International Journal of Materials, Mechanics and Manufacturing, Vol. 7, No. 2, April 2019

Study on a Load Classification Conveyor

Long Huang

***Abstract*—A certain type of conveyor is a widely used material conveying equipment. After a long period of use, some of the equipment are not able to release the lock when it is running. After analysis, the reason is that after the conveyor is loaded; the impact of the lock is increased, which leads to the lock failure over time. In this paper, a load classification conveyor is designed, including the overall design, induction mechanism design, hardware design and software design of the control system. Through comparative experiments, the effectiveness of load classification technology in reducing the impact of lock is verified, which has a certain reference value for similar problems.**

***Index Terms*—Conveyor, induction mechanism, load classification, stress and strain.**

I. Introduction

A certain type of conveyor is a kind of material conveying equipment developed according to the needs of users. Its function is to complete the transportation of materials between high and low places. This type of conveyor has the characteristics of high efficiency, safety and automation. So far, dozens of equipment have been submitted to users. After a long period of use, when the conveyor is in use, it may happen that the material tray and the lock have serious impacts during operation, and even if the two are struck after the impact, the lock cannot be released, which is the main reason affecting the failure rate of the conveyor. The greatest difference between the load classification conveyor designed in this paper and the previous models is that the load classification technology is applied. By identifying the load condition of the conveyor and adjusting the running status of the conveyor, the purpose of reducing the impact on the lock and reducing the failure rate is achieved.

II. Load Classification Conveyor Design

A. Overall Design

The load classification conveyor is divided into two working conditions: lifting and falling. When lifting, the conveyor is automatically controlled by the automatic control system, which can automatically control the operation of the conveyor and monitor the state of the conveyor in real time. Under this working condition, only one operator is needed, and the operator only needs to monitor the conveyor through the display during the whole process after starting the working condition. Semi-automatic control is adopted when falling condition. The main reason is to avoid material stucking between the conveyor and the lower platform. Although the probability of this situation is very low, two operators are required for this condition, one operator is responsible for monitoring the status of the conveyor and the other operator is responsible for operating the operation box near the lower platform, and responsible for observing the conveyor and the material handover under the platform, to ensure the safe operation of the conveyor. The general structure diagram of load classification conveyor is shown below:

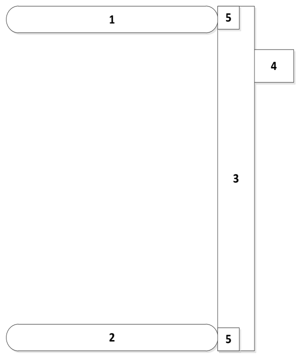

Fig. 1. Overall structure of load classification conveyor.

In the Fig. 1 is the upper platform, 2 is the lower platform, 3 is the conveyor body, 4 includes the motor, deceleration mechanism, angle transmitter, clutch, and 5 is the sensing mechanism.

When the motor is running, the conveyor drives the deceleration mechanism through the motor, transfers the power to the conveyor body through the clutch, drives the chain movement in the body, and the conveyor material bracket is installed on the chain, thus realizing the conveying of material. The operation process of the conveyor is as follows: after having the electric condition, the material bracket is locked off, the clutch is combined, the motor drives the conveyor chain to rotate through the clutch and the deceleration mechanism, according to the value of the angle transmitter, the clutch is disconnected and the material bracket of the conveyor moves to the clamping position by inertia, locked by the lock, then the material is taken away by the platform. Under the lifting condition, the conveyor automatically transports the materials from the lower platform to the upper platform in sequence. Under the falling condition, the conveyor transports the materials from the upper platform to the lower platform according to the operator's operation.

The load classification technique is to sense the transportation of materials into and out of the conveyor through the sensing mechanism. According to the amount of internal materials of the conveyor, the load is divided into different grades, so as to adjust the running status of the conveyor. The conveyor can hold up to 6 items of material at

Manuscript received October 9, 2018; revised March 18, 2019.

Long Huang is with No. 713 Research Institute of CSIC, Zheng Zhou, China (e-mail: 850682942@qq.com).

the same time. Taking into account the weight of the material and the clutch load capacity of the conveyor, the load is set to 3 levels, i.e. no load, half load, full load. Different stopping angles are used to make the clutch break time different.

B. Load Induction Machine Purchase Design

Load sensing machine purchase is the basis of load classification. In this design, non-contact sensor switch is used as the core of induction machine purchase. The schematic diagram of induction machine purchase principle is as follows:

Fig. 2. Schematic diagram of induction mechanism.

When the material enters and exits the conveyor from the platform, the sensing mechanism will sense the corresponding action, and at the same time determine the current load condition in combination with the current working condition to achieve load classification.

There are many kinds of contactless induction switches, including inductance sensor, capacitance sensor, photoelectric sensor and so on. Inductive sensor has the characteristics of simple and reliable structure, high sensitivity and high measurement accuracy. Because its working principle is to use electromagnetic induction effect, the measured object is limited to metal, and the frequency response of the sensor itself is not high, so it is not suitable for fast dynamic measurement [1], [2]. Capacitance sensor is a kind of sensor which converts the measured changes (such as size, pressure, etc.) into capacitance changes. It has a series of outstanding advantages, such as simple structure, small size, strong adaptability, good temperature stability, good dynamic response, non-contact measurement can be realized, and it has average effect. The working principle of the sensor shows that besides metal, it can also be used to measure more materials. At the same time, the measurement environment is not polluted. Otherwise, the dielectric constant will be changed and the measurement results will be affected. In addition, the parasitic capacitance of the capacitance sensor is greatly affected by the parasitic capacitance, which will lead to the decrease of the measurement accuracy and sensitivity of the sensor [3], [4]. In order to meet the requirements of material diversity and detection distance, photoelectric sensor is used in this paper. Photoelectric sensor is a sensor using photoelectric elements as detection elements. It first converts the measured changes into changes of optical signals, and then further converts optical signals into electrical signals with the help of optoelectronic components [5]. In general, photoelectric sensors are composed of three parts: transmitter, receiver and detection circuit. The transmitter aims at the target to emit the beam, which generally comes from semiconductor light source, light emitting diode, laser diode or infrared emitting diode. The beam is emitted continuously or the pulse width changes. The receiver is composed of a photodiode, a photoelectric triode and a photocell. In front of the receiver, optical elements, such as lenses and aperture, are installed. Behind it is the detection circuit, which can filter out effective signals and apply the signal. Photoelectric sensors have the following advantages: 1) there are many types of detectable objects, and there are few factors restricting the detection work; 2) higher resolution in detection; 3) accurate color resolution; 4) longer detection distance and easy adjustment; and 5) non-mechanical contact detection [6]-[12].

C. Hardware Design of Control System

Load classification conveyor control system adopts centralized control mode. The system is composed of main control module, junction box, distribution box, sensors and actuators. The control system structure diagram is shown in Fig. 3.

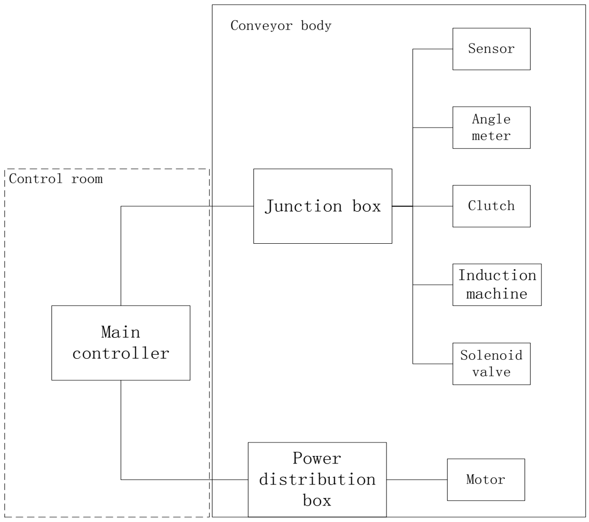

Fig. 3. The control system structure.

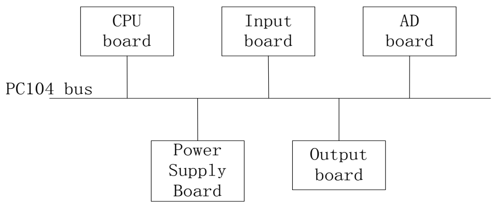

Fig. 4. The structure of the PC104 bus controller.

The core of the control system is the main control module. In this design, the PC104 bus controller is used in the main control module, it uses the Vxworks operating system to perform functions such as switch acquisition, analog acquisition, motor control, and switch signal output. The PC104 bus structure has the following advantages [13], [14]: (1) The small size makes the PC104 module board widely used in embedded systems; (2) PC104 bus products have high reliability in electrical characteristics and mechanical characteristics, and boards can pass through the stack. Reliable connection, strong anti-vibration capability, high stability; (3) Flexible scalability, increased system functionality and performance can be achieved only by changing the corresponding module; (4) low power consumption, bus current of 4mA can drive the module to be normal work, low-power features help reduce the number of components, and expand the scope of use; (5) stacking connection, this structure reduces the space occupied by the system, improve the space utilization. The structure of the PC104 bus controller is shown in Fig. 4.

The function of the power distribution box is to complete the external power supply to the electrical distribution, while controlling the positive and negative rotation of the motor. The function of the junction box is to complete the signal transfer between the main controller and the sensor, induction mechanism and actuator on the conveyor body, and to supply power for the above-mentioned electrical equipment.

D. Software Design

According to the working principle of the load classification conveyor, the design software flow are shown in Fig. 5:

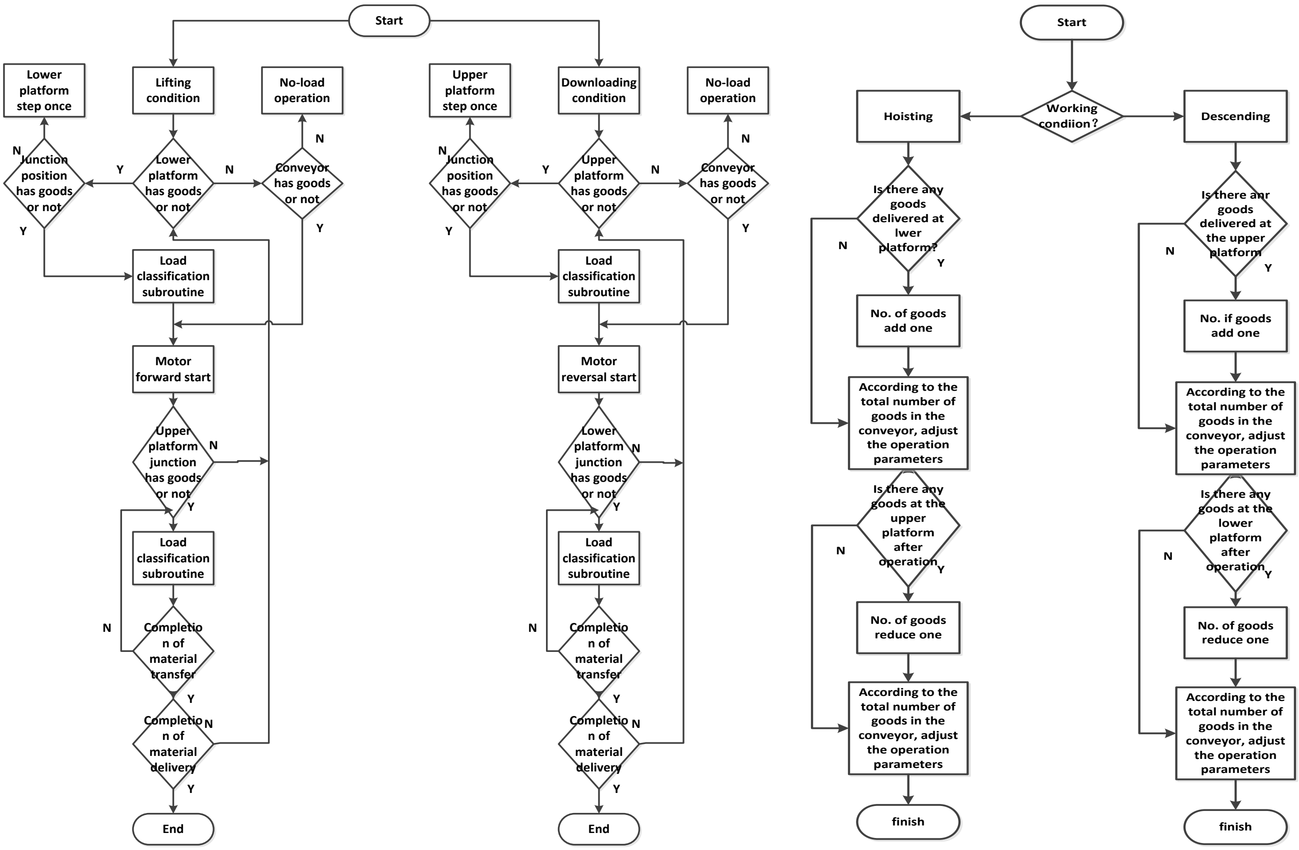

Fig. 5. Software flow chart and load classification sub process.

The software of load classification conveyor adopts the design method of multi-task, interrupt triggering and modularization. The software is divided into main function, interrupt processing module, display module, switch input acquisition module, switch output module, analog input acquisition module, load classification processing module, safety protection module, fault diagnosis and location. Module and so on. While satisfying the basic functional requirements, the software takes into account the safety of operators and equipment to ensure that even if misoperation occurs, it will not endanger the personal safety of operators. In addition, the software also designs a friendly human-machine interface, which enables the operator to quickly grasp the operation method, and accurately locate the fault when the equipment fails, so as to facilitate the operator to quickly remove the fault.

III. Load Classification Test

A relevant test was carried out for the impact of the lock during the operation of the conveyor after the classification of the load. The test tested the stress and strain of the lock when the lock was subjected to different impacts under different working conditions. The result shows that the impact of the lock is improved after load classification.

In order to achieve better comparative effect, the test divides the load into two situations: no-load and full-load, that is, the conveyor runs without material and full material. Small operation parameters are optimized parameters of a certain type of conveyor. The parameters have been verified in practical application, which can ensure the continuous normal operation of the conveyor. At the same time, it can be used as a reference to verify from the side that the load classification conveyor has better performance than a certain type of conveyor. The selection principle of large operation parameters under different working conditions is to meet the requirement that the equipment can continuously and faultlessly upgrade or decrease 20 groups of materials, each group has 13 maximum operation parameters, so as to avoid other faults caused by inappropriate selection of parameters and interrupt the test. Before the test, the large operation parameter selection test was carried out first, and the large running parameters of different working conditions were selected. The specific load classification test process is as follows:

A. Same Condition, Different Load

The lifting and lowering conditions of the conveyor were tested respectively. Under the same operating parameters, the no-load (blue line) and full-load (red line) card locks were impacted. The test results are shown in Fig. 6 to Fig. 9.

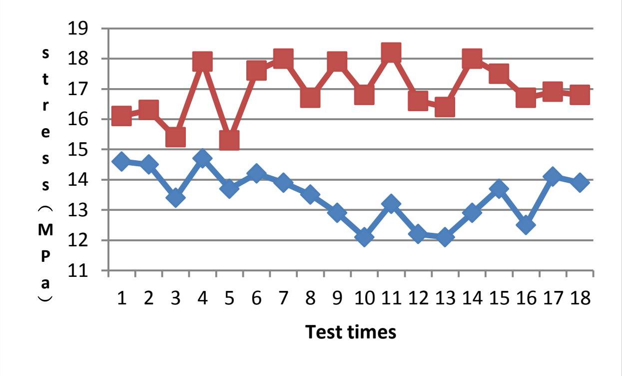

Fig. 6. Impact of lock of no-load and full load on lifting condition on small operating parameters.

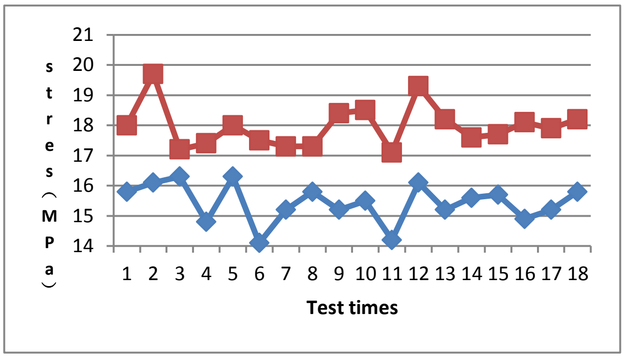

Fig. 7. Impact of lock of no-load and full load on falling condition on small operating parameters.

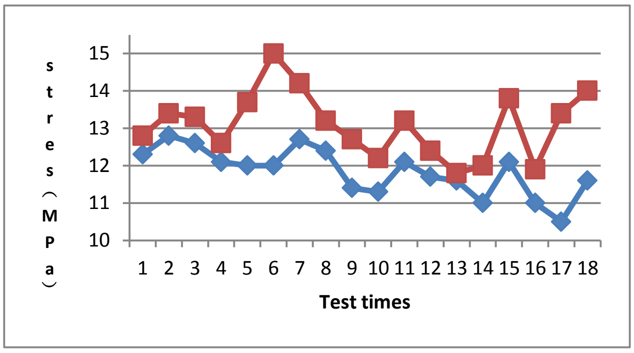

Fig. 8. Impact of lock of no-load and full load on lifting condition on big operating parameters.

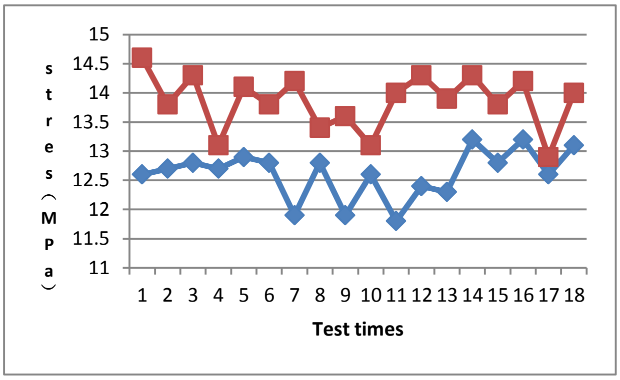

Fig. 9. Impact of lock of no-load and full load on falling condition on big operating parameters.

From the results, it can be seen that under the same operating parameters, the impact of lock under full load is stronger than that under no load. Under lifting condition, when the operating parameters are small, the average impact strength of the lock at full load is 3.5 MPa stronger than that at no load. When the operating parameters are large, the average impact strength of the lock at full load is 1.25 MPa stronger than that at no load. Under falling condition, when the operating parameters are small, the average impact strength of the lock at full load is 2.54 MPa stronger than that at no load. When the operating parameters are large, the average impact strength of the lock at full load is 1.24 MPa stronger than that at no load. From the test results, it can be seen that under the condition of small operating parameters, the impact of lock under full load is at least 16% larger than that under no load, and under the condition of large operating parameters, the impact of lock under full load is at least 10% larger than that under no load.

B. Same Load, Different Operating Parameters

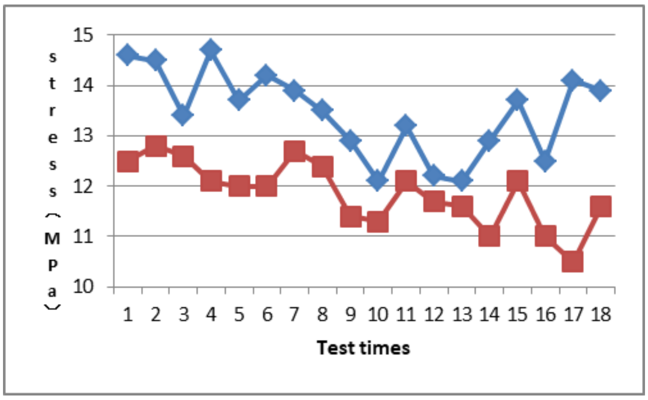

Fig. 10. Impact of lock on different operating parameters in no-load lifting condition.

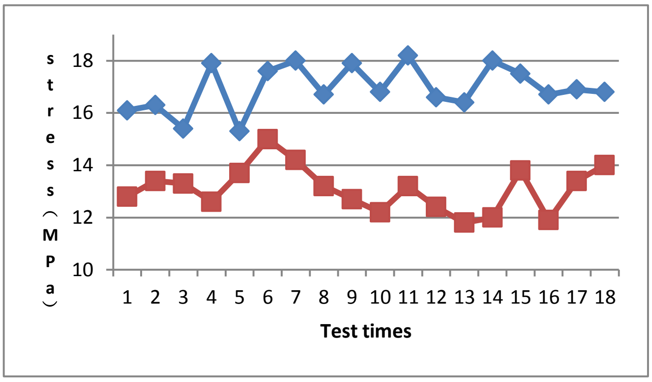

Fig. 11. Impact of lock on different operating parameters in full load lifting condition.

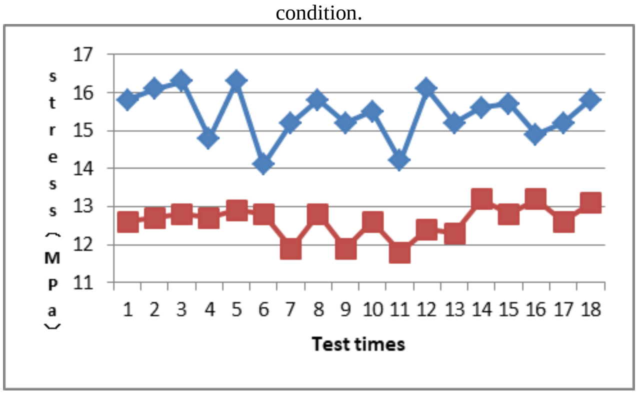

Fig. 12. Impact of lock on different operating parameters in no load falling condition.

The lifting and lowering conditions of the conveyor were tested respectively. Under the same load conditions, the locking was affected by the operating parameters. The test results are shown in Fig. 10 to Fig. 13. In Fig. 10 and Fig. 12, blue lines represent smaller parameters of no load, red lines represent bigger parameters of no load. In Fig. 11 and Fig. 13, blue lines represent smaller parameters of full load, red lines represent bigger parameters of full load.

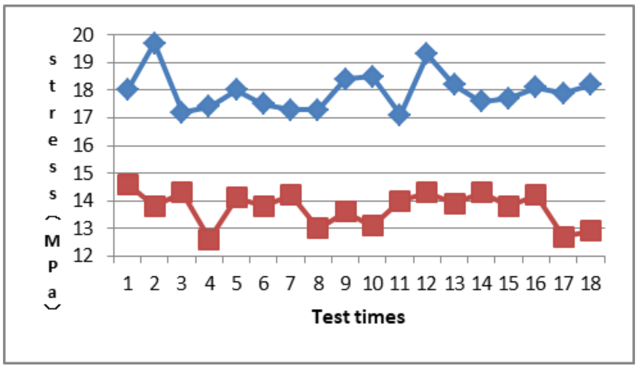

Fig. 13. Impact of lock on different operating parameters in full load falling condition.

From the results, it can be seen that after adjusting the operating parameters, the impact of the card lock under the same load is significantly reduced. Under the lifting conditions, after the adjustment of parameters at no load, the average impact of the lock is 1.61 MPa, and after the parameters are adjusted at full load, the average impact of the lock is 3.86 MPa. Under the falling conditions, the average impact of the lock on the lock is 2.81 MPa after adjusting the parameters in the no-load condition, and the average impact of the lock on the lock is 4.11 MPa after the parameters are adjusted at full load. The test results show that after adjusting the parameters, the impact of the lock under the same conditions can be significantly reduced, and the maximum can be reduced by 29.6%, which proves the effectiveness of using the load classification to reduce the impact of the lock.

IV. Conclusion

In this paper, a kind of load classification conveyor is designed. The effectiveness of the load classification to reduce the locking shock is proved through experiments, and the reliability test of tens of thousands of operations is performed to verify that the load classification conveyor has good reliability and similarity. Engineering issues have a certain guiding significance.

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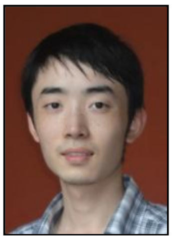

Long Huang was born in China, and graduated from Wuhan University of Technology, with a master's degree in engineering; the field of study is electromechanical control and automation.

He have got the engineer's title and publish the paper entitled: Design of a Conveyor Control System and The Scheme Research of Reducing EMI of Integrated Step-down DC-DC Switching Power Supply.