Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 10 (2011) 32 – 38

Procedia Environmental Sciences

2011 3rd International Conference on Environmental Science and Information Application Technology (ESIAT 2011)

Research and Application on Energy Saving of Port Belt Conveyor

Mingwang Dong[a],Qing Luo[b]

[a]School of Logistics Engineering,Wuhan University of Technology,Wuhan,430063,China
[b]School of Logistics Engineering,Wuhan University of Technology,Wuhan,430063,China

Abstract

This paper briefly introduces several energy-saving techniques used in belt conveyor in ports. According to the practical operating situation of belt conveyor in coal yard in Tianjin port, less motor operation technique is used to develop a study on electricity-saving experiment and improvement of the belt conveyor system, and analyze the related experimental data. Finally, it is proved that this system has some advantages of low cost, stable performance and obvious effect in energy saving.

Keywords:belt conveyor; energy-saving; less motor operation technique

1. Introduction

As a kind of continuous transportation equipment, belt conveyor is widely used in today's modern port, especially in the transport of coal and mineral powder because of its high efficiency and environmental protection. Motor's capacity is determined by the maximum load under ordinary usage, so it could cause the low efficiency and power wasting if motor runs without load or with light load for a long time.

There are four common energy-saving techniques of belt conveyor, such as asynchronism motor Y-△ switching technique, voltage reduction technique, flux-flow limiting technique, and less motor operation technique.

Aiming at the operation status of belt conveyor in coal yard in Tianjin port, this paper uses less motor operation technique to realize the purpose of energy conservation and emissions reduction. The experimental result shows that this technique has the advantages of convenient implementation, low cost, short cycle and stable operation, also of the remarkable energy-saving effect and broad application value.

2. The Energy-Saving Technique of Belt Conveyor

doi:10.1016/j.proenv.2011.09.007

2.1. Asynchronism motor Y-△ switching technique

Motor winding has Y and △ connections. Phase voltage of stator winding is equal to line voltage under △ connection, that is $V_{\Delta\phi} = V_L$, under Y connection, it's $V_{Y\phi} = V_L / \sqrt{3}$. Reactive power that motor needed includes excitation reactive power and magnetic-flux leakage reactive power. The motor's magnetic-flux leakage reactive power is equivalent under these two connections. The excitation reactive power is proportional to the square of stator winding's phase voltage, that is to say, the excitation reactive power under Y connection is one third to that under △ connection. Besides, their active power is equivalent under the same voltage and load. So comparing to △ connection, the total power consumption under Y connection is less [1]. The belt conveyor is always running with light load or without load, using the method of starting up motor with △ connection and operating with Y connection can reduce motor's power consumption and achieve energy conservation effecting.

2.2. Voltage reduction technique

When three-phase asynchronism motor runs with full load, its power factor is higher and the phase angle Φ caused by the current lags behind the voltage is lesser. As motor's load becomes lighter, Φ will increase and power factor will decrease. The voltage reduction technique is using three-phase power which has been regulated pressure by the bidirectional transistor to supply motor with electricity, and using transistor's firing angle α to track Φ automatically, when Φ increases, α increases, motor's terminal voltage and power consumption decreases, and finally realizes self-compensation of power factor[2].

2.3. Flux-flow limiting technique

Motor's power consumption will lesser if belt conveyor operates with some characteristics for material, such as stronger continuity, well-distribution and the average flow is more stable. The automatic current-limiting device of belt conveyor is shown in Fig.1.

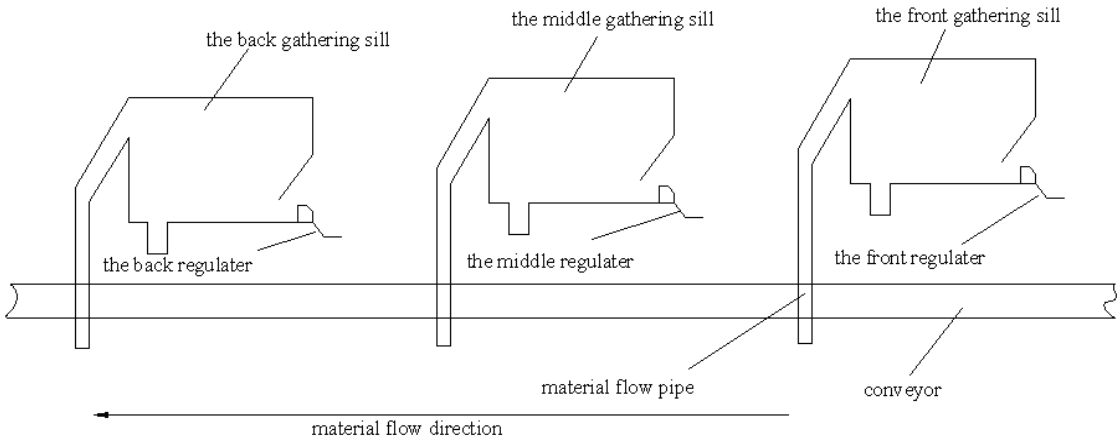

Fig. 1. The automatic current-limiting device of belt conveyor

The operational principle is using screw to adjust the height of three sections regulator according to material particle size. When material gets into the current-limiting device, the regulator will block the material flow over height into gathering sill. Material is stored temporarily in gathering sill until appears the lower flow, and then they will flow down the belt. Continuous excessive flow will cause the first gathering sill accumulates full materials, once this kind of problem appears, material will be overflowed through both sides of material flow pipe and piled up in both sides of belt conveyor as anchor material processing[3]. Using this device could adjust the material flow timely and accurately, enhance thestability of flow, improve working efficiency and reducesystem's energy consumption.

2.4. Less motor operation technique

In the belt transportation of bulk cargo wharf, if the working position of the stacker or reclaimer is different, the length of material stocked on belt conveyor is also different. When the length of material is longer, load is larger, and motor's working efficiency is higher too. Conversely, the shorter the length is, the lower the working efficiency is, and finally causes energy wasted [4]. Under this situation, using less motor operation technique, in other words, when the load is fewer, decreasing one or more motors, can achieve the purpose of saving energy and improving power factor.

Compared to other energy-saving techniques, less motor operation technique also can realize the effect of saving energy. Moreover, it has characteristics of low investment of equipments, low changing of lines, low cost of rebuilding and more suitable for energy-saving rebuilding of belt conveyor.

3. System Rebuilding

The system of belt conveyor equipment in coal yard in Tianjin port always runs in a totally good condition since it was put into usage. But as time went on, belt conveyor appears the phenomenon of low efficiency in the working process, and causes bigger power loss and waste. So according to this actual situation, coal yard in Tianjin port puts forward less motor operation technique.

3.1. Hardware rebuilding of belt conveyor system

The energy-saving rebuilding structure schematic diagram has been shown in Fig.2, system’s hardware mainly includes: upper industrial controlling computer, PLC controller, motor, overrunning clutch, printer, supervisory control and data acquisition system, data input/output card, RS232 / RS485 converter, RZ-102 intelligent instrument, mutual inductor, etc.

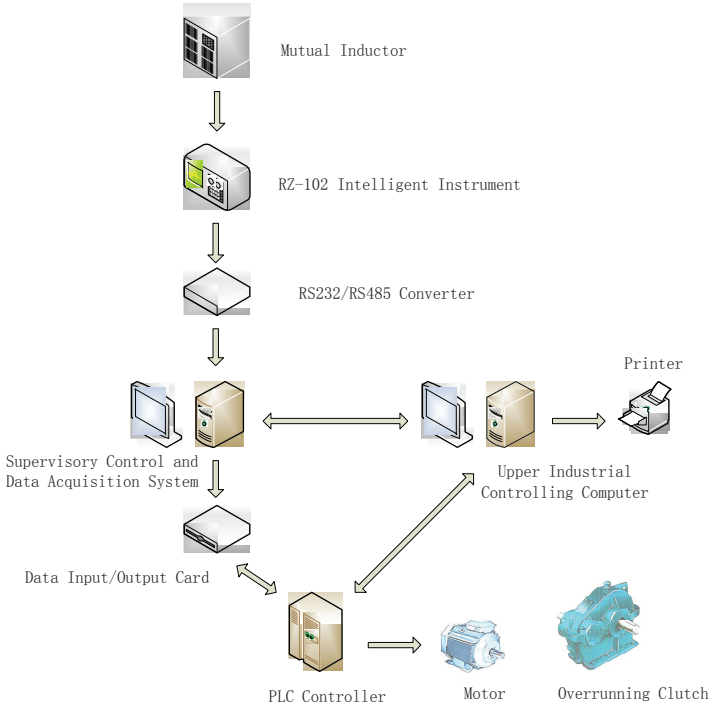

Fig. 2. Energy-saving rebuilding structure schematic diagram

3.1.1. Upper industrial controlling computer

Compared to the original system, it has the following changes after energy-saving rebuilding of belt conveyor:

- three drive motors of the original system's belt conveyor BQ1 have hardware interlock information in MCC. The requirement of assuring belt conveyor operating normally is that BQ1's motors are all starting normally. But now it just needs to any motors can run separately, so it must removes interlock information.
- adding allowed button of energy-saving running in belt conveyor to make system debugged conveniently.
- adding prompt message of energy-saving running in belt conveyor. It is convenient for controlling room technicians to know the real-time running situations of belt conveyor clearly.
- adding status record of energy-saving running in belt conveyor.

3.1.2. Supervisory control and data acquisition system

The main responsibility of supervisory control and data acquisition system is to collect some information, such as voltage, current, frequency, power factor, active power and reactive power of BQ1's three motors in time, and then store them in database. According to the real-time acquisition data, load

power of belt conveyor will be calculated and its change trend will be forecasted. Thereby calculating intelligently the number of running motors can assure belt conveyor operate normally.

3.2. Software rebuilding of belt conveyor system

3.2.1. The rule of programming

For better combination with PLC system, the programming rule of conveyor energy-saving monitoring system as follows:

- database record field consists of voltage, A phase current, B phase current, C phase current, frequency, power factor, active power, reactive power, motor's number and time.
- database records each half a second.
- according to the value of real-time voltage, A phase current, B phase current, C phase current and power factor, the real-time active power of conveyor's load will be calculated.
- the active power, which changes mostly in the next one minute, will be gotten from fitting two curves, one is the calculated real-time active power and the other is all active power which has been calculated within ten minutes before.
- when actual current value is greater than motor's rated value, and lasts for five seconds, motor's abrupt stop signal must be output immediately.
- when the value of load's forecasting active power is less than90%, the signal of cutting off motor will be put out.
- when the value of forecasting active power is greater than 95%, the signal of increasing motor will be put out.

3.2.2. Definition of digital quantity I/O

After analysis of algorithm, conveyor's energy-saving monitoring system will put out directly the result of cutting or investing motor to PLC through relays. The signal combination definition of three relays is shown in Table1.

Table 1. The signal combination definition of relay

Relay's signal	Combination definition
000	don't cut off motor
001	cut off motor NO1
010	cut off motor NO2
100	cut off motor NO3
011	cut off motor NO1 and NO2
101	cut off motor NO1 and NO3
110	cut off motor NO2 and NO3
111	stop motor abruptly

3.3. Experiment test

According to the twice experimental records, tidying obtained data to Table 2.

Table 2. Experimental data table under non-load condition

NO	Working Condition	Number of Motor	Active Power	Apparent Power	Phase Current			Power Factor	Average of Current	Current Ratio	Efficiency %
					A	B	C				
1	Three Motors Without Load	NO1	113.8	173.9	16.50	17.00	16.80	0.6475	16.77	0.40	39.0
		NO2	79.5	119.5	11.30	11.80	11.50	0.6523	11.53	0.27	4.0
		NO3	93.5	142.3	13.60	14.00	13.60	0.6564	13.73	0.33	35.0
	Total		286.8	435.8					42.03		
2	Two Motors Without Load	NO1	121.9	182.4	17.60	17.80	17.50	0.6587	17.63	0.59	43.0
		NO2	87.2	128.3	12.30	12.60	12.30	0.6565	12.40	0.41	20.0
	Cut off One Motor	NO3	0.0	0.0	0.00	0.00	0.00	0.0000	0.00		0.0
	Total		209.1	310.8					30.03		

From Table 2, it will be known clearly under the condition of non-load, when three motors run normally, the total active power is 286.8KW, the efficiency of NO1, NO2 and NO3 motor separately is 39%, 4%and 35%. When two motors run normally, just NO3 motor cut off, the total active power is 209.1KW, the efficiency of NO1 and NO2 motor separately is 43% and 20%.

By comparing and analyzing the experimental result, it can be seen that, under the non-load condition, total saving active power due to cut off one motor is 77.7KW. Electricity-saving ratio is 27%. The working efficiency of NO1 and NO2 motor has separately improved 4%and 16%. Total apparent power has reduced 120KW because of cutting off one motor.

The further analysis, the experimental value of each motor's active power is basically the same, so the current ratio value reflects that when all motors are put into working, apparent power (active power and reactive power are also the same) of different motor's input terminal is allotted by a certain rule.

Motor's power is allotted with disproportion, this may be relative to the current status of mechanical system. The corollary by current condition shows that, the most power allocation is NO1 motor, next is NO3. This two motor's power allocation is almost the same(40％and 33％), NO2 motor's power allocation is the least, so it suggests cut off NO2 motor, which can reduce the shock of NO1and NO3 motors.

4. Conclusion

This paper analyzes and inquiries the technique principle of several common energy-saving measures. They all can realize the effect of reducing energy consumption and raising utilization rate of motor. But according to the practical situation of coal yard in Tianjin port, the less motor operation technique is adopted, and gets obvious energy-saving effect. The realization of the system will supply the enterprises with technical data and successful experience for future energy-saving. It also can further produce greater economic and social benefits.

References

[1]XuehongXu.The Asynchronous Motor Y-△ Switching Energy-saving Technology of Cable-Belt Conveyor[J].Port Handling,No.2.1997:2~3 (in chinese).

[2]CongZeng.Research on the Controller Saving of Asynchronous Motor[J].Master's Degree Thesis of Hunan University,2006:24~28 (in chinese).

[3] TongxuZhang,DewenZhang,WenningXie.Overview of Energy-saving Technology for Port Belt Conveyors[J].Ship Scientific Research,2008:1~4 (in chinese).

[4]GuangjianCui,LipingChen.Experimental Study on Power Saving for Belt Conveyors in Coal Stack Yard in Rizao Port[J].Port Handling,2007(2):2~3 (in chinese).