Analysis Energy-Saving Effect Of Frequency Conversion And Speed Regulation Applications In Salt-Production Enterprise

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Abstract: This article analyses energy-saving principle of frequency conversion and speed regulation and discusses the practical applications and effect of energy-saving in salt production enterprise.

Keywords: Energy-saving and consumption-reducing Frequency conversion and speed regulation; Salt production

INTRODUCTION

Modern vacuum salt production enterprise is a mechanical, highly automatical process and it costs largely electric power consumption. In order to strengthen the core competitiveness in the market and improve the economic benefits, it is an important target for each salt production factory to develop and discuss how to strengthen the internal management, how to take practical measurements and innovate the technology to achieve the energy-saving and consumption-reducing which means further decrease of product costs and lower price advantage.

1 Energy-saving theory of frequency conversion and speed regulation

Mining enterprises usually control and regulation state or number of the materials to meet the needs of the production process. In this paper, we take pump and fan for an example. Pump and fan are important equipments to ensure the normal process during the production. Operating conditions must be adjusted any time in accordance with the requirements of the production process. They used to use traditional methods: reduce current that is, by changing the open extent of throttle (or air valve) which is set on the road of pump (or fans) outlet (or inlet), and by artificially setting the resistance on water or wind to achieve the goals. Taking pump as an example, its adjusting curve is shown in Figure 1. Suppose point A is the maximum efficiency when pump works, the flow Q is 100% rating and the pressure is H1, then axial power P1 is in direct ratio with area AH1OQ1; when the flow decreases from Q1 to Q2 we need to reduce the opening of the pipeline valve to increase the resistance pipe net. At this point pipe net curve changes into R_2 from R_1 curve, the pump work point changes to B point from A point and the pressure increases to H_2, then axial power P_2 is direct ratio with area BH_2OQ_2.

Theory and practice have shown the power consumption of pump (similar to the axial power, the below is the same) is as follows in this case:

$$P_A = P_N [0.4 + 0.6 (Q / Q_N)]$$

Where:

P_N-Pump power consumption in rated working condition

Q_N-Rated flow of pump

Q- Actual flow of pump

Assumptions: $Q / Q_N = 50\%$, while $P_A = 0.7P_N$

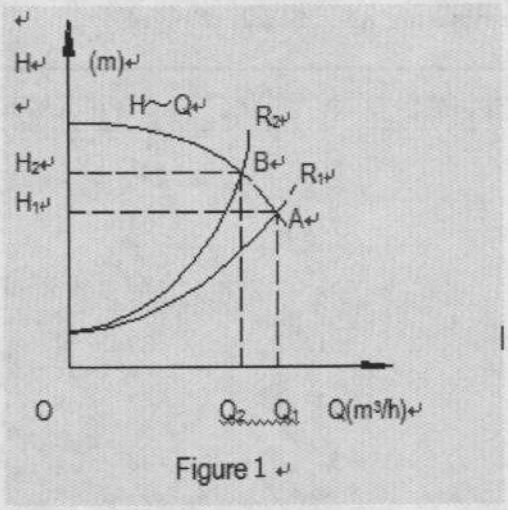

Figure 1

If we change the pump speed in stead of this traditional throttle, the situation is different. Figure 2 shows this difference.

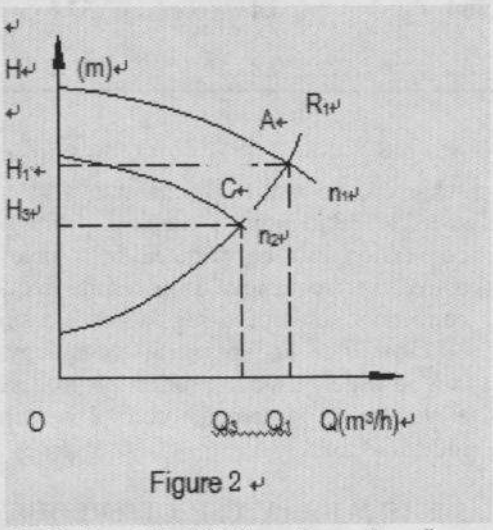

Figure 2

If Q is still 100% rating, the flow decreases to Q_3 from Q_1, the pump speed decreases to n_2 from n_1, [according to the speed formula of induction motor : $n = 60f(1-s)/p$, we can change Frequency f (that is, Frequency conversion) to achieve continuous adjustment of the Frequency conversion, which is the most common and most effective method.], And now outlet valve of the pump is wide-open (that is, the open extent is not changed), which does not increase the pipe net resistance and the pipe net curve R_1 remains unchanged, as a result, the pump work point changes to C from A , the pressure fell to H_3, and axial power P_3 is in direct ratio with area CH_3OQ_3 which is significantly reduced comparing with its former axial power P_1 (in direct ratio with the area AH_1OQ_1). According to theory, when the speed changes to n_2 from n_1, the formula about the flow Q, head (pressure) H, the pump power consumption (the axial power) P is $Q_1/Q_2 = n_1/n_2$,

$H_1/H_2 = (n_1 / n_2)^2$, $P_1/P_2 = (n_1/n_2)^3$, that is, $P_C = P_N (Q_1/Q_2)^3$.

Where P_C- the power consumption of pump after changing the frequency conversion and speed regulation

So the saving power $\triangle P = P_A - P_C$, If the P_A and P_C are substituted in the formula above, then $\triangle P = P_A [0.4 + 0.6 (Q / Q_N) - (Q / Q_N)^3]$,

Similarly, supposing $Q / Q_N = 50\%$, then $P_C = 0.125P_N$,

$\triangle P = P_N [0.4 + 0.6 (Q / Q_N) - (Q / Q_N)^3] = 0.575P_N$.

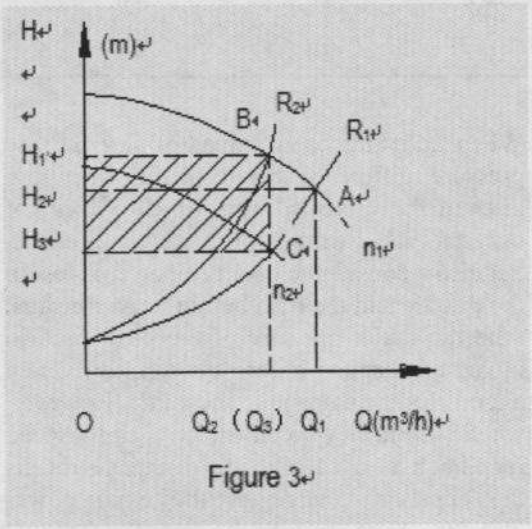

Figure 3

The area of shadow part in Figure 3 is the saving power $\triangle P$. It is obvious that the energy-saving is significant using frequency conversion and speed regulation, that is, $\triangle P / P_N = 57.5\%$. The parameters changes are shown in table 1 for these two ways.

According to table 1, the pump speed is not changed for valve adjusting way which is based on the open extent of throttle to change flow and increases the resistance consumption. However, the pump input power does not change much in this way.

Table 1, the parameters change and energy saving when flow is changed

Q/Q_N (%)	n/n_N (%)	H/H_N (%)	P_A/P_N (%)	P_C/P_N (%)	$\triangle P/P_N$(%)
95	95	90	97	86	11
90	90	81	94	73	21
85	85	72	91	61	30
80	80	64	88	51	37
75	75	56	85	42	43
70	70	49	82	34	48
60	60	36	76	22	54
50	50	25	70	12.5	57.5
40	40	16	64	6.4	57.6
20	20	4	52	0.8	51.2

When adopting open extent of throttle, the pressure difference between the front and after of the valve is large, which causes not only the valve damage and life time reduce, but also a considerable part of power is lost in the throttle and the road before it. At the same time the outlet pressure of the pump is also increased (happen before the throttle) which aggravates the damage to the pump. However, when frequency conversion and speed regulation is used, the speed change results the apparent change of the axial power directly. As a result, the input energy is reduced greatly. Meanwhile, the pump abrasion is also fallen down because the pump outlet pressure is lower which extends the pump service life.

2 ACHIEVING METHOD OF FREQUENCY CONVERSION AND SPEED REGULATION

From the speed formula of induction motor $n = 60f(1-s) / P$, we can see that as long as changing one of the three parameters: frequency f, Magnetic pole number P and Speed difference s (in terms of the synchronous motor, $s = 0$), the motor speed will be changed. However, if the s is changed using motor slip, the scope is limited and slip-conditioning power is cost in the coil excitation which does not save power; if P is changed, the scope is also limited and can not succeed for stepless speed regulation. Change the frequency f is the only way that can achieve substantially continuous stepless speed regulation. Stepless frequency conversion can be targeted in a below or above the frequency. As a result, frequency conversion and speed regulation is a simple, efficient, safe and practical technology that can be widely used in production process and a variety of automatic control system of industrial field.

3 THE WIDELY USE OF FREQUENCY CONVERSION AND SPEED REGULATION

As a conclusion, since frequency conversion and speed regulation is considerable for the energy-saving benefit, is helpful to improve the equipment operation and reduces the equipment friction extending the equipment life time, it has been gradually spread in industrial and agricultural production, household electrical appliances and municipal engineering in recent years.

Basically the power drag is realized by the induction motor in vacuum salt production. For these motors, we must selectively use frequency conversion and speed regulation on some equipment according to its operation characters during production process to see the practical results.

3.1 Boiler fans

The traditional way for the blower and attract fan of boiler fans in heat power station is mechanical air valve to control the throttle in heat and power combined vacuum salt production enterprise, The air valve is adjusted by the electric actuator, which actually set up the resistance for the duct pipe net and the speed of electric motor dragging the fan does not change. As a result, there is no energy saving. Take one salt production factory as an example: the boiler model of thermal power plant is SHF20-25/400A III, the matching blower power is 160KW and the attract fan power is 110KW. They adopted electric actuator to adjust the throttle initially. The years of operation has shown: the blower opening is generally 60% which has a larger margin to regulate and a great potential for energy saving; however, although the rate adjustment of attract fan is limited (the normal opening is 85%), it also need adjust, especially for the ignition. If the adjustment is not done during the attract fan operation, too much wind will tow away some of the cited coal, which not only reduces the combustion efficiency of coals and thermal efficiency of boiler, but increases the corrosion and abrasion for certain components of low temperature section of the boiler that are bad for the boiler's maintenance. For the traditional throttle adjustment, as the throttle lies in the duct which is after the water membrane dust catcher and before the fans and usually there is a number of coal dust and water vapor mixture in the duct in operation which will corrupt the throttle and aggravate the throttle damage, the throttle will be damaged to fall approximately six months. The throttle will drop into the vortex chamber of fan and collide with rotating impeller resulting the fan strong vibration, the impeller damage sequentially, bearing box until the electrical motor shell break, and even the basis bolts break, which will end the fans life time and cause the plant to shutdown. This loss is very heavy and the lessons are very profound. But for many years, the fundamental solution has not been found. Change the throttle is only a temporary solution. After a lot of analysis and feasibility study, based on the practice principle, the plant decided to use Frequency conversion and speed regulation. They reformed the blower and induced fan separately. They installed two corresponding capacity frequency converter in the blower and the induced fan, removed the induced fan completely and maintained the 100% opening of throttle. By frequency converter, the operation just need to do in the control room — adjust the power supply fan frequency correspondingly, then the fan speed can be changed in order to facilitate continuous stepless speed regulation for the blower and the induced fans, which is very easy to use and maintain.

Analysis of energy saving: according to statistics, the yearly (calculate the production time as 300 days) power consumption of two fans is 1555200kwh. After using frequency conversion and speed regulation, the power consumption each year is 1057536kwh. As a result, the power saving in one year is 497664kwh and the power-saving rate is 32%. Calculated as local electricity price 0.60 yuan RMB/kwh, money saving yearly is 298,598 yuan RMB. At the same time, the damage of the fans is avoided from the vibration break, which saves more than 30,000 RMB for the maintenance and reduces the indirect loss of about 300,000 yuan RMB / year for the shutdown of the equipment. However, the total cost is 286,500 yuan RMB for purchase and installation of these two frequency converter and the accessories, which has been recovered in one year and the economic benefit is very clear.

3.2 Salt production fans

The blower and the induced fan combined with drying bed is used to dry wet salt in the drying system of salt and glauber's salt production system. In the past these two fans were also controlled by the traditional throttle. As the on-site environment is poor in the salt production factory, the throttle will be damaged by corrosion in three months in this situation, resulting in the air volume is out of control, even if the throttle is frequently changed. After adopting frequency conversion, the fan speed is adjusted by corresponding frequency conversion and speed regulation instead of completely opening the blower and the induced fans. This way achieves the stepless adjustment in wide range and can meet the production process requirements. It not only saves power energy but also increases the production and quality of salt and glauber's sodium, reduces the salt dust loss for too much air flow and protects the environment effectively; at the same time,

these two frequency converters can be installed in a closed room away from the blower and the induced fans, which not only maintains a better condition for their operation, but reduces the trouble rate, extends the life time and further reduces the delay loss. Meanwhile, the economic benifit is also very gratifying

3.3 Boiler feed pump

In the past, there is no regulation for the boiler feed pump in thermal power plant, the water level in the boiler is controlled by pipe valve (manual or electric regulating valve)manually. Because this regulation is to set water supply pipe resistance manually to increase the pressure of feed pump outlet, it will exacerbate the abrasion between the pumps and valves. For example, the actual working period is only six months for an electrical control valve in one salt production factory, however, after adopting frequency conversion the water level is achieved by adjusting the speed of the feed pump which reduces the abrasion and extends the life time. In this way, the service time of the eclectic control valve is kept over three years and the wear down of the feed pump and the power consumption is declined significantly.

3.4 Circular water system in salt production

The recycled water system is used to cool the process in salt production enterprises to ensure the vacuum. According to the contrast in design and practical operation, we can easily find unscientific and unreasonable configure in circular water system. Normally in several pairs of cold, heat pumps, the throttle is installed in the outlet of the pump which costs a lot of energy. We adopt a pair of pump-and multi-frequency pump running in parallel way on cold and heat pumps with the all water valve to open and adjust the speed of the frequency pump to boost the entire cycle water system in order to meet the different flow needs. Control is made by shift between pump frequency / multi-frequency manually, which starts the multi-frequency pump and pump frequency sequentially. If the multi-frequency circuit fails, change to pump frequency operation in time.

Take an actual operation in salt production factory as an example, if the operation frequency of two frequency conversion equipments controlling the water is $30H_Z$ or so, not only the running current of the pump decreases significantly (approximately 26% of the original), but also the working characteristics of the other two parallel operation pumps is changed, resulting in higher efficiency at work point and lower working current(approximately 82% of the original). In addition, inlet and outlet valves of all cold, heat pumps are avoided from "pressure hold" damage that greatly extends the service life of valves and energy saving effects is obvious.

3.5 Other applications

Frequency conversion and speed regulation is being widely used in salt production enterprise. Except from the boiler, the blower and the induced fan in drying process of salt production and water feed pump, it is also applied to feeding coal machine to boiler (change slip speed to frequency), softened water (non-salt water) pump, industrial clean water pump, circulation pump in salt production, all water pumps, mining brine pumps and transportation brine pumps in brine purification system. All of these bring us encouraging efficiency and the cost recovery is about one year. In addition, according to the characteristics of the salt production process, some manufacturers combine the frequency conversion of the feed and transportation pumps with the new intelligent thermal instruments to form a computer distributed control system (DCS), which can adjust the level of the evaporation tank by closed-loop PID computer automatically and save energy .

4. CONCLUSION

Energy saving and consumption reducing is the eternal topic in salt production enterprise. Frequency conversion and speed regulation technology popularized in recent years is not only the energy saving application of electric power and electronics technology in salt production, but also the main task for technology innovation and energy saving. Practice over years has proved that the greater the process parameters are adjusted, the higher the energy saving rate is .Meanwhile, the equipment operation condition can be improved and the life time can be extended. In recent years, a new cooperation way of frequency conversion and

energy saving has been promoted, which the supplier invests all the equipments, installation, commissioning and maintenance instead of demand part invests and shares the benefits from the power savings to achieve the interests sharing model, it is worthy of introduction and promotion to industrial enterprises. As the win-win cooperation model of "an investment, the benefit of the two" is used flexibly, frequency converter will win greater developing scope and the application of frequency conversion and speed regulation will become more and more widely.

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