VFDs driving the boiler feed water pump of #11-13 Combined Cycled Generation Unit in Yangpu Thermal Power Plant

by Bin Li

Brief introduction to Author: Li Bin, born in 1969, graduated from Beihang University in 1991, working in the field of gas-fired and steam combined cycled generation unit for many years, is mainly responsible for equipment operation and maintenance.

Extract: This article mainly concerns causes, modification method and running scheme for the application of variable frequency drive (hereinafter refer to as VFD) in the high-pressure water feeding system of boiler erected in the #11-13 combined cycled unit of Hainan Yangpu Thermal Power Plant.

Preface:

Oil to gas technology modification was completed in September 2003 in the #11 combustion engine (Simens V94.2) which then began generating power. It is the first heavy turbo machine energized by natural gas in China. The combined cycled unit mated with the machine was put into use in January 2004. #11-13 combined cycled unit is the largest combined cycled unit to date in China with actual maximum capacity of 220MW. In the meantime, three main equipments incorporated in the unit are China-made products, which include residual heat boiler, made by Hangzhou Boiler Factory, model Q1396/556-228(47)-8.14(0.588)/532(252), double-steam, double pressure natural circulation with oxygen removing device and no supplementary burning; turbo machine, made by Haerbin Turbo Machine Co., Ltd., model LN82.6-8.0/0.65/530/250, condensate type with double pressure; power generator, made by Haerbin Motor Co., Ltd., model QF-82-2,closed type, air cooled/ excitation with brush.

Introduction to the high-pressure water feeding system

The water feeding system erected in the #11-13 combined cycled unit consists of two sets of high-pressure water feeding pump and pneumatic water feeding valve as well as other relevant valves and pipelines. Two sets of high-pressure water feeding pump are manufactured by KSB, model HGB4/10, rated flux is 255.3m3/h, delivery is 1092mH2O, and rated rotating speed is 2985r/min. Meanwhile, the operation mode is one in operation and one in standby. The pneumatic water feeding adjusting valve is designed by SIMENS, manufactured by Indian company. The adjusting mode features 3-impulse closed loop control which includes water level, water flux and steam flux.

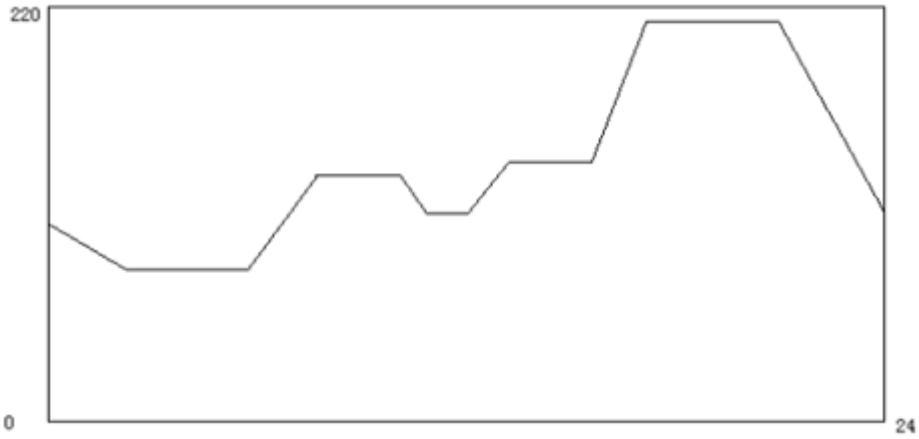
Appearance of trouble and analysis before using VFD

In March 2004, #11-13 combined cycled unit passed the 168-hour examination. However, during the following 2 months after April 2004, breakdown turned up for many times on the high-pressure water feeding adjusting valve, which resulted in the water level of the high-pressure steam druming out of control and caused the turbo machine shutting down due to machine fault for 5 times and trip-off for 1 time. Such

problem inevitably affected the normal operation of the power plant; and gave some negative influence on the safe operation of the Hainan electric grid. Generally speaking, most of the faults were caused by trip-off or rupture of the feedback connecting rod in the valve position. In combination with the periodic vibration occurred on the high-pressure water feeding pipeline during the course of operation, it was believed that the main reason causing breakdown of the adjusting valve was huge pressure difference between the outlet pressure of the high-pressure boiler feed water pump and the high-pressure steam drum, and furthermore, led to vibration. In addition, due to the poor rigidity of the water-feeding platform supporting the pipeline, vibration could not be absorbed and then gave rise to the high-axle fatigue on the connecting rod. In the end, when impulse load reached fatigue limit, the connecting rod broke. Once the connecting rod got loose or ruptured, the valve would turn to full-open position, water feeding rate reached maximum, which led the water level of the steam drum to rise quickly. In the meantime, pressure of the high-pressure water feeding dropped abruptly and caused the standby pump to start-up by interlock. In this situation, if the operator did not take timely measures, water level of the high-pressure steam drum would act, and the turbo machine shut off. In the yearly overhaul of 2004, the valve core was taken out, and the damage was found on many parts of the valve. It was concluded then the problem was resulted from action of high-pressure and high-speed water current and the valve core was scoured forcefully with huge throttling energy loss. After replacing valve core and repairing feedback connecting rod in the valve position, the machine was put into use. However, the valve core was damaged again in June 2004. When taking out, it was found that two arc-shape notches with 20mm in length, 10mm in depth were produced. Also, many damage were found in other areas. After printing the typical curves embodying the outlet pressure of high-pressure water feeding and the pressure of high-pressure steam drum, it was found that the difference was approximately 10Mpa in maximum, 4Mpa in minimum. Not including the loss of current resistance sourcing from the pipeline and coal-saving device, the remaining pressure gap was almost borne by the high-pressure water feeding adjusting valve, approximately 8Mpa in maximum. Thus, such pressure difference would absolutely produce vibration and lead to wearing on the valve core.

To identify the causes leading to the above-mentioned trouble, it firstly had to re-check the project design. As the designing institute did not fully consider the operating special characteristics of the generate unit in our power plant, the designing institute set up the equipment configuration as per the rated working condition, and prepared certain overmeasure according to the instruction when conducting preliminary design. In the real situation, Yangpu Power Plant is the second largest power generation unit in Hainan province that undertakes the task of peak adjusting and frequency adjusting for Hainan electric grid. With reference to the following daily load curve in the plant, it was easily observed that the machine was in full load only at night for 3-4 hours in the peak period. While for most of the remaining time, the unit was operated in partial load. Even sometimes in the deep night, the load was only 20%(calculated as per total output of the combined cycled unit). Therefore, the generation unit was operated in most of the time below rated working condition and

could not reach the designed capacity. In the meantime, there are no appropriate measures in place for adjusting outlet pressure of the high-pressure boiler feed water pump, which left the high-pressure water feeding adjusting valve to work under vibration continually and suffered enormous throttling energy loss. Thus, the valve core was damaged in the blowing and brushing action.



Typical load curve in a day in Yangpu Thermal power plant

Scheme selection

Based on the above-mentioned situation, it was believed that the exiting problem could be solved through application of VFD. Also the application experience showed that VFD featured obvious energy-saving effect. In the meantime, comparison was conducted between the VFD and the hydraulic coupling system. In the field survey to the Haikou Thermal Power Plant with respect to the hydraulic coupling, it was found that the hydraulic coupling system had much more systematic links, low reliability and huge maintenance work. Though hydraulic coupling system features the advantages such as lower price, yet, it was not acceptable, especially taking consideration of the limited space in the thermal power plant. Therefore, VFD was in the end taken.

Brief introduction to variable frequency drive

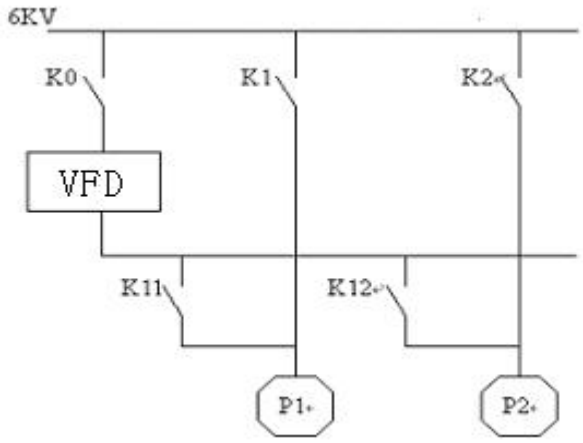
The technology of modern VFD has undergone steady development in recent years. Owing to its sound reliability, VFD has been widely used in various industrial and civil facilities such as air-conditioner driven by variable frequency. The speed adjusting through varying frequency features opened loop or closed loop control. The power module of the VFD outputs alternative current for the motor with specified frequency to drive the prime motor through basic AC-DC-AC single phase inverting circuit, meanwhile, make the output produced from the prime motor conform to the final technological requirement and thus fulfill the objective of target control and energy saving.

Based on inquiry and comparison, 2 units of HARSVERT-A06/130 VFD systems with the capacity of 1350KVA manufactured by Beijing Leader & Harvest Electric Co., Ltd. were selected. The system features series-connected multi-cell and high voltage source. Also, the system has low harmonic pollution to the electric grid. It is easily

mated with common type of asynchronous motor and produce good output waveform.

Modification with VFD

Due to the reason that there was no enough space in the 6KV switch room, it was decided that each surplus heat boiler was driven by one set of VFD. Also, taking consideration that the one variable frequency drive could drive 2 sets of pump as well as the by-pass function, two sets of variable frequency drive were arranged for the 2 sets of surplus heat boiler feed water system. In other words, 2 sets of VFD could drive 4 sets of pump. Detailed system diagram for the boiler feed water pump cold refer to the following diagram.



Introduction to the operation mode

Owing to the existence of the above-mentioned situation, special operation mode must be adopted in order that the water feeding system is running safely. Thus, detailed accounts with respect to the technical scheme is as follows:

In normal operation state, start-up the VFD driven water feeding pump and adopts closed-loop control of single impulse by the water level in the high-pressure steam drum. While put the high-pressure water feeding valve in the manual position, and set it in the full open position. The standby water feed pump energized by the electric grid with the power supply frequency of 50Hz is not interlocked to start up in order to prevent turbo steamer from tripping-off for higher water level in high pressure steam drum, and to prevent the steamer eroded from water steam.

In case of failure of VFD or the running pump, they shall be stopped by manual or automatically, operator shall put the standby pump into operation and set the high-pressure water feeding adjusting valve to the appropriate opening degree according to the actual load. Afterwards, go on adjusting and maintaining water level of the steam drum by manual. In the meantime, exit from the lower level protection of high-pressure steam drum for the purpose of avoiding turbo steamer trip-off due to manual switchover or control untimely. However, this situation would inevitably need operator to pay much attention. If the failure occurred to the VFD, the pump driving by VFD could still continue to operation by switching the power supply directly to electric power grid as the standby pump, which then ensure that the high-pressure water feeding system possesses very high reliability, and to great extent eliminate possibility of shut-down of combined cycled generation unit.

Conclusion after using the VFD

With reference to the statistics accumulated in 6 months, energyr consumption was greatly reduced after applying VFD. Specifically speaking, energy consumption for the combined cycled unit was 15000kwh less than that before daily, calculated based on 24 hours a day. Generally, the energy-saving rate reaches 60%. In the field operation, the high-pressure water feeding adjusting valve works normally, and adjustment to the water level of the high-pressure steam drum achieves satisfactory effect. Furthermore, vibration on the high-pressure water feeding pipeline is fully eliminated. In a word, reliability of the combined cycled generation unit is enhanced obviously, and exerts positive influence to the operation of Hainan electric grid.