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Analysis of Nordex N43/600 Wind Turbine

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Abstract –The paper mainly analyzes the Nordex N43/600 wind power system based on an investigation of wind farm. Wind turbine's structure and parameters are introduced. It also introduces the electric control system through the following aspects: the eletricity circuit, the grade of voltage, the patameters which are measured or controled, the main controler and the soft connection control module. Finally it gives the main functions of Nordex N43/600.

Keywords - Wind Generator, Electronic Control System, Nordex N43/600, Blade, Miss Speed Regulate

I. INTRODUCTION

The wind energy is a rich clean green energy. Theoretically speaking, on the Earth 1% wind energy may satisfy the world energy need [1]. More and more environmental pollution nowadays, green energy is especially valuable. The main use of wind energy is power generation. In recent years, with the maturation of the wind power generation technology, wind power is an increasingly large share of power generation in the world. According to developed countries' plan, this proportion will be at 25% in 2030[2]. The development of wind turbine has experienced the 50KW-100KW small machine, 500KW and 600KW medium-sized machine. Now, it is developing toward the level of megawatt large machine.

The wind power generation technology is now being light, efficient, reliability and large [3]. There is a rich resource of wind energy on the earth. Compared with the developed countries which have mature technology, China drops behind. The wind turbine mainly relies on the import. Because of high price, wind power generation develops difficultly in China. Therefore, our country urgently waits to develop the large and medium -sized wind turbine independently to reduce wind turbine cost, so that the rich resource of wind energy in China can be utilized effectively.[4][5]

To provide a reference of development of wind turbine, this paper mainly introduces the internal structure, control system and related function in Nordex N43/600 wind turbine which comes form Danish - Germany Nordex Corporation and is used in some wind power generation station.

II. STRUCTURE AND TECHNICAL DATA OF NORDEX N43/600 WIND TURBINE

The N43/600 wind turbine is a kind of stall control and blade tip brake wind turbine. Fig. 1 is its internal structure. The leaf blade of impeller 1 is made of fiberglass-reinforced plastics. The wheel hub 2 structure is the steel frame. In the generator room, the frame 3 uses the metal welding skeleton. The main axle 5 is made of high-strength anti-pull steel. The impeller shaft which has dual-ball roller bearings 4 with the flexible steel shield is connected with the main axle. The gear box 6 is a first-level planet/second-level spiral gear box, which is depended on the customer request. The brake disc 7 is a caliper disk brake at the side of high speed axis of gear box.

The generator 9 is an asynchronous generators at 600/125kW which is cooled by air and connected with the main axle by flexible shaft coupling 8. The control system 11 monitors wind turbine movement. The wind measurement system 10 includes an anemometer and a wind vane, which monitors real-time wind condition and sends a signal to wind turbine control system. The leeway bearing 12 is a four-point ball internal tooth bearing. The leeway drive 13 is run by the two planet gear boxes with motor drive. In addition, a set of initiative leeway brake system is installed in the wind turbine. The tower shelf 14 uses the steel frame. The hatch 15 is made of fiberglass-reinforced plastics. The table 1 has given the related technique data of N43/600.

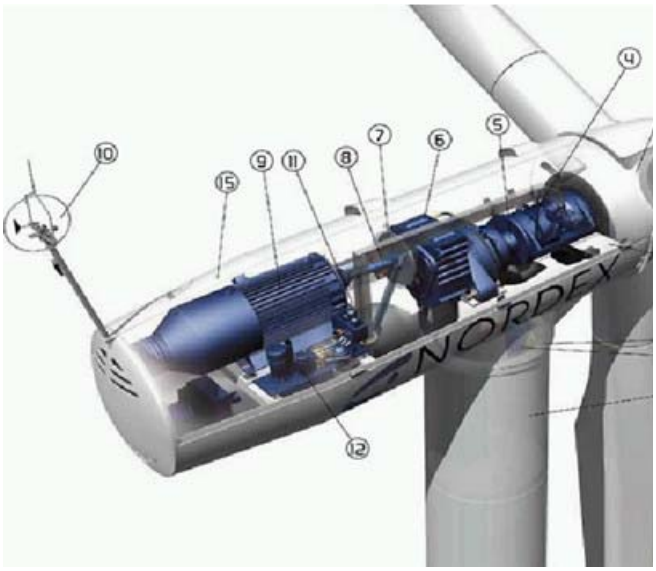

Fig. 1: Internal structure of N43/600 wind turbine (from http://www.ceclub.cn/)

1- impeller 2- wheel hub 3- generator room internal frame 4- connection impeller axle with main axle 5- main axle 6- gear box 7- brake disc 8- connection of generator 9- generator 10- wind

measurement system 11- control system 12- leeway bearing 13- leeway drive 14- tower shelf 15-hatch

Table 1: Technique data of N43/600

Part	Parameter name	Data	Part	Parameter name	Data
Power output	Rating wind speed power	600kW	Leaf blade	Material: Fiberglass-Reinforced Plastics(FRP) of polyester with flange wheel hub of cast steel	
	Max wind speed power	620kW		Model	LM 19.1
	Max current rating power	620kW		Length	19.1m
Wind speed	Min wind speed (cut-in wind speed)	3-4m/s	Gear box	Gear model	First-level planet/second-level spiral
	Max wind speed of output rating	16m/s		Transmission ratio	55.801
	Max wind speed (cut-out wind speed)	25m/s	Generator	Asynchronous generator , double winding	
	Max current rating wind speed	14m/s		Power rating	600 / 125kW
	Safety or structure limit wind speed	55m/s		Nominal frequency	50 (or 60)Hz
Wind wheel	Run time speed	27.1r/min		Voltage rating	690 V
	Max limit speed	31.1r/min		Pole number	4 / 6
	Diameter	43m	Weight	Generator gross weight(40 m tubular tower): 70.3kg Wind wheel with leaf blade (wheel hub + leaf blade): 14.0kg Generator room: 25.0kg Tower shelf gross weight (tubular tower 40 m): 39.3kg Tower shelf gross weight(lattice 40 m): 25.0kg Generator: 3.4kg Gear box: 4.5kg Max step up weight: 25.0kg	
	Leaf blade number	3			
	Change oar distance	Stall			
	Nature vibration frequency (wind wheel & leaf blade)	1.4Hz			
	Rotation direction (up wind direction)	Clockwise			
	Elevation (level)	4°			

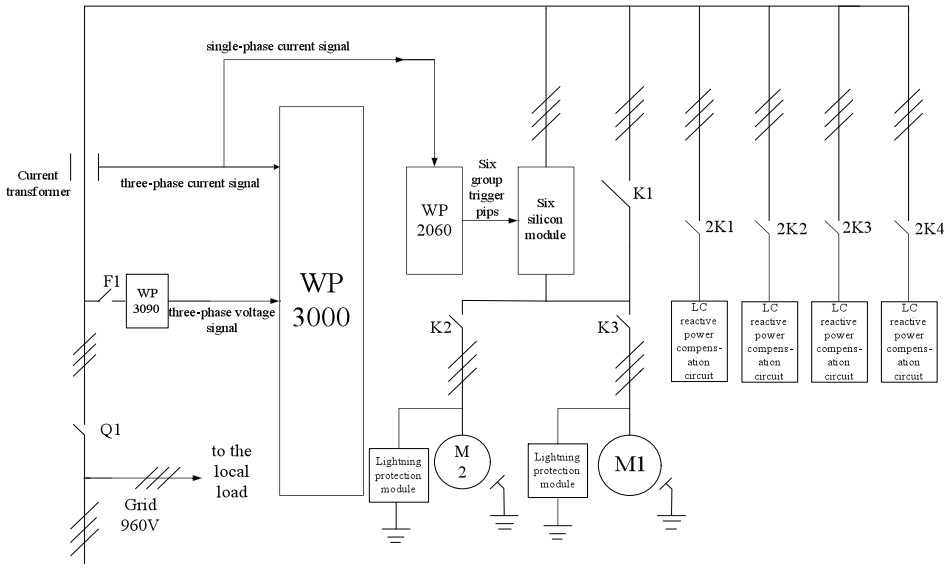

Fig. 2: N43/600 control system high voltage circuit

III. Analysis of Control System

The control system controls wind turbine to run normally. According to the variety of wind speed, the wind turbine is able to start and stop, soft cut-in and off grid, cut in or out big and small generator automatically at corresponding compensation. The generator room can be windward initiatively (veer on own initiative) when wind direction changes. When the wind turbine or the grid have some problems, the system can diagnose and protect itself. In this article, the structure and function of wind turbine control system is discussed at the aspects of high voltage circuit, voltage rating, detection and control parameter, master controller WP3000 and soft cut-in module WP2060 etc.

1 High voltage circuit

Fig. 2 is the high voltage circuit diagram of wind turbine control system. It includes master control system, soft cut-in system, generators and reactive power compensation devices etc.

A. Master control system:

The master control system is mainly composed of the WP3000 master controller and its peripheral circuit. In order to maintain the operation of system normally, it depends on the current and voltage signal of grid which is get from current transformer and WP3090 and feedback signal to control various switches in circuit.

B. Soft cut-in system:

The soft cut-in system is composed of soft cut-in module WP2060, six silicon module and by-pass switch. WP2060 cut-in model and cut-in time are based on the WP3000. Six silicon module includes three pairs of anti-parallel or the bidirectional thyristor with their protection circuit. The protection circuit which is RC absorption circuit mainly utilizes the characteristic of capacitors whose terminal voltage cannot change suddenly to absorb the peak voltage to protect the thyristor. Six silicon module receives the WP2060 trigger pip to turn-on circuit so that the phase angle of generator is synchronized with grid. Completed the phase angle synchronization, master controller WP3000 will turn on the by-pass switch and completes the soft cut-in.

C. Generator:

Generator is asynchronous generator with air cool at 600/125kW. According to the wind speed, master controller cuts in or off big and small generators. It does not only cut in and starts easily at low wind speed, but also transfers wind energy effectively and improves wind energy efficiency at high wind speed.

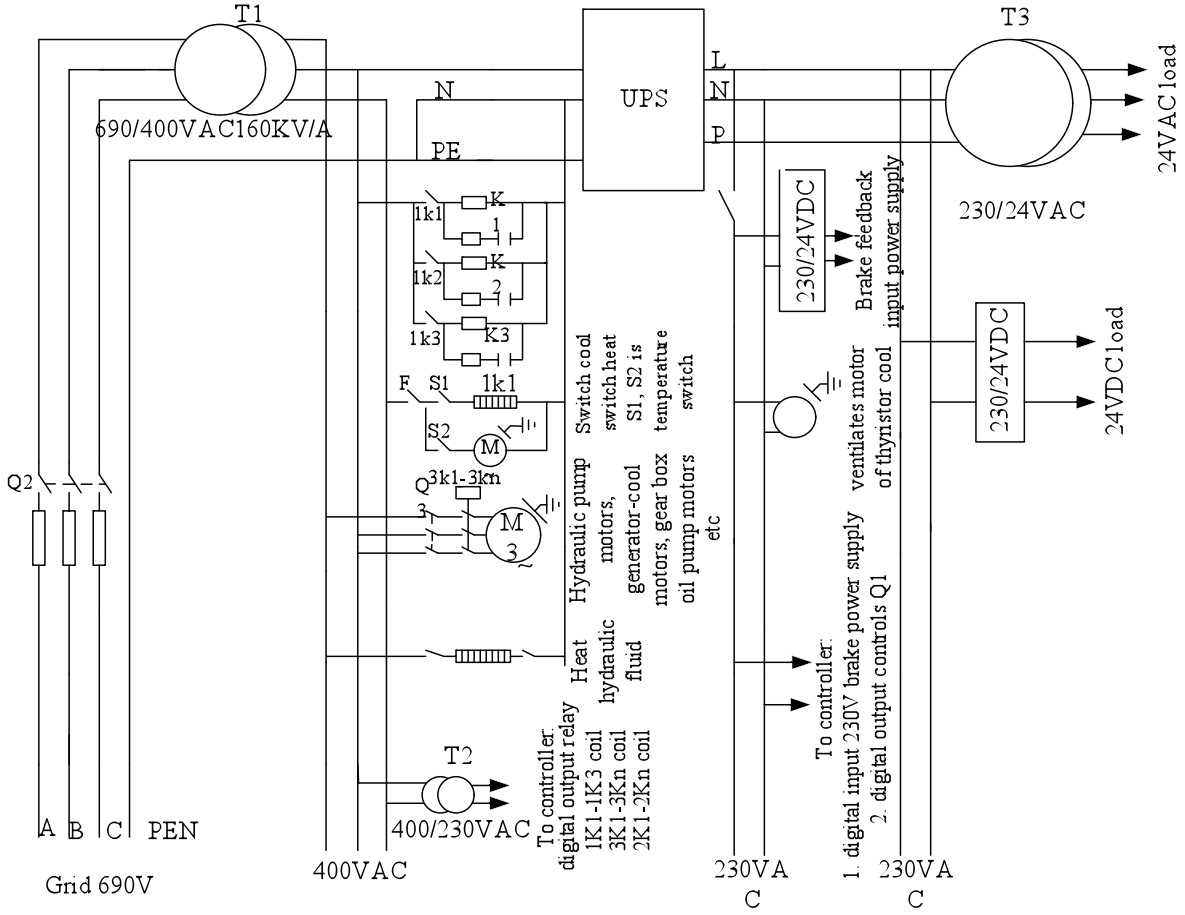

Fig. 3: N43/600 control system voltage rank chart diagram

D. Reactive power compensation devices:

The system has four groups of compensation capacitors with different capacity. When the power output is less than the power rating of generator, its output is changed by variety of wind speed. Therefore, the master controller should depend on output of generator to cut in to ensure

that the power factor of generators meets the request of grid.

2 Voltage rating

As shown in Fig. 3, the voltage of N43/600 wind turbine is divided into four ranks. They are 690VAC, 400VAC, 230VAC and 24VAC, 24VDC.

When the generator works, output voltage phase angle of generator is synchronized with voltage phase angle of 690V grid by soft cut-in module WP2060, then the by-pass switch bypasses the six silicon module and let the generator cut in grid.

As shown in Fig. 3, the 690V three-phase AC voltage is the grid voltage. The 400V three-phase AC voltage which comes from the transformer T1 supplies power for system hydraulic motors, generator-cool motors and gear box oil motors etc. In addition, its single-phase voltage heats the system hydraulic fluid, cools switch cabinet and heats power source. Two phases of 400V three-phase AC is transformed into 230V two-phase AC by transformation T2 which supplies power for the digital output of 230V relay to control 1K1-1K3, 2K1-2Kn and 3K1-3Kn coils in the figure.

The single-phase voltage supplies power for important parts of system through an uninterruptible power supply (UPS). For instance: supplies for the ventilates motor of thyristor cool; connects the controller as a digital input 230V brake power and the digital output controls Q1 (as Fig. 2); the voltage dropped by rectification at 24VDC as the power source of brake feedback input; the 24VAC load power supply by transformer T3.

3 Detection and control parameter

The master controller's function is: monitoring, system start/stop control, other functional module start/stop control, grid and wind situation monitor, change control parameters and so on. In order to assure the wind turbine security and reliability, the master controller monitors grid, wind situation and wind turbine parameters beyond various sensors. The master controller analyses different signals to output control commands.

The parameters which are monitored by the master controller can be divided into the unit exterior and interior operational parameters. The unit exterior parameters include grid voltage, current, frequency, wind speed, wind direction, outdoor temperature etc. The unit internal parameters include generator speed, the temperature of main bearings, gears and windings, the pressure and temperature of hydraulic system, attrition of brake lining, twisted winding situation as well as state variable of each control switches and the feedback parameters etc. The master controller analyses each kind of parameters, then sends out control signals to control the soft cut-in module, swatches, the leeway, the brake, the heat-cool system, the hydraulic device and so on so that guarantee security and stability of the system finally.

4 WP controller

The key master controller WP3000 and soft cut-in controller WP2060 will be introduced in this part.

WP3000 is a controller which is designed by the MITA-TEKNIK corporate especially for the wind turbine system. There is the advanced data collection, memory part and complete real-time measurement module as well as the characteristic of easy expanding. WP3000 integrates many kinds of control functions which can be designed flexibly to meet user's various requirements.

Fig. 4 is the WP3000 interface diagram. The communication ports monitor the communication between system and wind turbine. WP3000 is equipped with the direct serial communication ports and the hub management interface (HMI) which memorizes the wind turbine system's parameter in the text or graph. The succinct design of WP3000 makes its noise low and composes control system easily with other devices. In the WP3000, the control program is compiled with C language which can be downloaded to the controller.

The WP2060 linking module is used for soft cut-in, which is suitable in one or two generator wind-power system. It can control current actively to avoid the impact to grid when wind turbine cuts in grid. Control parameters can be set in master controller and WP2060 turns thyristors on or off based on control commands of the master controller. There is a phase angle measuring device in WP2060, which guarantees proper phase angle when system cuts in grid. In addition, WP2060 also monitors the temperature of thyristor continuously by the temperature sensor to ensure system working well, data records as well as downloads.

IV. FUNCTIONS

The control mode of N43/600 wind turbine is stall control with the fixed prop pitch. The following is the main functions:

1 Start and stop of wind turbine

Before the N43/600 wind turbine starts, the control system measures wind speed at first. If the average of wind speed is higher than the start speed in 10 minutes, the control system will release the mechanical brake, retract the tip damping plate and adjust the wind wheel against the wind to get ready to start wind turbine. During this process, the control system examines various parameters in the system continuously to guarantee that the wind turbine can start smoothly. In the startup procedure, the control system controls the soft cut-in module and the by-pass switch according to the real condition. Finally, the system cuts in grid and finishes the start-up of wind turbine. The wind turbine startup procedure should not exceed 40s, otherwise the system will control the generator to cut out and show startup failure.

There are two sets of brake system which are blade tip air damping plate and disc brake in the N43/600 wind turbine. The blade tip damping plate which absorbs the wind energy is controlled by hydraulic system when the wind turbine runs. When the wind turbine needs to stop, the hydraulic system releases pressure and then the blade tip damping plate rotates 90 degrees along the predetermined path to brake by the air resistance. The disc mechanical brake is installed on high speed axis of the wind turbine transmission system. It can brake the wind turbine safely by itself. The control system examines attrition situation of brake disc regularly to ensure disc brake reliability. The

stop process is divided into the normal stop and the urgent stop. The following is the normal stop procedure: first, cut out compensation capacitor, and then release blade tip damping plate, finally cut out grid. The urgent stop procedure is: first the blade tip moves and then calipers take action after 0.3s delay. Examine instantaneous power at negative or generator rotational speed at low of synchronous speed and then cut out grid. If the brake is longer than 20s, the brake will releases and the generator room will deflect 90 degrees.

2 Soft cut-in, reactive power compensation and operation monitor

In order to avoid the surge current for the grid, there is a soft cut-in device in the N43/600 wind turbine. When the wind turbine starts, the system examines operational parameters of generator unceasingly to control soft cut-in module WP2060 and thyristor by-pass switch. When the generator reaches nearby synchronous speed, the by-pass switch is cut in so that the wind turbine achieves connection. In addition, before the wind turbine reaches the power rating, the control system controls four groups of reactive power compensation capacitor to cut depending on different power factor to meet the factor of grid.

Not only the control system surveys the start parameters continuously, but also monitors the temperature of generator and gear box, power factor of generator and hydraulic pressure etc. So the system runs stably.

3 Switching control

For the higher wind energy efficiency, the N43/600 wind turbine is developed with the asynchronous double winding generator. The control system switches big and small generators according to the variety of wind speed.

When the wind turbine works, the control system examines its power output. When the small generator works, if in 1s the instantaneous power is more 20% than power rating of the small generator or the average of power output is more than some setting value in 120s, the system will switches the small generator to the big as following process: cut out compensation capacitance → small generator off→ when the leaf blades reaches a certain speed, the big generator soft cut in grid. If the wind speed gets low after the small generator off-grid, the leaf blades speed cannot reach the request and then the system will switch the small generator softly. When the big generator works, if the average of power output is less than some setting value in 120s or the instantaneous power is less than the other setting value in 50s, the system will switches the big generator to the small one as following process: cut out compensation capacitance → big generator off→ the small generator soft cut in grid.

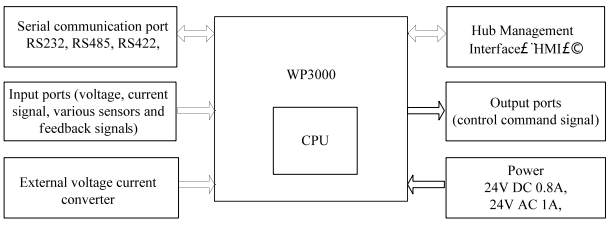

Fig. 4: WP3000 interface

4 Leeway control and auto-untie

In the N43/600 wind turbine, the oil motor realizes the leeway. This mode avoids the vibration of generator room for steady leeway. Regardless of the wind turbine at the running or the readiness status, if generator room deviates from wind direction at certain angle, the control system will send signal to oil motor that controls the error between generator room and wind direction in some required scope.

After the generator room transferring 2, 3 rounds accumulatively in the same direction, if the wind speed is less than that the wind turbine starts and the generator has no power output, the wind turbine will stop. The system controls generator room to reverse 2, 3 rounds to untie automatically. If there is power output in this time, the system will not carry on untying automatically. If the generator room continues to transfer 3 rounds accumulatively, the control system will stop automatically. After automatic untying, the wind turbine will start again.

In addition, the wind turbine control system also carries out processing different disaster dump. When disaster dump happens, the wind turbine will enter the readiness situation automatically. For example, the generator stops because of too fast or too slow wind speed, grid breaking down and so on. If disaster dump happens because of the interior malfunction of wind turbine, a manually operation is needed to repair the malfunction and reset. So the wind turbine can enter the readiness situation.

V. CONCLUSION

This paper mainly introduces the internal structure, control system and related function in Nordex N43/600 wind turbine which comes form Danish - Germany Nordex Corporation and is used in a wind power generation station. According to the research at the scene, there are many advantages that are strong adaptability, high reliability, easy maintenance, security etc in this wind turbine. This article supplies a reference to develop the large and middle scale wind turbine independently in China by analysis of wind turbine. The abundant wind energy will be taken full advantage better.

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