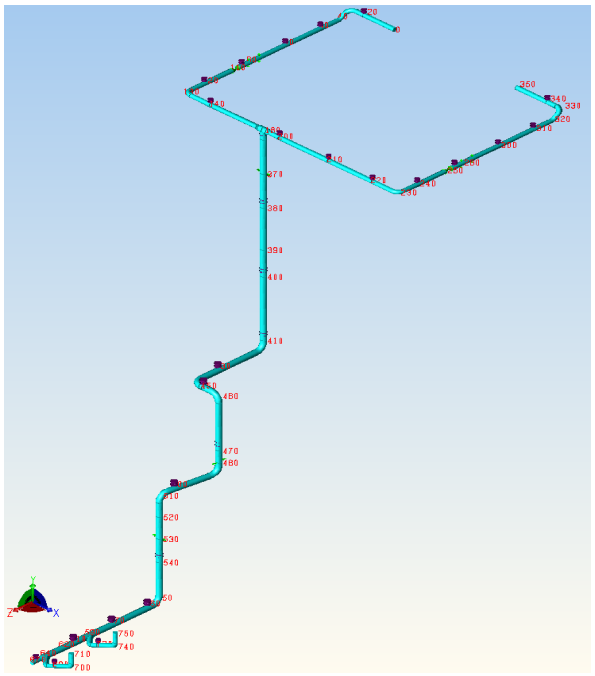

Fig. 1. Main steam pipeline.

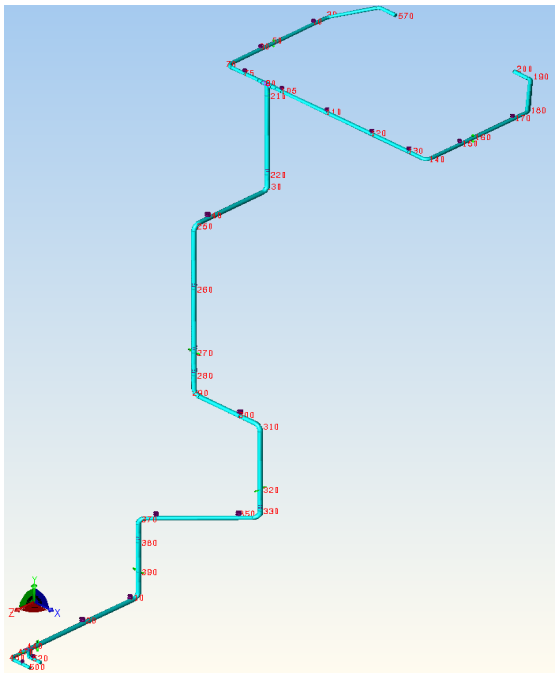

Fig. 2. Reheat hot section pipeline.

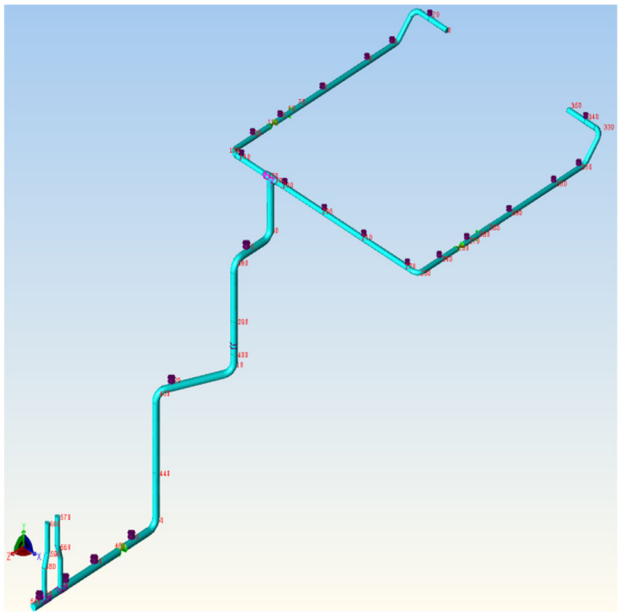

Fig. 3. Reheat cold section pipeline.

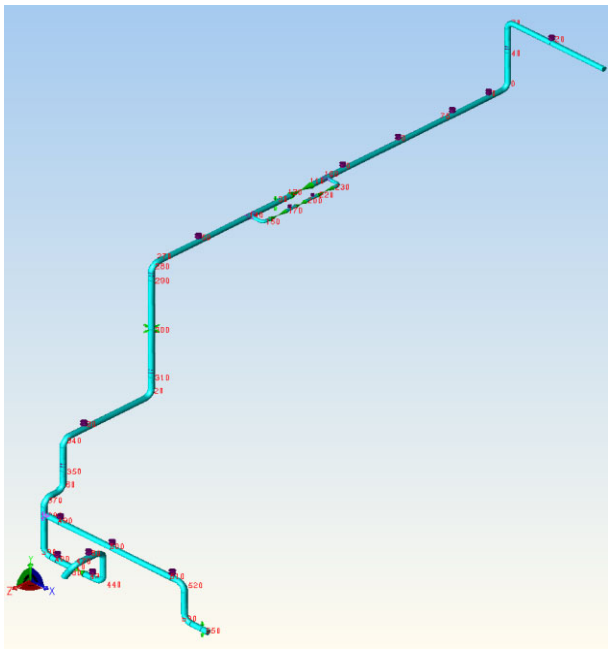

Fig. 4. Main water supply pipeline (high temperature section).

5 Adjustment and treatment of pipe supports and hangers

According to DL/T 616-2006 Maintenance & adjusting guide for thermal power plant Steam-water piping and support-hangers, design and installation drawings of four major pipeline supports and hangers, hot and cold inspection results, pipeline stress distribution and practical experience in adjustment and treatment of supports and hangers, practical adjustment measures are formulated on the basis of careful analysis of the causes of support and hanger faults and defects Adjust the functional parts and connectors of the damping device to

eliminate the existing hidden dangers and ensure the safe operation of the pipeline.

Adjustment and treatment sequence of supports and hangers: for single line pipeline, it shall be carried out from the furnace top down in sequence; For multi line pipelines, they shall also be carried out in parallel and in sequence. After the pipe supports and hangers are adjusted, the load will be transferred and redistributed. Therefore, the supports and hangers at adjacent lifting points shall be retested and adjusted if necessary to ensure that the adjacent supports and hangers are still in normal working condition. After the operation of the unit, the working state under hot working conditions shall be checked, and the existing problems shall be analyzed and adjusted to make the whole support and hanger system in normal working state under cold and hot working conditions. When preparing the technical report, the report shall include the standard basis for inspection and adjustment, cold and hot inspection data of supports and hangers, stress analysis data, displacement and load verification data, support and hanger adjustment measures, construction scheme, working status before and after adjustment, distribution diagram of pipeline supports and hangers, conclusions and suggestions, etc.

6 Conclusion

Through the on-site inspection, stress recheck calculation, adjustment and treatment of the four pipelines of a 350MW unit in Shandong, this paper realizes the full cycle maintenance technology of steam water pipeline supports and hangers, eliminates the hidden dangers of supports and hangers, improves its operation state and improves the health level of pipelines. It is suggested that the technicians of the power plant should conduct a thermal visual inspection on the supports and hangers of the main steam and water pipelines of the unit once a year according to the requirements of relevant standards and regulations, and record the inspection results in the file. During each overhaul, all pipe parts, roots, connectors and functional parts of pipe supports and hangers shall be inspected and maintained, and records shall be made, and problems found shall be handled in time.

References

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