Application of ALPHA Inverter in the Energy-Conservation Transformation of Fengshou Sugar Corporation

I. Instruction

In China's sugar industry, many important production equipments have high energy consumption. Electric drive of equipment needs speed regulation, and limited by the technical conditions during the design, drive speed regulation of many devices has adopted energy consumption regulation in design. AC (alternating) motor frequency-conversion speed regulation is a new technology developed based on modern microelectronic technology, which is not only superior to traditional DC (direct current) motor speed regulation, but also superior to other speed regulation methods such as variable voltage speed regulation, pole-changing speed regulation and cascade speed regulation. Its characteristics are smooth speed regulation, wide range of speed regulation, high efficiency, simple structure, rigid mechanic characteristics, complete protection functions as well as stable, safe and reliable operation. It can obtain optimal speed parameter during the production process, and it is an ideal method for speed regulation.

Practical application shows that AC motor frequency-conversion speed regulation can generally save energy of about 30%. At present, industrial advanced countries have widely adopted frequency-conversion speed regulation technology, which is also a new technology of energy conservation highly promoted in China. Inverter is applied in various loads of the sugar industry such as the fan, water pump, presser and centrifuge, and significant energy conservation effects have been achieved.

II. Energy-Conservation Transformation Plan for Production Water Supply

1. Operating mode of original water supply system

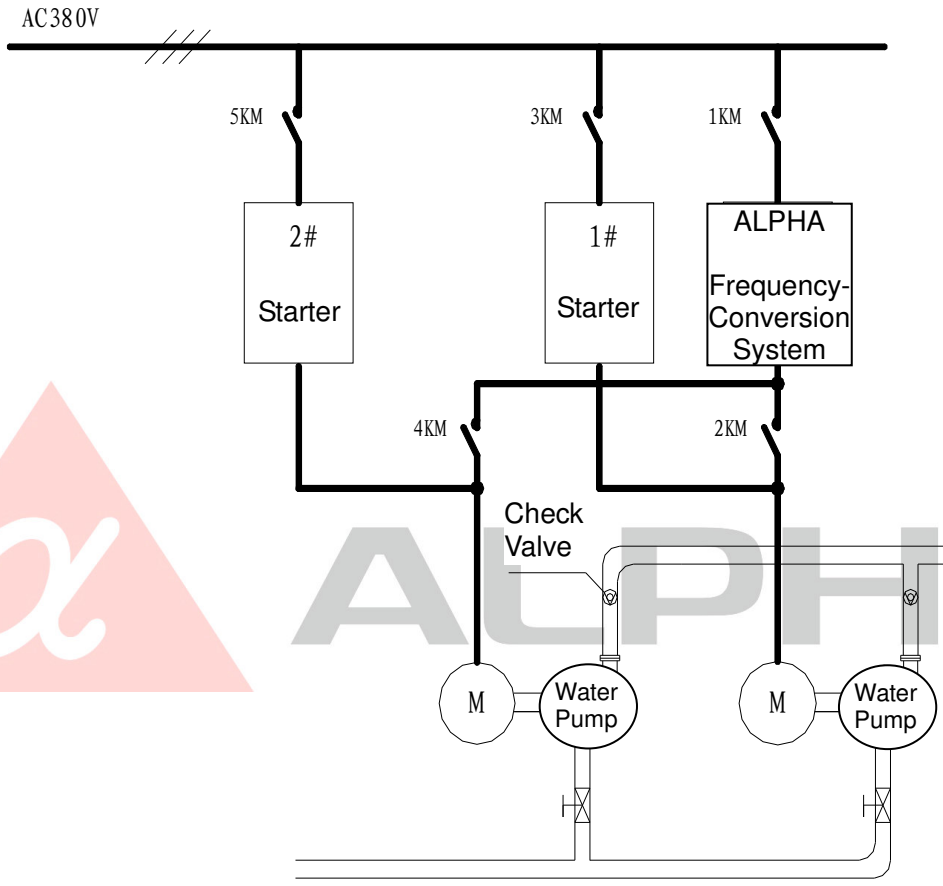
   The original water supply system consisted of two pipeline systems: the first pipeline system had six water supply pumps, and the pumps were drive by five motors of 110KW and one motor of 75KW respectively; the second pipeline system had six water supply pumps, and the pumps were drive by five motors of 155KW and one motor of 220KW respectively. The switching of the water pump was conducted by the watch-stander in accordance with the pressure, there was huge fluctuation of water pressure in accordance with the change of water consumption and switching of the pump unit, switching of the pump unit had a huge impact on the power system, and the reflux valve had to be opened to conduct regulation in accordance with the production process' requirement of water pressure and flow.

2. Frequency-conversion energy conservation transformation plan

   From the above system operating mode, we can know that frequency-conversion energy conservation transformation can be conducted to this system, and the transformation plan is as the following:

   Part of the system can adopt frequency-conversion control. Pressure sensor can be installed on each pipe, real-time inspection of the pipeline water pressure can be conducted, the frequency-conversion control system automatically regulates the rotation speed of the pump motor in accordance with the water consumption in production to further control water supply of the system, and in this way, it can be guaranteed that the water pressure of the pipeline is

constant. The first pipeline network has the 110KW frequency-conversion energy conservation system to control two pump motors, one primary and one spare, and the other four are under power frequency control; the second has the 220KW frequency-conversion energy conservation system to control one 220KW pump motor and one 155KW pump motor, one primary and one spare, and the other four are under power frequency control. After transformation, the energy conservation effect is significant, and water is supplied under constant pressure, which has significantly improved the production process. The control diagram of the transformation system is as the following:



3. Principle of frequency-conversion energy conservation transformation

a. Characteristics and parameter of the pump

The power only used for pumping the water is called active power.
Active power = (1000QH)/(75×60/0.736)=QH/6.11(kW)
Where, Q refers to the flow (m3/min); H refers to the total lift (m).

Assume the weight of 1m3 water is 1000kg within the lift, so
Shaft power of the pump =(Active power)/ Efficiency of the pimp (kW)
Output power of the motor=(1.05～1.2)×Shaft power (kW)

In accordance with different lifts and models of the pump, the pump also has different efficiencies. In general, efficiency curve of the general standard pump is like that shown in FIG. 2.

Because there might be error in design and manufacturing of the pump, so the output power of the motor should have 5～20% surplus capacity compared with the shaft power, and then the power of the motor should be calculated in accordance with the flow and lift. FIG. 3 has shown the flow-lift characteristic curve.

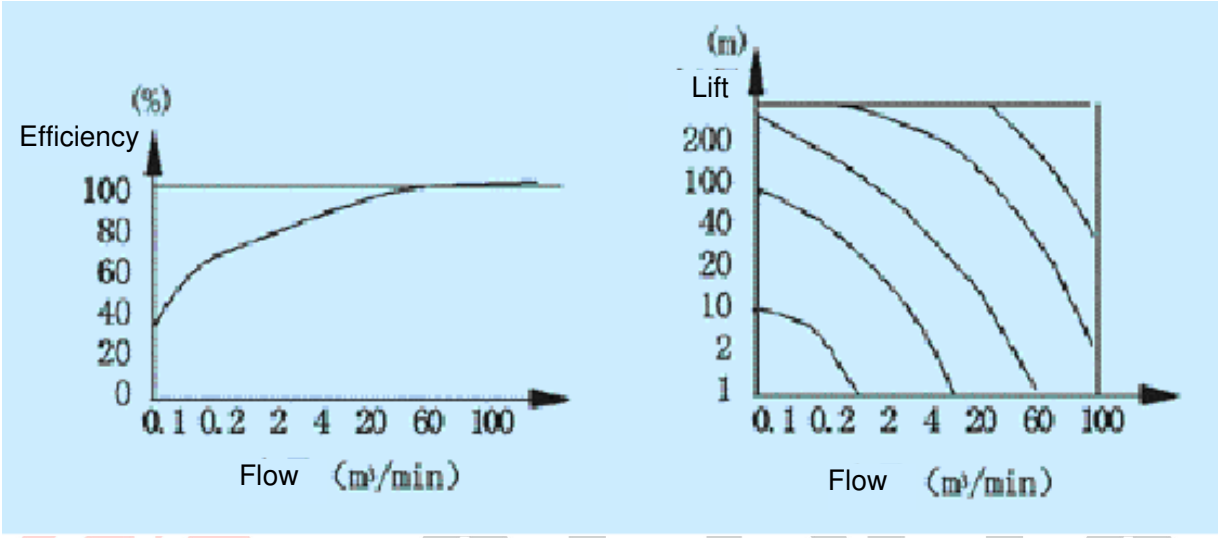


FIG. 2 Efficiency of General Standard Pump FIG. 3 Flow-Lift Characteristic Curve

b. Water resistance characteristic of the pipe network

When the water resistance R of the pipe network stays the same, the relation between the water volume and the rinsing resistance is not certain, i.e., the water volume Q and the rinsing resistance h change in accordance with the law of resistance, and its expression is:

$$H=RQ^2 \quad (Pa)$$

Where, H—rinsing resistance

R—water resistance coefficient

H= f(Q) relation curve is the water resistance characteristic curve, which is in form of parabola, as shown in FIG. 4. From FIG. 4 we cans see that the bigger the water resistance coefficient R is, the steeper the curve, i.e., the bigger the rinsing resistance.

c. Principle of speed-regulation, control and energy conservation of pump

From fluid mechanics we can know that the water volume Q is in proportion to the rotation speed, the pressure H is in proportion to the square of rotation speed, and the power P is in proportion to the cube of rotation speed.

$$Q/Q_e = n/n_e$$
$$H/H_e = (n/n_e)^2$$
$$P/P_e = (n/n_e)^3$$

Where: Qe—Rated air (flow) volume of fan and pump;
He—Rated pressure of fan and pump;
Pe—Rated power of fan and pump;
ne—Rated rotation speed of fan and pump.
From the above formula we know that, if the efficiency of the pump is certain, when it is required turn down the water volume, the rotation speed will decrease proportionally, and at this moment, the shaft power of the water pump will decrease in accordance with the cube of the speed decrease.

In addition, in accordance with the characteristic curve of the water pump and the relation curve of the water resistance characteristic, we can obviously see the energy conservation effect of the fan and pump. FIG. 5 has shown the speed regulation and energy conservation schematic diagram of the fan and pump, in which, H refers to the H-f(Q) curve under constant speed, its water resistance curve and air resistance curve intersect R1 at point A, and the corresponding air volume is Q1.

At this moment, the shaft power of the fan and pump is in proportion to the area of the rectangle Q1AH1Q. When it is required to reduce the air volume from Q1 to Q2 by using the baffle or valve, then the new air water resistance and resistance characteristic curves H intersect at point B; at this moment, the shaft power of the fan is in proportion to the area of the rectangle Q2BH2Q. If speed regulation is adopted to reduce the rotation speed of the fan and pump to n2 to make the corresponding fan characteristic curve H and air resistance characteristic curve R2 intersect at point C, then, at this moment, the shaft power of the fan which is in proportion to the area of the rectangle Q2CH3Q is significantly reduced, which means there the shaft power has been significantly reduced, and the energy conservation effect is obvious.

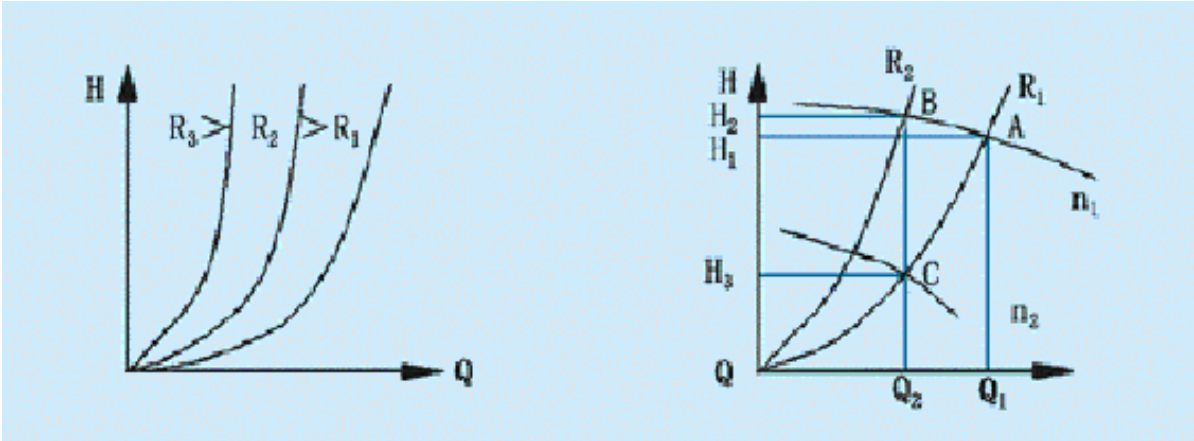


FIG.4 Water Resistance Diagram

FIG.5 Pump Speed-Regulation and Energy-Conservation Schematic Diagram

III. Main System Functions

1. Constant-pressure water supply function

ALPHA6000 inverter system has built-in PID regulator. The pipeline pressure sensor detects the pressure of the pipeline in a real-time way, transfers it into 4-20 mA current signal, directly sends it to the simulation current input port on the inverter and sets the pressure and PID parameter, and the built-in PID of the inverter controls the output frequency after calculation. The system parameters can be regulated during actual operation to provide fast system control and response. The pipeline pressure can be set freely in accordance with the production process, and the frequency-conversion system automatically follows the control to maintain the set constant-pressure of the pipe network, which can not only provide energy conservation but well satisfy the requirement for water pressure by sugar production.

2. Pump unit switching instruction

The system can detect water pressure of the water supply pipeline in a real-time way, and when current pump unit fails to satisfy or exceeds water requirement during production, the system will automatically send instruction to put the pump unit into use or cut it off, and it will also send acousto-optic switching alarm of pump unit to instruct the watch-stander to switch the pump unit, in this way ensuring water supply during production.

3. Power frequency/frequency conversion switch function

The sugar industry has a high requirement for reliability of its water supply system. Once there is failure, it will have serious impact on the whole production, so this system has been equipped with power frequency/frequency conversion switch function. Under normal operation, the system is under the frequency-conversion constant-pressure water supply state, and when there is failure of the inverter or during routine overhauling, it can switch to the power frequency operation immediately, during which, the original auto-transformer reduced-voltage start system is used to start the water pump, in this way ensuring continuous water supply, and the

reliability of the whole system can well satisfy the requirement of production. The two start systems have electric interlock to prevent misoperation and to ensure safe operation of the system.

IV. Benefits after Transformation

1. It can increase the service life of the equipment and pipe network, as well as reduce the work amount of system maintenance.

   Due to adoption of the frequency-conversion constant-pressure control, the water pump has soft start, which has eliminated the impact of the impact torque on the motor during the start of big motor. The impact on the water pump during the start has been significantly reduced, and in the meantime, due to soft start and constant-pressure control of water pressure, water hammer impact on the pipe network during the start has been eliminated, and there won't be any boosting pipes. In this way, the service life of the original equipment has been significantly increased, the failure rate has been significantly reduced and the work amount of system maintenance has also been reduced.

2. It can improve the quality of water supply and increase reliability of the whole system.

   Since adoption of the frequency-conversion constant-pressure control system, the pressure of water supply can be smoothly regulated, and the watch-stander can have more stable and flexible regulation and control of the system. In accordance with the change of the production process, the pressure of system water supply can be regulated smoothly. Due to adoption of the new system, the failure rate has been significantly reduced, and because two start systems compensate each other, continuous system water supply can be ensured, which can guarantee cost-effective and optimized operation of the system.

3. It can improve energy consumption situation of the plant.

   Since adoption of the frequency-conversion soft start, impact on the power system of the original start system during the start has been eliminated. The power factor of the new system can reach 0.95, its efficiency can reach 0.98, the operating current of the system has been significantly reduced, the line loss has been significantly reduced as well, and the energy consumption situation of the plant has been improved.

4. It has significant energy conservation effect and impressive economic benefits,

   During operation of the original system, in order to maintain basically constant water pressure, in addition to the requirement of repeated switching of the pump unit, it also requires small-range regulation through the reflux valve. Switching of the pump unit does not only have an impact on the power system, it also consumes energy, and regulation through the reflux valve almost does not reduce energy consumption by the water pump. Since adoption of the frequency-conversion system, the frequency-conversion pump unit can automatically regulate the rotation speed of the water pump motor in accordance with the water pressure required in production, and maintain a constant pressure of the pipe network. Regulation of the frequency-conversion pump unit has a wide range, switching frequency of the pump unit has

been significantly reduced and the system has impressive energy conservation effect. In average, the system has an energy conservation rate of about 30% with impressive economic benefits.

5. It can reduce the labor intensity of the watch-stander.

   After transformation of the original system, water pressure of pipe network can be inspected and controlled automatically, the reflux valve does not need regulation, switching of the pump unit has acousto-optic alarm instruction, and the watch-stander doe not have to worry about production accidents caused by too low or too high water pressure due to untimely switching of the pump unit or turning on of the reflux valve. ??

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