REALIZATION OF AUTOMATIC CONVEYING LINE OF WIRE HARNESS TRAY BASED ON PLC

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ABSTRACT: To study the automatic conveying line of wireless harness tray, in the process of auto parts harness production enterprises, the production mode of artificial mechanical operation and artificial quality inspection is applied, with many posts, disperse process, and low productivity. It is difficult for the production line to adopt the traditional relay control method to meet the requirements of "lower production line running costs and improve product quality", so it is necessary to make automate reform of the old production lines. Based on the characteristics of the old production line, the production line, process flow, mechanical structure and detection principle are discussed, and the automatic conveying line of wireless harness tray based on PLC (Programmable Logic Controller) is transformed. It effective integrates the processing link, detecting link and conveying link together, which realizes the automatic production, greatly reduces the number of workers, improves the production efficiency and reduces the cost.

KEY WORDS: wire harness, production line, mechanical structure.

1 INTRODUCTION

At present, the level of automation and network and information technology in China is relatively low, and compared with developed countries in Europe, the foundation is weak, the development is not mature, and the automation degree is not high, which are the barriers of the production manufacturing enterprise restructuring and development innovation [1]. We visited a large number of manufacturing enterprises, such as Nansha (Guangzhou DENSO) Co. Ltd., Guangzhou Aiji Automobile Fittings Co. Ltd., Midea Group, Guangzhou Zhongke Electric Co., Ltd. and Guangdong Vanward electrical.

Limited by Share Ltd around Guangzhou manufacturing enterprises. Through the investigation, it is found that the automated production ratio of several companies is not high. Part of the assembly workshop is a labor-intensive production line, which has not completely got rid of the backward situation of manual manufacturing. In the whole manufacturing environment in China,it results in that the quality of the product is difficult to improve, and the production cost is higher and higher [2]. Therefore, it is necessary to carry out the automatic production line reform in the manufacturing enterprises. In the mass production of manufacturing products, the automation technology, sensor technology and information technology are made use of, to realize the production line automation or semi automation production. It has remarkable application effect and value of perfecting working conditions and improving labor productivity, improving product quality and stable production capacity, and reducing production cost and personnel management cost. As a result, this paper studies the realization of PLC wireless harness automated conveying line, and carries out automation transformation of the original production line, which achieves the goal of reducing production costs and improving product capacity and quality.

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2 HANDLING ACTION ANALYSIS AND STEP DESIGN

The new production line reformed has a total of 6 stations that needed to be conveyed. In order to reduce the number of poles and reduce the conveying time, the neutron process and thermal melting terminal station are placed together side by side, to eliminate the distance between the station and terminal process neutron thermal melting process station. In order to improve the production efficiency and reduce the wiring harness terminal processing cycle, the conveying action of each segment is the parallel action, which needs to act at the same time. According to the literature [3], it is known that the automobile wiring harness assembly line balancing problem can be optimized and simulated with the help of the optimization formula, to calculate the production position, reduce the production cycle and improve the reasonable completion rate. With reference to the balance

formula, it is known that when the number is set to 4, the balance rate is the highest. As a result, the number of poles of this transformation is designed as four, and according to the order, they are named pole 1, pole 2, pole 3, and pole 4. The action task that each pole completes is shown in the following figure 1, pole action division diagram.

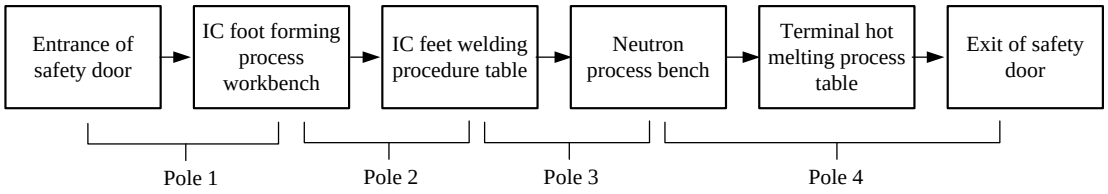

Figure 1. Sketch map of pole action division

3 METHOD

The production line realization is to transform on the basis of the old production line, which needs to consider the machine position of original production line, conveying movement and space design of original production line. In addition, according to the existing production characteristics, the aluminum is used as the frame, and the production process of the whole production line adopts closed structure. For the convenience of observation and debugging of production situation of the machine, while preventing debris and dust from falling into the production line and thus affecting the quality of wiring terminals, the shell of the production line adopts the transparent organic glass decoration. In the closed production line, it is divided into four processes in total, namely IC foot molding conveying, IC foot welding conveying, thermal neutron terminal hitting, and the tray melt conveying [4]. The conveying action of four positions require parallel actions, also need a single action, so it needs for multiple pole components. To save the operation space and simplify the electrical wiring, reduce the failure rate, and make it convenient for debugging and operation of the machine action, in accordance with the requirements of factories, a human-machine interface control box is designed above the production line. At the same time, in order to reduce debris and dust from falling into the production line, the safety door is installed at both ends of the production line.

3.1 Line specification and major technological parameters

Equipment name: wiring tray automatic transfer line;

Equipment functions: wire harness tray pushing and conveying, on-line status monitoring, quality inspection and fault alarm display;

Design dimensions of equipment shape: L=2360mm, W=490mm, and H=1500mm;

Arm thrust: about 131N;

Supply voltage: AC 220V;

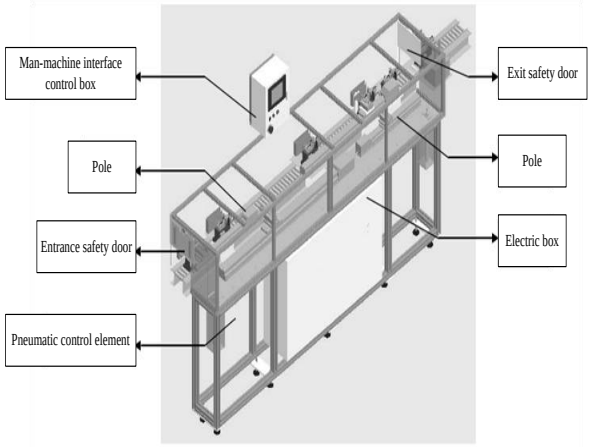

Figure 2. Whole machine structure scheme 3D effect diagram

Figure 2 shows the 3D effect diagram of whole machine structure scheme. It is just the preliminary reform direction and idea combining with customer's requirements, according to the actual situation of the original production line. It constructs the framework and outline of the whole mechanical structure, the details in terms of the mechanical structure and electrical design are not considered yet [5]. For instance, the auxiliary mechanism of the station, the anti reversing device, the position sensing device, operation and thrust device and so on devices will be taken into account in the following design. The whole design idea follows from top to bottom and from the overall to components.

3.2 Design of whole production line action

The transformation retained artificial wire harness into the tray and artificial removable harness actions, which solves the neutron production line process of midway artificial

removal of wire harness tray on the production line, and it is done automatically by the production line. Combined with the IC foot molding production process, IC foot welding process and terminal hot melt process on the original production line, it ensures that the wire harness in the process of conveying completes full automation. In order to improve the production efficiency, it requires that the industrial automatic production line handling and pushing action are parallel actions, and the action design process is as follows.

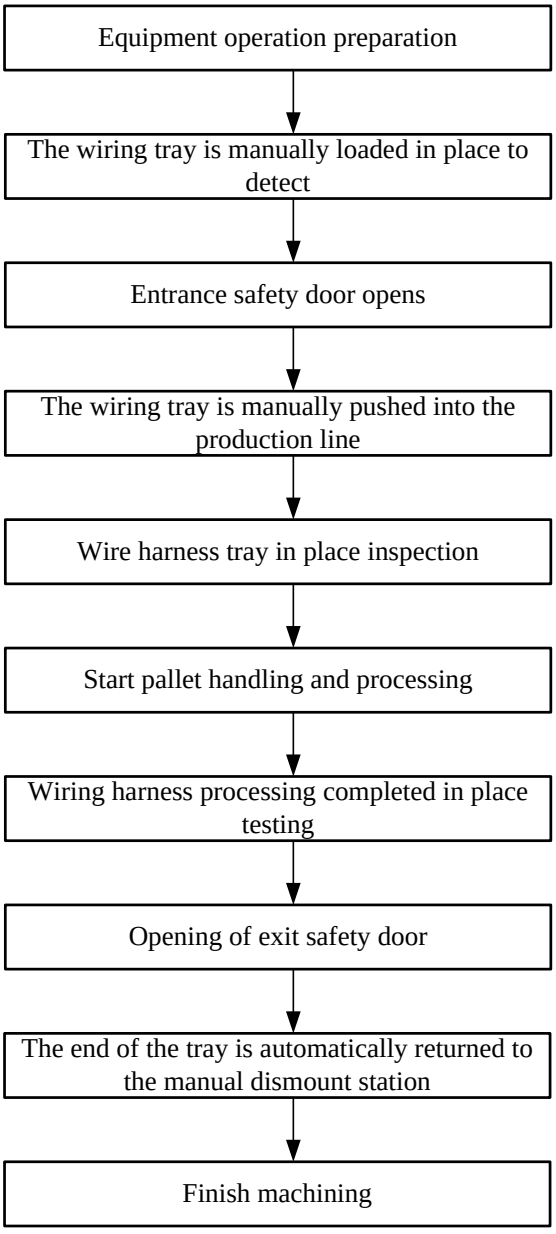

Figure 3. Main action flow chart of production line

Figure 3 shows the flow chart of main action of the production line, which is the main action sign process. In the process, part of the actions are not completely expressed due to the limitation of the map, such as wire tray in place promotion, wire tray pushing into each machine and the machine processing actions [6]. At the same time, part of the actions have been achieved in the original production line. The transformation does not need to repeat the construction and design, such as tray pushing into each machine action, each machine processing action, wire tray automatically conveying for artificial removable station action and so on.

3.3 Wire tray design

In the processing of the original production line, before the terminal heat melting process, it needs to manually remove the clamp device on the wire harness tray, to ensure that the outer surface of the wire harness and beam conducts complete terminal heat melting process. In order to meet automatic control of the production process, in the clamp device of wire harness tray, the neutron device is added. In the IC foot molding process and IC foot welding processing process, neutron rises the clamp device, and the neuron device supports the wire harness on the top, so as to prevent wire harness offset and blocking. In the terminal thermal melting processes, neutron device goes down, avoiding space between harness and terminal space, and making the hot melt processing device carried out smoothly. The wire harness tray

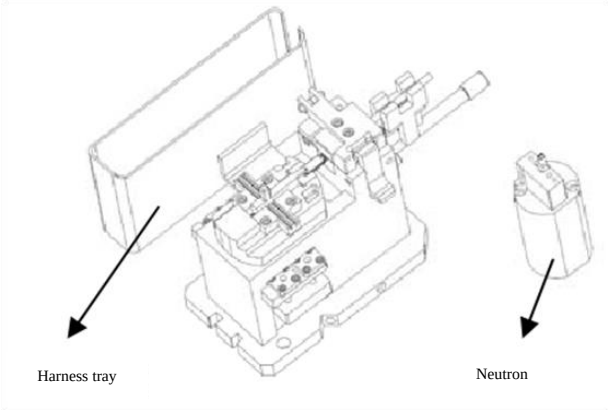

Figure 4. 3D diagram of wire tray structure (with neutron)

3.4 Action principle and action design of safety door

From the view of safety protection and production line dust prevention and other requirements, in the transformation and design process, the safety door is added in the closed production line entrance and exit. The size of safety door at the two positions is about 350mm length * 200mm width [7]. The transparent organic glass materials are used, whose quality is about 2.5KG. And the requirement on positioning accuracy of safety door opening and closing is not high. In the

early stage of the design, according to the common design, some ordinary motor driving gear rack structure, servo motor driving safety door structure and cylinder driving wire rope structure and so on schemes are put forward. The positioning accuracy and the cost of the security door is taken into consideration, and it is confirmed by the customer through discussion and examination [8]. The cylinder driving wire rope structure scheme is applied, and the working principle diagram is shown in Figure 5, schematic diagram of entrance security door and exit security door principle. In the specific mechanical design, considering from safety and noise elimination, the safety door in place buffer and cylinder in place throttling speed regulation and so on functions are designed. The overall design structure is simple and compact, with low cost. The mute rail and cylinder components are standard parts, convenient for maintenance and debugging.

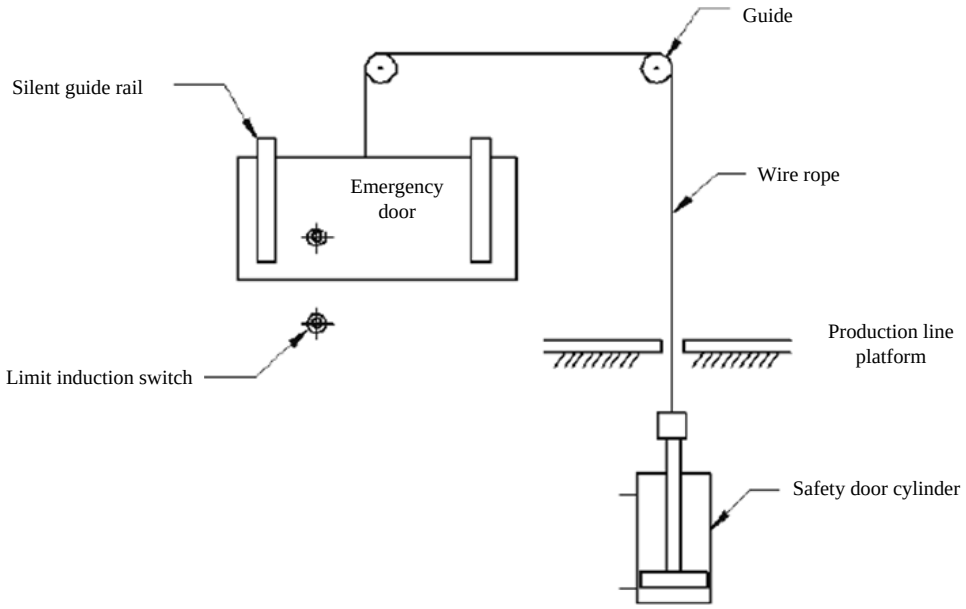

Figure 5. Schematic diagram of entrance safety door and exit safety door

When the wire harness tray in place induction signal is valid, the start signal is issued by the PLC, to open the security door cylinder. The piston rod of the cylinder is decreased, while the security door goes up. And until the security door upper limit sensor generates signal, the cylinder movement stops. When the PLC issued the signal to close the safety door, the electromagnetic valve cylinder piston rod rises, closing the safety protection door. The security door goes down under the action of gravity, and until the security door lower limit sensor generates signal, the cylinder decreasing stops and the safety door movement ends [9]. Considering that this mechanism may have a lag or accidental action, limiting sensor is installed on the terminal, namely the security doors, not the shell of security door cylinder, which improves the movement stability and safety of the mechanism.

From the mechanics analysis, the entrance and exit door opening and closing action is implemented by the cylinder. It is necessary to check the pull thrust and shrinkage on the cylinder. The quality of the safety door is about 2.5KG, the gravity is about 24.5N, and the system gas source compressed pressure is about 0.38Mpa. The safety door cylinder, according to the experience, at the beginning chooses the SMC company brand cylinder, type of CDM2B20, cylinder piston diameter of 20mm, and extension rod diameter of 8mm [10]. When the extension rod of the safety door cylinder shrinks back, the safety door rises and opens; while the cylinder rod is launched, the safety door decreases and shuts down. It is calculated according to the formula (1) pull force and push force.

$$F = P \times \pi \times \frac{D^2}{4} \quad (1)$$

The cylinder extension rod is launched, the compressed air enters the cylinder rod-less cavity. The cylinder piston effective diameter is 20mm, and the cross-sectional area is $100 * 10^{-6} m^2$. According to the formula (1), the thrust is 120N. Considering the friction loss of the safety door and the guiding wheel, the safe system is chosen as 0.8, and the

effective thrust of cylinder is 96N, 24.5N<96N [11]. At the same time, when the safety door is closed, because of gravity, it will naturally decrease, so the cylinder movement force meets the requirements. When the cylinder rod shrinks back, the compressed air enters the cylinder rod chamber. The cylinder piston effective diameter is 12mm, and the cross-sectional area is 36 * $10^{-6}m^2$. According to the formula (1), the pushing force is 43N. Considering the friction loss of the safety door and the guiding wheel, the safety system is chosen as 0.8, and the effective thrust is 34N, 24.5N<34N, so the cylinder shrinking back action force meets the requirements [12].

Analyzing from the dynamic control process of gas, the security door in the two positions is controlled by the PLC controller programming of the system. The principle is relatively simple, as shown in Figure 6, the principle of safety door control. The wire harness tray in place information is sensed by the sensor, the signal detection X signal inputs the PLC controller, and the PLC controller automatically executes PLC program. The PLC controller outputs Y signal, and Y signal controls the solenoid valve coil, to drive the spool of solenoid valve moves, to change the inlet and outlet order of the safety door cylinder, so as to achieve the movement of the cylinder [13]. But in the actual implementation of the safety door control project, we need to pay attention to the stability and reliability of the mechanism. In order to ensure the stability of the PLC signal, it is necessary to protect the PLC comtroller from being affected by the coil fault mutations of the voltage or electromagnetic valve. Between the PLC controller and the electromagnetic valve, it needs to increase the intermediate relays and other components, so as to improve the safety and stability of the entire system [14].

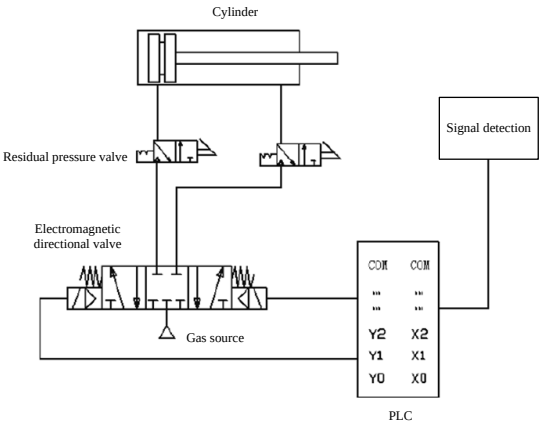

Figure 6. Safety door control principle diagram

4 RESULTS AND DISCUSSION

After the wire harness tray begins automatic conveying line production, the production indexes have obvious changes, as shown in figure 7 unit production time comparison and figure 8 comparison of operator numbers. The unit production time of new production line improve from 15.1s/pcs before to 13.6s/pcs [15]. The operators that the normal operation of production line required is reduced from 6 people to 3 people. That is to say, it eliminates the artificial operation number of tray conveying of IC foot molding process, IC welding process and hot melting process, retaining only the artificial operation number of wiring harness into the tray and that of removing wire harness procedure from the tray holder [16]. The qualified rate of workshop increased from 93.9% before to 99.6%.

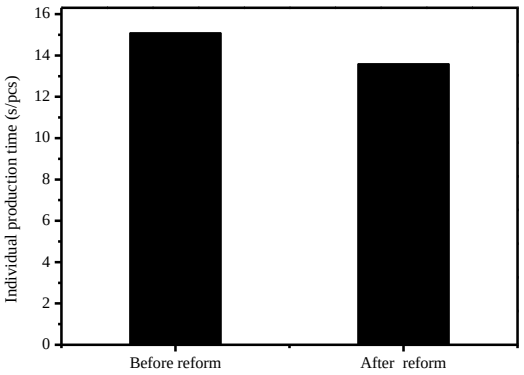

Figure 7. Unit production time comparison

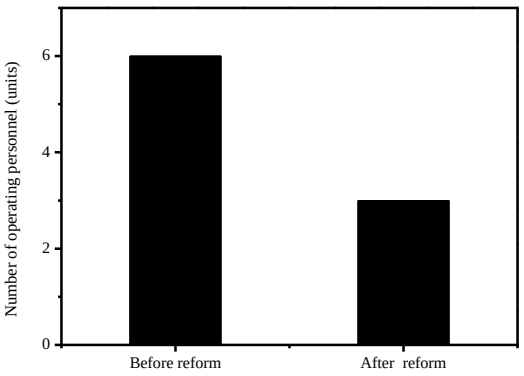

Figure 8. Comparison of operator numbers

5 CONCLUSION

The design and transformation combined with the technological process of the original production line and characteristics of processing equipment of wire harness. The automatic control technology is

used for the research and the transformation of the PLC based wire harness tray conveying automation production line. And the machining process, transport links and link detection of wire harness are effectively integrated together, which increases the online detection and alarm information display function, improves the harness production efficiency, and reduces the production cost. This paper completed the design of PLC based wire harness automation conveying production line scheme. In the operation of production line, the operation and control effect is stable and reliable. The unit production time is improved from 15.1s/pcs before to 13.6s/pcs, the required workers for the normal operation are reduced from the original 6 people to 3 people, and the product pass rate increased from 93.9% before to 99.6%. It greatly reduces the number of manual operators, and increases the economic efficiency of enterprises, which has the promotion and application value in the production of similar auto parts.

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