Transformation Plan for Fan & Pump of ALPHA6000 Inverter

I. Energy Conservation Significance of Speed Regulation through Variable Frequency

The model of most fan and water pump loads is selected in accordance with the work load. In actual application, most of the time, it is not in the full work load state. A wind deflector, reflux valve or start/stop time are usually used to regulate the air volume or flow. In the meantime, it is difficult to frequently start/stop big motors under the power frequency state when the power shock is big, and it tends to cause a loss of electric energy and current shock during start/stop. It is the most scientific way to use the inverter to directly control the fan and water pump loads. When the motor operates at 80% of rated rotation speed, in theory, the power it consumes is the cube of 80% of rated power, i.e., 51.2%. Minus the impact of mechanical loss as well as motor copper and iron loss, the energy conservation efficiency is close to 40%. In the meantime, the closed-loop constant-pressure control is easier to be realized to further improve the energy conservation efficiency. Because inverters can realize soft stop and soft start for big motors, voltage surge during the start can be avoided to reduce the failure rate of the motor and to increase its service life. Furthermore, it can also reduce the capacity requirements of the power system and reactive power loss.

II. Energy Conservation Analysis

Through the basic principles of fluid mechanics we know that devices like fans and pumps are square torque loads, and its rotation speed n, flow Q, pressure H and shaft power P have the following relations: $Q \propto n$, $H \propto n2$, $P \propto n3$, i.e., its flow is in proportion to its rotation speed, its pressure is in proportion to the square of its rotation speed, and its shaft power is in proportion to the cube of its rotation speed.

Next, the principle of energy conservation will be analyzed by taking a fan as the example. As show in the FIG. below, when the fan rotates with the rated rotation speed, the air volume and air pressure of the fan will change in accordance with the characteristic curve 1, and this curve intersects with the pipe network resistance curve 2 at the rated working condition point N when the air door is fully open; the air volume of the fan is Qn and the pressure is Hn. In general, the working condition point is moved to point E by closing the regulation air door and increasing the resistance in ventilation pipe network. At this moment, the air volume is reduced to Qe and the generated pressure head is He. If the air volume is regulated by reducing the rotation speed of the fan, the fan will operate in accordance with the characteristic curve 4, and when the required air volume Qe is generated, it will intersect with the pipe network resistance curve 2 at the working condition point C when the air door is fully open.

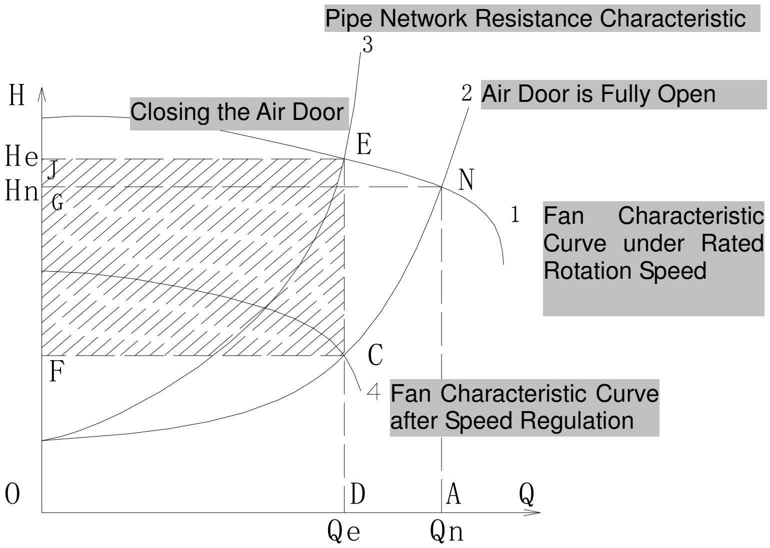


FIG.1. Fan Characteristic Curve

In accordance with the similar principles between fan and water pump, the air volume, rotation speed and power of the fan satisfy the following formula:

$$\frac{Q_2}{Q_1} = \frac{n_2}{n_1} \qquad \frac{n_2}{n_1} = \sqrt{\frac{H_2}{H_1}} = \sqrt[3]{\frac{N_2}{N_1}} \qquad N_2 = N_1\left(\frac{n_2}{n_1}\right)^3$$

Where:

Q1 — air volume of the fan before regulation, m3/h; Q2 — air volume of the fan after regulation, m3/h;

H1 — pressure head of the fan before regulation, Pa; H2 — pressure head of the fan after regulation, Pa;

n1 — rotation speed of the fan before regulation, r/min; n2 — rotation speed of the fan after regulation, r/min;

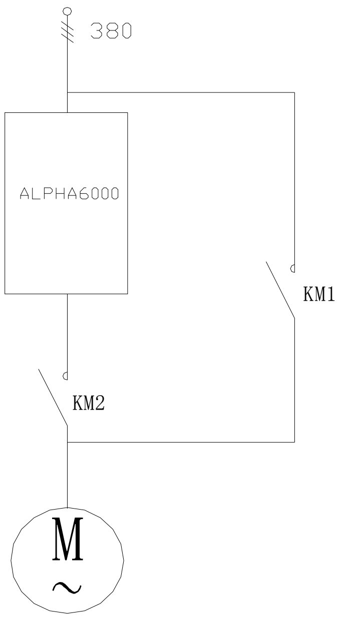
N1 — shaft power of the fan before regulation, KW; N2 — shaft power of the fan after regulation, KW.

In accordance with similar principles, when the rotation speed of the fan is reduced to n2 from n1, the shaft power of the fan N2 will be reduced to the product of N1 and (n1/n2)^3; the shaded area in the FIG.—the area covered by JECF represents the saved electric quantity by reducing rotation speed compared with closing the air door to regulate the same amount of air volume. Both theory and actual measurement prove that it will cause waste of electric energy by manual increasing ventilation resistance (closing the valve) to regulate the air volume, which is unacceptable.

If Variable frequency technology is adopted to change the rotation speed of pumps and fans to control other process control parameters on the field such as pressure, temperature and water level, the comparison results mentioned above can also be obtained by drawing the relation curve in accordance with the system control characteristics. In other words, the method to adopt Variable frequency technology to change the rotation speed of motor is more energy and cost efficient than by using valve and damper, and the operating condition of the equipment is also significantly improved.

III. Variable Frequency Transformation Plan:

1. Main Electric Circuit Diagram:



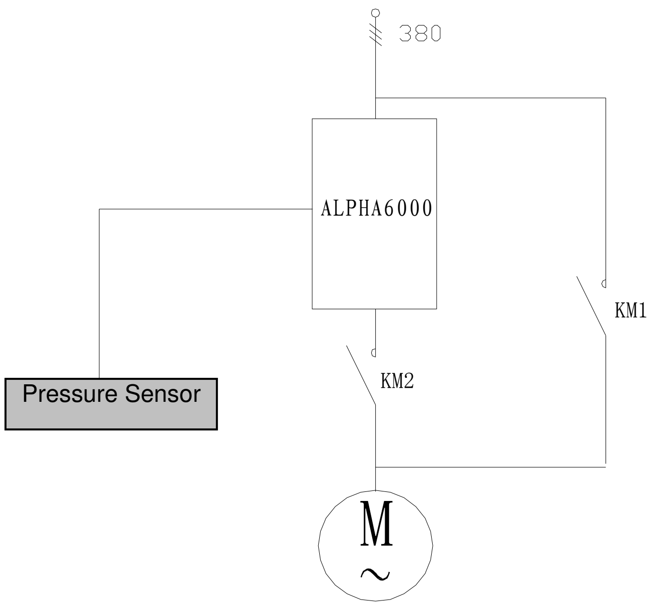
As shown in the above FIG., to keep the original system, add the variable frequency part, various motors in the system are all driven by corresponding inverters, and when the inverter has failure,

power-frequency start can be chosen to use to original control system and ensure the production continuity.

2. Control Circuit

A. Manual regulation (i.e., open-loop regulation) system, when manual control is used, in accordance with the requirement, the output frequency of the inverter can be regulated and rotation speed of the fan or pump can be changed to regulate air volume or water volume. This method is consistent with the previous method to regulate air door (gate valve).

B. Automatic regulation (i.e., closed-loop regulation) system:



As shown in the above FIG., the automatic control system uses the closed-loop regulation consisting of the built-in PID function of ALPHA6000 and pressure sensor or pressure gage. The sensor quickly detects the air pressure or water pressure, transforms it into 4-20mA current signal (or 0-10V voltage signal), and sends it to the PID regulator, and through internal calculation of the inverter, the operation frequency of the inverter is automatically regulated to stabilize the air volume or water pressure at the set value.

3. Characteristics of the ALPHA6000 Inverter used in Fan and Water Pump

The ALPHA6000 Inverter used in Fan and Water Pump is a product specially designed for load with square torque. Its application is cost effective and reliable, it has diverse control functions, it is popular among the users, and it is an ideal choice for you. It has the following advantages:

※ Multi-path definable multi-function input/output terminal

※ Multiple V/F curves to be chosen from

※ Instant outage restart function

※ Stable start, applicable to speed regulation of big-inertia load

※ Wide voltage range operation, the allowable fluctuation range of voltage: 304--456V

※ Advanced built-in PID algorithm, it is easy to realize closed-loop automatic operation

※ Special ALPHA hardware rotation speed tracking technique, it can realize no-shock tracking of rotation speed.

※ Built-in RS485 communication, it supports MODBUS-RTU communication protocol.

III. Functions and Characteristics of the System after Transformation

(1) By adopting a inverter to control the rotation speed of the motor, the damper adjustment can be canceled, the equipment failure rate is reduced, and the electricity conservation effect is significant.
(2) By adopting a inverter to control the motor, it can realize soft starting of the motor, increase the service life of the equipment and avoid shock on the power system.
(3) The motor will operate in a state below the rated rotation speed, which will increase the impact of noises on the environment.
(4) It has overload, over-voltage, over-current, under-voltage and lack of one phase of the power automatic protection functions as well as audible and visual alarm function;
(5) During installation, it won't damage the original power distribution facility and its production won't impact the environment.
(6) Because it won't damage the original system wiring, the current system has the two working modes of power frequency/Variable frequency, and the whole system has more reliable operation.

IV. Calculation of the Energy Conservation Effect

Assume the rated air volume is Pn, the power loss coefficient is 0.1, and the utilization rate is A% (the proportion between the actual air volume and rated air volume), in accordance with the characteristics of square torque load, when the motor operates under the rated rotation speed A%, in theory, the power it consumes is the cube of the rated power (A%), and we can get the following formula for calculation:

$$P_j = Pn - Pn * 0.1 - (Pn - Pn * 0.1) * (A\%)^3$$

We get the following results:

Fan and Water Pump Electric Energy Conservation Statistics

Equipment Name	Rated Power	Total Quantity	Annual Electric Quantity	Rated Air Volume	Actual Air Volume	Utilization Rate	Electric Energy Conservation Rate	Save Electric Quantity (kilowatt hour)
Fan	30kw	1	161460 kilowatt hour	28005m3/h	22000m3/h	78%	47%	75886
	45kw	1	242190 kilowatt hour	39122m3/h	30000m3/h	77%	48%	116251
	55kw	6	1776060 kilowatt hour	35000m3/h	29000m3/h	83%	38%	674902
	75kw	4	1614600 kilowatt hour	42933m3/h	31000m3/h	72%	50%	807300
	110kw	3	1912680 kilowatt hour	55924m3/h	45000m3/h	81%	39%	745945
	160kw	1	927360 kilowatt hour	85060m3/h	76000m3/h	89%	30%	278208
Water Pump	37kw	2	490176 kilowatt hour	150m3/h	130m3/h	86%	33%	161758
	22kw	5	110424 kilowatt hour	160m3/h	120m3/h	75%	51%	56316
	15kw	2	198720 kilowatt hour	200m3/h	180m3/h	90%	24%	47692
	11kw	2	145728 kilowatt hour	90m3/h	80m3/h	88%	28%	40803
	7.5kw	2	99360 kilowatt hour	50m3/h	45m3/h	90%	24%	23846
	5.5kw	2	72864 kilowatt hour	40m3/h	38m3/h	95%	12%	8743
	4kw	2	52992 kilowatt hour	30m3/h	28m3/h	93%	18%	9538
Total Saved Electric Quantity:								3047188