

PAPER • OPEN ACCESS

Analysis and treatment of Free end vibration of condensate pump motor towards ultra-supercritical 660MW turbine

To cite this article: Wanjun Li *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **300** 042010

View the [article online](#) for updates and enhancements.

Analysis and treatment of Free end vibration of condensate pump motor towards ultra-supercritical 660MW turbine

Wanjun Li^{1,*}, Xiaoxia Li², Qingliang Niu¹, Tianqi Huang¹, Deke Zhang¹,
Yang Dong¹

¹Huadian Electric Power Research Institute Co., LTD., Jinan, 250014, China

²CRRC Wind Power (Shandong)CO., LTD, Jinan, 250022, China

*Corresponding author e-mail: 418907504@qq.com

Abstract. The motor free end vibrates at rated speed after overhaul of condensate pump; Through collecting field data and checking maintenance records, the fault diagnosis and troubleshooting of A condensate pump motor with excessive vibration was carried out based on the mechanism of vibration, and the cause of the fault was accurately analysed. By taking effective measures such as replacing the expansion joint at the inlet pipe, adjusting the concentricity of the pipes before and after the expansion joint, and adding A safety valve on the inlet pipe, the problem of excessive vibration of the condensate pump motor A has been thoroughly solved, and the hidden danger of equipment has been eliminated successfully.

Keywords. Condensate pump motor; Free end; Abnormal vibration; Fault diagnosis and treatment.

1. Overview of equipment and system

A power plant ultra-supercritical 660MW steam turbine generator set is equipped with two condensate pumps, one for operation(A) and one for standby(B). The condensate pumps are vertical double pump which produced by Shenyang industrial pump manufacturing co. LTD(the model is 10LDTNB-5PS).The condensate pump motor is a vertical three-phase asynchronous motor with variable frequency speed regulation produced by xiangtan electric machinery factory(the model is yspkkl560-4).Filter screen is set at the condensate pump inlet, which is produced by Shenyang industrial pump manufacturing co. LTD (10LDTNB-5PS-LW00). The pressure difference alarm value before and after the inlet filter screen is 5kPa.

The condensate pump set is a single vertical foundation structure, the motor and the pump share a cement foundation, connected by a pin coupling. Connection diagram of condensate pump A and motor is shown in figure 1.

The flow chart of the condensate water system is shown in figure 2. After the exhaust steam of the low-pressure cylinder is condensed by the condenser, it is divided into two parts through the condensate jellyfish tube, and then into two condensate pumps along the condensate branch pipe through the inlet electric door, the inlet filter net and the inlet expansion joint.



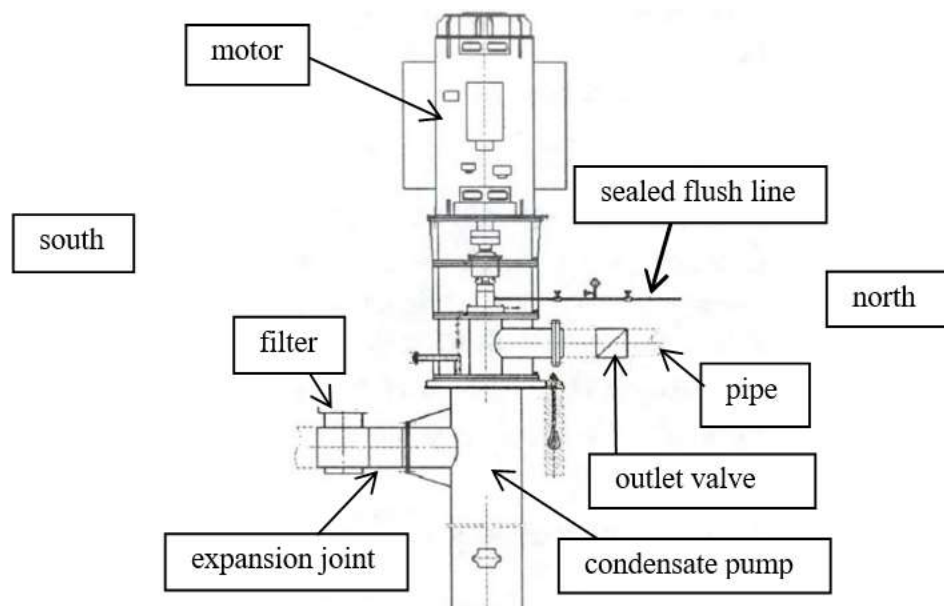
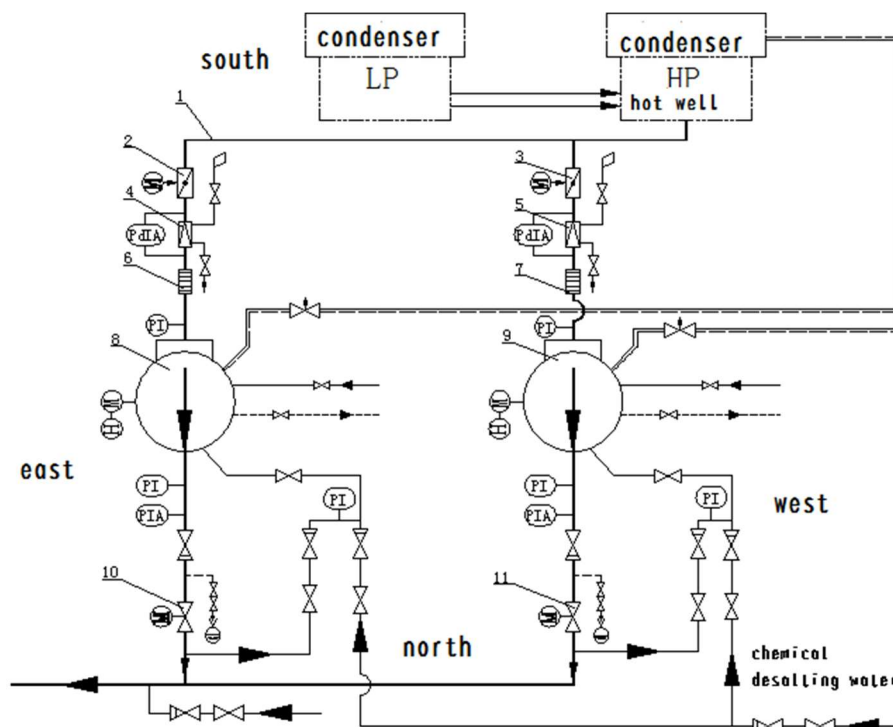


Figure 1. Connection diagram of A condensate pump and motor.



1 Congealed medusa tube; 2,3 Entrance motor door; 4,5 inlet filter; 6,7 Inlet expansion joint; 8 B condensate pump; 9 A condensate pump; 10,11 Exit motor door

Figure 2. The flow chart of the condensate water system.

2. Description of fault phenomenon

On April 6, 2018, the vibration of the free end of A condensate pump motor exceeded the standard at the rated speed of the motor after the overhaul of A condensate pump of an ultra-supercritical 660MW steam turbine generator set in a power plant. The vibration of the condensate pump and the motor were monitored in three coordinate directions, and the vibration values were shown in table 1.

Table 1. The vibration values of condensate pump and the motor. mm/s

	vibration value		
	in horizontal direction	in vertical direction	in axial direction
Free end of motor	1.7	7.93	2.9
Driving end of motor	0.95	3.59	2.13
Driving end of pump	0.89	1.87	1.05

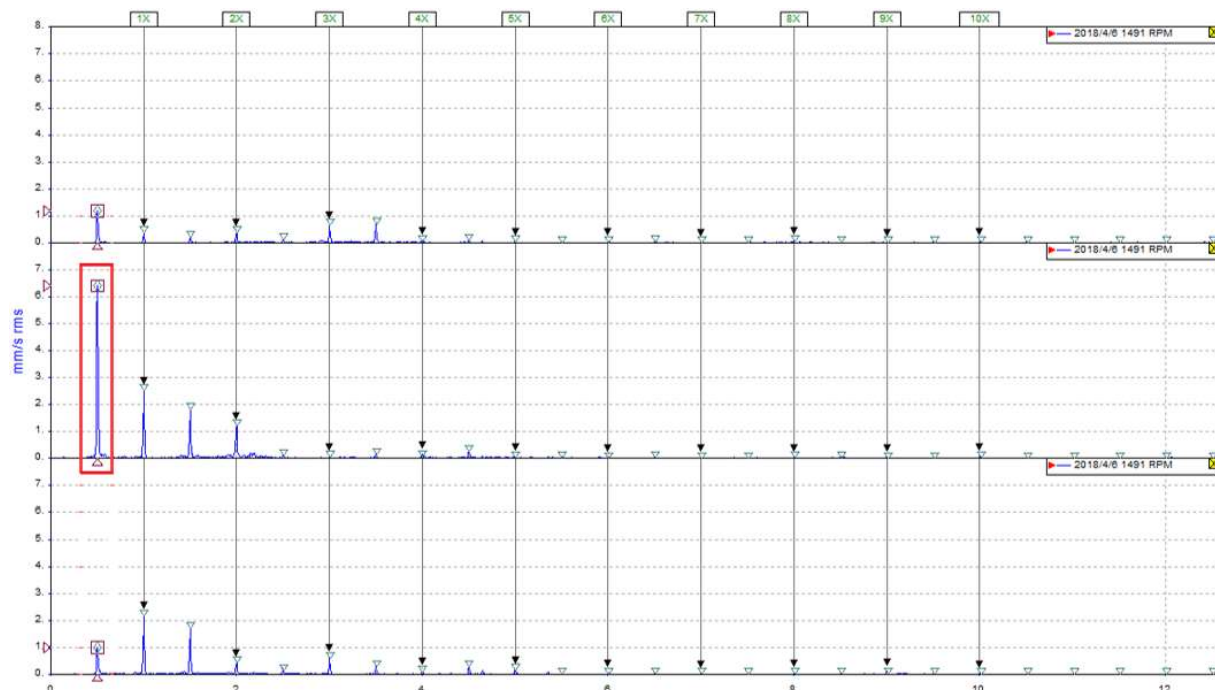
Note 1: the horizontal direction is the east-west direction in figure 2; The vertical direction is the north-south direction in figure 2.

3. Analysis of Fault cause

3.1. Analysis on the major causes of free end vibration of condensate pump motor

The vibration of condensate pump set can be divided into four types according to the difference of external interference force: mechanical vibration, hydraulic vibration, electromagnetic vibration and foundation structure design defect vibration[1-5].

The free end vibration value of condensate pump motor is the maximum in the vertical direction, up to 7.93 mm/s, that is along the direction of the inlet and outlet pipe of the condensate pump A. The vibration value seriously exceeds the standard (alarm value 4.5mm/s, stop value 7.1mm/s). From the spectrum in figure 3, the vibration frequency is mainly shown as 0.5X rotational speed frequency, and the corresponding vibration value is 6.9mm/s; There are components of 1X, 1.5X, and 2X rotational speeds.

**Figure 3.** Frequency spectrum of free end vibration of condensate pump motor.

The driving end vibration value of condensate pump motor is the maximum in the vertical direction, up to 3.59 mm/s. The vibration frequency is mainly shown as 1X rotational speed frequency, and the corresponding vibration value is 2.89mm/s; There are components of 0.5X and 2X rotational speeds.

The driving end vibration value of condensate pump is the maximum in the vertical direction, up to 1.87 mm/s. The vibration frequency is mainly shown as 0.5X rotational speed frequency, and the corresponding vibration value is 1.37mm/s; There are components of 1X to 5X rotational speeds.

It can be seen from the frequency spectrum that the vibration value of the driving end of A condensate pump, the driving end of the motor and the free end of the motor increases gradually from the bottom to the top.

The vibration frequency spectrum of the free end of the motor is mainly manifested as the low-frequency vibration characteristics at the frequency of 0.5x rotational speed, and the vibration trend is like an unstable vibration. The vibration characteristics of bearing vortexes and water-induced forces are mainly low frequency vibration near half frequency[1]. Therefore, the vibration value of the free end of A condensate pump motor exceeds the standard may be caused by the vortexing of the motor's bearing, or it may be that A condensate pump, affected by the water-induced vibration force, transfers the vibration to the motor.

In order to investigate the excessive vibration caused by the vortexing of the motor's bearing itself, the records of motor disassembly inspection and motor bearing oil injection were checked. It is found that the motor bearing clearance is within the design range, and there is no abnormality, no wear phenomenon of the bearing, and the color of lubricating grease is normal. The vibration of the free end and the driving end is normal in the no-load operation of the motor, so it is excluded that the excessive vibration of the free end of the motor is caused by the vortexing of the motor bearing itself, which should be caused by the water flow excitation force generated by the condensate water system.

3.2 The cause of exciting force of condensed water flow

Combined with practical operation experience, the excitation force generated by the condensate on A condensate pump may be caused by the following reasons, which will be investigated one by one.

1) inspection of the support and hanger of the A condensate pump outlet pipe

By calculating the load distribution of the spring, the support and hanger were adjusted, and the support of the export pipeline was adjusted to reduce the torque produced by the pipeline on the condensate pump, and the vertical height of the pipeline was changed. After the adjustment, the vibration does not reduce, so the influence of the support and hanger of the export pipeline could be eliminated.

2) inspection of A condensate pump outlet pipe flange

Disassembled the outlet connecting flange, removed the connecting bolt, nut and gasket, measured the deviation of flange center line respectively, no abnormal phenomenon could be found, so the influence of A condensate pump outlet pipe flange could be eliminated.

3) inspection of the electric gate at the inlet and outlet of A condensate pump

Opened and closed the electric door at the inlet and outlet of A condensate pump respectively, the valve could move freely without jam and falling off. Checked the maintenance record of the electric door at the inlet and outlet of A condensate pump, no abnormal phenomenon could be found, so the electric gate at the inlet and outlet of A condensate pump could be eliminated.

4) inspection of the filter screen at the condensate pump inlet

Checked the operation record of the condensate pump, the differential pressure protection of the inlet filter did not alarm, and the inlet filter has been cleaned during the maintenance, so the reason of the inlet filter could be excluded.

5) inspection of A condensate pump inlet pipe expansion joint

It can be found that the inlet pipe expansion joint had been seriously deformed after inspection, and the inlet pipe of expansion joint has removed and produced the dislocation with the outlet pipeline. Thus the cross section area of the condensate pump inlet was reduced, resulting in a decrease in the inlet water flow of the condensate pump. After the deformation and dislocation of the expansion joint at the inlet of the condensate pump, due to the serious deformation of the internal strengthening plate and its extension to the water flow channel, the fluid flow in the inlet pipe was not smooth. As a result, some low-frequency hydraulic pulses changed and gradually approached the natural frequency of the pump, which becomes the flow excitation force and thus generated resonance. Meanwhile, the

tube where the inlet filter screen is located and the congealed jellyfish tube were also removed. So it can be concluded that the deformation and dislocation of the expansion joint of the inlet pipe are the main influencing factors of excitation force.

Through the above analysis, it can be determined that the main cause of excitation force is the deformation and dislocation of the expansion joint of the condensate pump inlet pipe.

3.3 Analysis of deformation and dislocation of expansion joint of condensate pump inlet pipe

Checked the condensate pump and system pipeline and motor maintenance records, we found that the end cover of the filter and the flange behind the entrance electric door were leaking after cleaning the B condensate pump inlet filter screen. The leakage phenomenon disappeared after tightening the flange connection bolts at the leakage point.

When the inlet and outlet electric door of B condensate pump and pump air door were all closed, the operators used mechanical seal backwater mother (interface for condensate pump discharge pipe pressure is 2.4 ~ 3.0 MPa) to water injection pipeline, when the mesh upper air door after emptying valve of the water, but he didn't open the condensate pump and electric door entrance to the valve, causing B condensate pump suction line between electric door with export electric door pressure-out, then the system pressure increased to 1.25 MPa, exceeding design pressure rating system (the original design of negative pressure), causing end cover slightly up on inlet screen deformation (60 mm end cover thickness), so lead to leakage of sealing parts of flange of upper end cover.



Figure 4. Deformation diagram of expansion joint at B condensate pump inlet.

After the system pressure increases, axial thrust was formed on the pipe and exceeded the load of the expansion joint. The axial tensile deformation of the expansion joint was up to 260mm (The design compensation of expansion joint is 70mm). After the entrance electric door was opened, the pressure of system pipeline was reduced, the elastic deformation of expansion joint was restored to 100mm, and the remaining plastic deformation could not be restored to the original position (shown in figure 4 and 5). The axial lengths of A and B condenser pump expansion joint are 360mm and 420mm respectively after deformation, and severe distortion occurred (Standard length of A and B condensate pump expansion joint is 260mm). The pull rod bolts of A and B condensate pump inlet expansion joint were all pulled out. The main pipe at the condensate pump inlet moved 200mm to the south (along the direction of the condensate pump inlet pipe and away from the condensate pump), and the branch pipe at the condensate pump inlet (before the expansion joint) moved 100mm to the east (perpendicular to the direction of the condensate pump inlet pipe and away from the condenser).

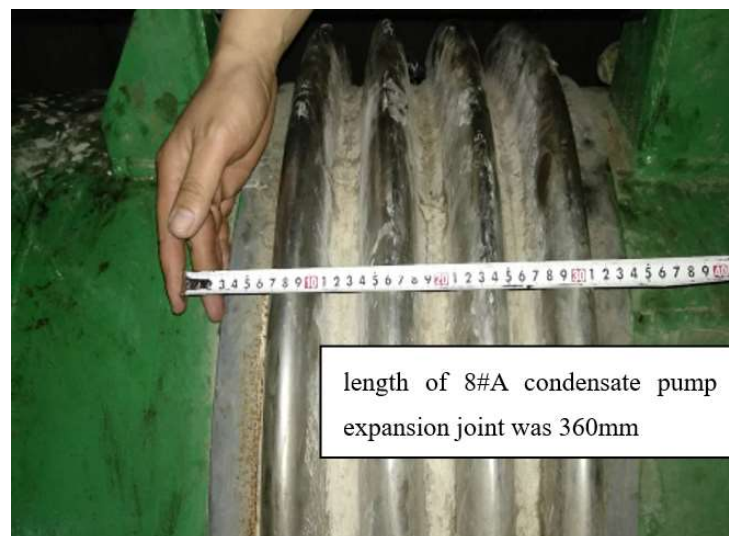


Figure 5. Deformation diagram of expansion joint at A condensate pump inlet.

4. Treatment measures and effects

1) Cutted the expansion of the condensate pump twisted section out, adjusted the position of common protopipe, at the same time, ensured the position of the two branch pipes, then fixed the pipes after adjusting to normal position. Ensure expansion in concentricity of pipeline, redesign guided sliding bracket, ensure smooth expansion, noskewed.

2) The inlet of the condensate pump was connected with the condenser by the common master pipe through welding, and the welding seam at the connection was inspected to ensure the quality.

3) The expansion joints were selected again to determine the technical parameters such as structural form, length and material, replaced the expansion joints at the inlet of condensate pump A and B, conducted flaw detection on the welding seams at the connection between expansion joints and pipes to ensure the welding quality.

4) After design institute to check the system, increased safety valve between the electric door entrance and the pipeline inlet screen, and through the pipe connected to the condenser, the relief valve and pipeline, pipe and welding connection between the condenser, coagulation on the weld inspection, ensure the welding quality. When the system pressure was too high, it can be relieved in time, thus can avoid expansion joint deformation.

After the treatment of A condensate pump and its system, run A condensate pump again, and the motor vibration value returns to normal.

References

- [1] Han Jian, Guan Huiling, Liang Chuan et. al, A Practical analysis method of the rotary machine fault diagnosis, Mechanical strength, 1998,20(3):212-215.
- [2] Yi Liangji, Simple vibration diagnosis field practical technology, China Machine Press,2003.
- [3] Xia Songbo, Zhang Jiangxin et al., A review of research on misalignment fault of rotating machinery, Vibration, testing and diagnosis, 1998(9):112-115.
- [4] Shi Wei-xin, Large Imbalance in the Rotor Vibration Research, TURBINE TECHNOLOGY, 2010(52):51-56.
- [5] Zhang Xinjiang, Jiao Yinghou et al, Research on feature extraction and diagnosis of misalignment fault of rotating machinery, Turbine Technology, 1999(4):104-107.