Research and Application on the Unit’s RB of the Control System Modified with Frequency Converter

Han Ying Kun¹  Pang Xiang Kun¹  Mou Lin²  Gao Song¹  Yu Qing Bin¹  and Yan Qing¹

¹ State Grid Shandong Electric Power Research Institute, Jinan, Shandong 250002, China
² Shandong University Engineering Training Center, Jinan, Shandong 250061, China
Email: hanyk8086@163.com

Abstract. The paper introduces the typical design of the unit’s fans with frequency converter. Combined with the modification on the 300MW unit with frequency converter, the paper gives some designs of the key problems in the modified process, especially RB (RUN BACK) control system with frequency converter. At the same time some typical problems in the operating process are analyzed, which can improve the reliability of the unit’s fans with frequency converter.

1. Introduction
With the development of the large frequency converter, many power units are using the variable frequency control mode instead of the original mode which consumes more energy in operating process, such as fans and the condensate pumps. The variable frequency control mode can reduce current of the motor running and the throttling loss, which has the ideal energy saving effect. On the other hand, it improves the starting current of the high-power motor, which can realize the smooth start of the high-power motor. In the actual operating on the power unit, the modification with the frequency converter on the units has obvious security effect and economic effect.

2. Control Modes of the Frequency Converter
The motor is controlled by the frequency converter according to the characteristic parameters of the motor and the operating requirements of the motor. In the operating process, the voltage and current of the motor are provided to control the load, which meet the requirements of the unit. If the control method on the frequency converter is different, the control effect is different. Then the control mode represents the level of the frequency converter.

At present, the motor with the frequency converter has many control modes, such as U/f constant control, slip frequency control, vector control, direct torque control, and so on. The principle of variable frequency control is available in all kinds of technical data. This article is not covered in detail. [1][2]

3. Typical Control Scheme on the Unit with Frequency Converter
When the unit’s fans are modified with the frequency converters, the energy saving effect and economical efficiency of the unit should be considered. In actual operating process, two typical control schemes on the unit with the frequency converter usually adopted.
3.1. OTO Control Mode
OTO control mode (one frequency converter to one motor) is usually used when two motors are running in the operating process of the units. Its control structure is shown in figure 1. Because the control principle is simple and the equipment is independent, the “OTO” system is easy to maintain. For example, the fan is running in the variable-frequency mode (The circuit breakers used to control the frequency converter are ON (QF3 and QF4). The by-pass circuit breaker is OFF (QF5)). When the frequency converter is abnormal, the motor automatically switches to work in 50Hz (The QF5 is ON. The QF3 and QF4 are OFF). In order to ensure the safe operation of the motor, the circuit breakers(QF3 and QF4) and the by-pass circuit breaker(QF5) cannot ON at the same time[^3][^4].

![Figure 1. the control structure of “OTO” mode](image1)

Notes:  
QF1: the 6KV circuit breaker  
QF3: the input circuit breaker of the frequency converter  
QF4: the output circuit breaker of the frequency converter  
QF5: the by-pass circuit breaker (the circuit breaker of the rated frequency)

3.2. OTT Control Mode
OTT control mode (one frequency converter to two motors). Its control structure is shown in figure 2. In this mode, one frequency converter can control two motors to work. The frequency converter can support to anyone motor running in variable frequency. But two motors cannot run in variable frequency at the same time. It is usually used to the control system which has one running motor and another motor standby, such as condensate pump system, open circulating water system, etc. The economy of the mode is better. [^3][^5]

![Figure 2. the Control Structure of “OTT” Mode](image2)

4. An Instance of Modification with Frequency Converter
For example, the 300MW unit has been modified with frequency converters on the fans. Before the fans were modified, it adjusted the air flow by the baffle. When the unit’s load is lower, the throttling is very strong. It affects the economic operating of the units. The system structure of frequency
conversion adopts OTO control mode, namely, one frequency converter to one fan in the system. Its control structure is shown in figure 1. If the fans were modified, the baffle is full open when the fans are running. There is no throttling in the fan duct. According to the requirements of the system air flow, the frequency of the converter is adjusted. We can realize the air flow adjustment by controlling the fan’s speed. It can meet that demand of economic operating of the unit in the whole process.

4.1. Control Modes Switching of the Fans

There are two modes on the fans with the frequency converter in the operating process (Variable Frequency (VF) and Rated Frequency (RF)). Generally, in order to improve the unit economy, the fans operates in the VF control mode. When the frequency converter fails, the fan must be automatically converted to RF control mode. In this process, many circuit breakers were operated by the controller when the switching conditions are satisfied, such as QF3, QF4 and QF5. At the same time, the baffle of the fan is set to the specific position according to the operating load, which can keep the unit stable operating. If the operating mode switching cannot finished in the set time, and the load is greater than 50%P0, the controller must set QF1 to OFF, at the same time RB control logic starts to work. If the load is lower than 50%P0, the controller only stops the fan with the defective frequency converter. The control logic is shown in figure 3.

4.2. RB Control Scheme with Frequency Converter

The system’s control performance would be changed when the fans were modified with the frequency converters. Especially, the same type of the fans runs in different control mode. For example, the unit has two FDF (forced draft fan) which one works in VF mode and another works in RF mode at the same time. In the operating process, any fan maybe fail. If one fans stops, we hope that the RB control system can work reliably. It is an important problem that how to design an effective RB control scheme in the process of modification with the frequency converter.

If the frequency converter faults when the fan with the frequency converter is running which load greater than 50%P0, the fan will change operating mode (from VF mode to RF mode). At the same time, the baffle of the fan will be set to the specific position according to the operating load. In constant time, the baffle of the fan cannot be increased. When the baffle reaches the specific position, it will be adjusted freely. The maximum constant time is 20 seconds. If the baffle cannot reach the specific position, its locking is automatically released, namely, it can be adjusted freely. If the fan cannot change mode from VF to RF within 5 seconds, the QF1 must be disconnected from the 6KV bus. At the same time, the RB control logic starts to work when the load is greater than 50%P0.

When the RB control logic is working, the different control parameters need to be configured according to the fan’s operating mode. The controller adjusts the baffle or the frequency converter, which can meet the different requirements of the unit’s operation.

The RB control system block diagram is shown in figure 4.
Notes:
Block1: the control parameter deviation generator. The block1 can calculate the parameter deviation according to the set value and real-time parameter, which send the parameter deviation to the PID controller.
Block2: the PID controller I. It can meet the operating requirements of the normal operation with two fans or one fan working in RF mode when the RB is working.
Block3: the PID controller II. It can meet the operating requirements of one fan working in VF mode when the RB is working.
Block4: the selector module. It selects the PID controller I output or the PID controller II output as its input, according to the fan’s operating mode.
Block5: the balance module. It automatically balances the control instructions to the two fans according to the fan’s operating mode.
Block6: the running status recognition module. It recognizes the running state of the two fans.
Block7: the alarm module. It can alarm when the fans are abnormal or the RB occurs.
Block8: the RB recognition module. It recognizes RB signal.
Block9: #1 fan’s baffle actuator. It can adjust the position of the baffle (#1 fan working in RF mode).
Block10: #2 fan’s frequency converter. It can adjust the speed of the fan (#2 fan working in VF mode).

When the unit has two running fans, such as two IDF or FDF and so on, the PID controller I(block2) automatically adjusts the fan’s output according to the parameter deviation of the set value and real-time parameter. Through block4 and block5, the control instruction would be sent to the actuators of the fans. With the change of the operating condition of the unit, the fans automatically adjust its output. At the same time, the PID controller II tracks the output of the PID controller I, which can be ensured that the switch between two controllers is undisturbed.

When the RB occurs, the system operates as follows(For example, #1 fan is working in RF mode and #2 fan is working in VF mode. Also apply to #1 fan is working in VF mode and #2 fan is working in RF mode).

(1) Block8 recognizes RB signal according to the load and the fan’s running state. When the RB occurs, block7 will alarm which tell operator to monitor operating system.
(2) If any fan is stopped, the running fan may be work in VF mode or RF mode. The block6 can sent different signal to other blocks, such as block2, block3, block4 and block7. According to the block6 output signal, the controller automatically adjusts the control mode. The RB system can reduce the load quickly and rebalance the running state of the unit.
(3) If the running fan works in RF mode, the block4 will select the PID controller I output as its input. The output of block4 is the instruction which will be sent to the actuator to control the running
fan. At the same time, the PID controller II tracks the output of the PID controller I, which can be ensured that the switch between two controllers is undisturbed.

(4) If the fan working in RF mode is stopped and the running fan works in VF mode, the block4 will select the PID controller II output as its input. The output of block4 is the instruction which will be sent to the frequency converter to adjust the running fan’s speed. At the same time, the PID controller I track the output of the PID controller II, which can be ensured that the switch between two controllers is undisturbed.

When two fans are running simultaneously, they can be controlled by one PID controller. Because when the fan works in RF mode or VF mode, it has different control characteristics. So when the RB occurs, the different fan must use different PID controller. The scheme use different PID controller can improve RB success rate and reduce the number of unit failures.

5. Typical Problems in the Operating Process
The energy saving effect of fan frequency conversion is obvious, but there are some problems that need to be paid attention to during the operating process.

5.1. Two-sided System Imbalance
For example, the FDF modified with frequency converters operating process are good when the load is lower. But as the load increase, the instructions on two fans are getting higher and higher. There is a big difference on the output between the two fans in the process of rising speed which is not good for the system to run automatically. In order to make the system operating smoothly, we can change this running status by lowering the baffle opening.

5.2. Fan Vibration Increase
When the fan works in VF mode, its speed adjustment range is increased. The fan has the resonance region of shafting and blade. If the fan’s speed is in the resonance region, the vibration is increased obviously. The operating condition of the fan is worse, which may cause damage to the equipment.

5.3. Quality Problem of Frequency Converter
The energy saving effect of the frequency converter with high voltage depends on its reliability. When we select the frequency converters, high performance equipment must be selected to ensure the safe and economical operation of the unit. In the actual production process, the failure of the frequency converters often occurs in the fault of its quality.

In consideration of the failure of the frequency converter, the fan will be stopped. Therefore, the electrical switch integrated cabinet is used to automatically change running mode and maintain the fan's continuous operation when the frequency converter fails.

6. Conclusion
The frequency converter with high voltage is used to adjust the fans and pumps, which can extend the life of the equipment and improve the automation level of the unit. The proper plan modified with the frequency converter can improve operation reliability of unit and reduce maintenance cost, which will bring greater economic and social benefits for thermal power plants. In addition, the correct RB control scheme can reduce the unplanned downtime, at the same time which can enhance the support capability to the power grid.

References
[1] Chen B. 2002 Electric Drive Automatic Control System (Beijing: China Machine Press) pp15-18
[2] Han A. 2000 General Frequency Converter and Its Application (Beijing: China Machine Press)
[3] Han Y and Meng X. Analysis on the Frequency Converter Alteration of the Power Generation Unit's Fans. Shandong Electric Power, 2011, No5, pp51-54
[4] Chang H. The Frequency Converter Alteration on Circulating Pump of 350MW Unit. Electric
Safety Technology, 2008, No3, pp38-41

[5] Wang R. Research on High Voltage Variable Frequency Transformation of Fan. Mechanical and Electrical Information, 2012, No33, pp64-65