

## Research Article

### The Optimization Test Study for the Vacuum System of Piping Main-Scheme in the 600MW Unit

<sup>1</sup>Li Qiong, <sup>1</sup>Chang Shuping, <sup>1</sup>Guo Jianglong, <sup>1</sup>Wang Xingguo and <sup>2</sup>Fu Jiancheng

<sup>1</sup>Hebei Provincial Electric Power Research Institute, Shijiazhuang, Hebei Province, PRC, 050021

<sup>2</sup>Hebei Datang International Power Generation Co., LTD, Tangshan, Hebei Province, PRC, 063611

**Abstract:** The operation mode of dual-pressure condenser directly influences the vacuum, which makes the entire enthalpy change to affect the economy of the unit. In the vacuum system for the dual-pressure condenser, it is different for the vacuum influenced by both the piping-main scheme and the individual running, which gets along with the load. When the load is higher, the piping-main scheme running is suggested. Contrarily, the individual running is done. Compared to the piping-main scheme running, it can make the higher side pressure reduce 0.12 kPa, which is an obvious effect. The method provides the operation references for energy-saving of the plant.

**Keywords:** Dual-pressure condenser, operation optimization, vacuum pump, vacuum

#### INTRODUCTION

In the dual-pressure condenser of large-scale unit, the piping-main scheme for the pumped vacuum system is mostly adopted, which the air extracted for both higher and lower pressure sides is collected to a main pipe, then is linked the vacuum pump or ejector through the pipe. Because of equalized pressure for the main pipe, there is an inevitable crowded phenomena in pumped air pipe to affect the low pressure air discharged, affecting the energy-saving benefits.

The field engineer carried on different aspects research on the pumped vacuum system. The literature (Guo *et al.*, 2010) studied the affecting factors such as the opening of regulating valve on the higher pressure side and the numbers of vacuum pump to be started up, which showed there was an optimal opening for the regulating valve. The literature (Xing *et al.*, 2011; Zeng, 2011) took 600MW supercritical unit as an example to optimize and retrofit on the facility, which indicated the higher and lower pressure side should be separated layout. However, they didn't give the pumped vacuum system how to operate. Some required the individual running, the others indicated the piping-main scheme and individual running discretionarily switched each other, but still don't give the concrete running programme. Against this, the N-38000-1 type dual-pressure condenser of some 600 MW units is taken as an example to carry on analysis research. On base of the literature (Guo *et al.*, 2010), with the piping-main scheme and the individual running as the study objective, the optimal operation mode will be given after the pumped vacuum system retrofitted.

#### TEST CONTEXT AND METHOD

In the condition of normal running, extraneous flows which enter or leave the cycle or bypass a component in such a manner that if ignored will cause an error in the flows though the turbine shall be isolated or measured. Typical of such flows are station-service steam, boiler blower, boiler blow down and make-up water and so on. The unaccounted-for leakage shall not exceed 0.5% of the test throttle flow at full load. Preparatory to and test run, the turbine and all associated equipment shall be operated for a sufficient time to attain steady-state condition. Appropriate means shall be employed for securing constant load.

Adjust combustion to make the turbine parameters meet the requirement. Every effort shall be made to run the tests under specified operating conditions, or as close to specified operating conditions as possible as in order to avoid the application of corrections to test results, or minimize the magnitude of the corrections. The drain mean of each heater is flashed heater, while the water level keeps normal. Don't use reheater desuperheating water as possible. If necessary, the reheater water flows should be constant during the test.

After the adjustment of each condition, the water level of deaerator and condenser are supplied to the higher level and then stop it. The condition stabilizes about 30 min and then start to record test data, which each condition last one hour. The data recorded by the worker is recorded at 2 min except the flow and rate at 5 min. The acquisition frequency of IMP Data Acquisition System is set 30 sec. If the data is from DCS, it is two minutes.

**Corresponding Author:** Li Qiong, Hebei Provincial Electric Power Research Institute, Shijiazhuang, Hebei Province, PRC, 050021

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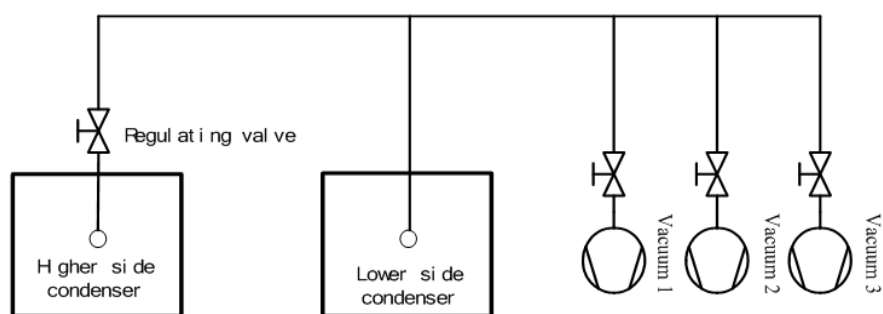


Fig. 1: Vacuum system of the condenser

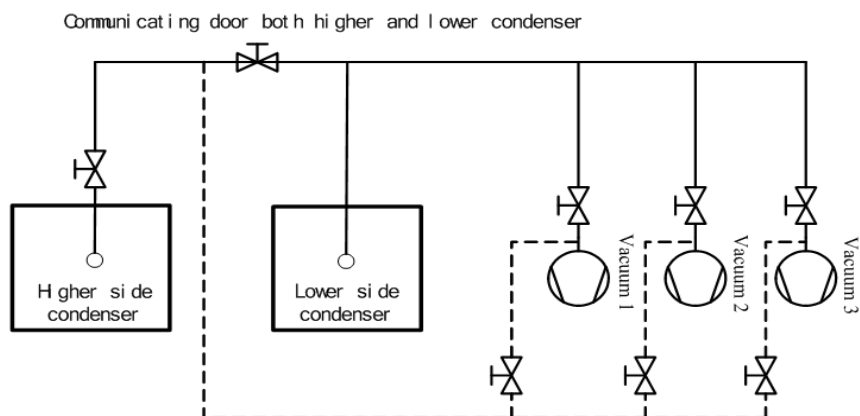


Fig. 2: Off-gas system after retrofit

Table 1: Test data and calculation results for 6

Title	Unit	Condition 1	Condition 2	Condition 3
Numbers of vacuum pump	Unit	1	2	2
Attended mode of the suction system		The piping-main scheme	The piping-main scheme	Individually operated
Opening of regulating valve	%	4	4	100
Higher side pressure	kPa	8.882	8.887	8.909
Lower side pressure	kPa	7.600	7.603	7.623
Pressure difference	kPa	1.282	1.284	1.286

**Retrofit test for vacuum system of the dual-pressure condenser:** Figure 1 is the sketch of off-gas attended mode before retrofit. The literature (Jing, 2008) showed when the load was 100, 75, 50%, respectively rated load, the optimal opening of regulating valve was about 3, 5 and 7% respectively.

Figure 2 is the sketch of off-gas attended mode after retrofit. Add a communicating door both higher and lower sides to divide them. The original mode is changed to individual running and piping-main scheme. Two modes can arbitrarily switch each other.

### TEST RESULTS ANALYSIS

When the load is variable, the pressure variation ranges both higher and lower sides are different from to the individual running. When two vacuum pump operate and the regulating valve is optimal, it shows in Table 1 compared with the piping-main scheme The

numbers of vacuum pump to be started up gets along with the load. When the load is full, one vacuum pump can meet running condition. Two vacuum pumps can meet it fewer than 75% rated load no matter individual running and piping-main scheme.

With some 450 MW load taken as an example, when with piping-main scheme, rise instead when another pump is started. When the piping-main scheme is changed to individual running, the higher side pressure drops 0.15 kPa, while the lower side changes nearly. This shows the regulating valve has one large throttle on the higher side to the disadvantage of air extracted when the opening of regulating valve keep 3% (Table 2 and 3).

When the opening of regulating valve changes from 3% to 6% (two vacuum pump), there is a smaller throttle and the higher side pressure drops 0.008 2 kPa.

The test results shows it can make the higher side pressure reduce 0.12 kPa after retrofit, meanwhile it

Table 2: Test data and calculation results for 450MW

Title	Unit	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
Numbers of vacuum pump	Unit	1	2	2	2	3
Attended mode of the suction system		The piping-main scheme	The piping-main scheme	Individually operated	The piping-main scheme	The piping-main scheme
Opening of regulating valve	%	3	3	100	6	6
Higher side pressure	kPa	7.629	7.680	7.530	7.598	7.596
Lower side pressure	kPa	6.719	6.717	6.738	6.727	6.740
Pressure difference	kPa	0.91	0.963	0.792	0.871	0.856

Table 3: Test data and calculation results for 300MW

Title	Unit	Condition 1	Condition 2	Condition 3	Condition 4
Numbers of vacuum pump	Unit	1	2	2	3
Attended mode of the suction system		The piping-main scheme	The piping-main scheme	Individually operated	The piping-main scheme
Opening of regulating valve	%	9	9	100	9
Higher side pressure	kPa	6.354	6.222	6.113	6.121
Lower side pressure	kPa	6.055	5.738	5.683	5.708
Pressure difference	kPa	0.299	0.484	0.43	0.413

also removes crowded phenomena. If the exhaust pressure reduces 1kPa, the heat rate will reduce 1%. If the design coal consumption is 330g/(kW/h), the coal consumption reduces 0.4 g/(kW/h). According to 6000 hours as the average running time, every year the total coal reduces  $6000 \times 60 \times 104 \times 0.4 / 106 = 1440$  t, the whole year can save 1,008,000 RMB.

### CONCLUSION

In the suction system for dual-pressure condenser, it is feasible to switch from the piping-main scheme to individually operated or piping-main scheme, which gets along with the load. When the load is higher, the piping-main scheme running is suggested. Contrarily, the individual running is done. Compared to the piping-main scheme running, it can make the higher side pressure reduce 0.12 kPa, which is an obvious effect.

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