Sensors & Transducers, Vol. 176, Issue 8, August 2014, pp. 244-248

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Sensors & Transducers

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Research of Control System and Fault Diagnosis of the Sound-absorbing Board Production Line

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Received: 20 May 2014 /Accepted: 31 July 2014 /Published: 31 August 2014

Abstract: Programmable Logic Controller is the core of the control system of the sound-absorbing board production line，and the design of fault diagnosis is an essential modules in the sound-absorbing board production line. The article discourses the application of PLC in the control system of the production line, and designs the methods of grading treatment and prevention of troubles, which makes use of PLC'S logic functions. The method has good expansibility, and has good guidance to the fault diagnosis in other automation equipments. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Control system, Troubleshooting, PLC, Grading treatment, Automation equipments.

1. Introduction

The perlite sound-absorbing board is a kind of new decorating materials, whose main composition is the expanded perlite. The perlite sound-absorbing board has a lot of characteristics, such as sound absorption, moisture absorption, fire prevention, electrostatic prevention, lightweight, environmental protection and so on [1-4]. It conform to the direction that the sound-absorbing material shouldn't be fibrosis or polluting, which makes its share of the market expand constantly and makes its prospect very considerable [5].

For a long time, domestic enterprises take artificial production way, leading to a low degree of automation, low productivity. Besides, when the levels of workers are different, the plate quality is uneven [6].

For the purpose of automated production of the board and improving the production efficiency, the production line of automatic molding of the sound-absorbing board is invented. However, once the line goes wrong, it will take much time to check out where is wrong. Some troubles even can cause serious consequences [7]. To solve this problem, the article develops a control system with PLC as the core, which can achieve the function that monitors the line's status and prevent or eliminate the troubles after diagnosing the faults timely and accurately [8].

2. The Design of the Control System

2.1. The Introduction of the Process of the Production Line

The line's process adopts 'rectangular cycle' that manly consists of the pushing forward device and the traversing device. After completing the required processes in one side, the line through the traversing device traverse the mould to the other side. Then it completes the same processes in this side, thus realizing to product the boards in two sides at the same time, whose efficiency is twice the production

only in one side. The schematic diagram of the production line is shown in Fig. 1. The required processes include putting a baseboard, putting the first layer of material, putting the net, putting the second layer of material, and separating the board and mould in turn. Every process occupies a position and act at the same time, for example, when putting the first layer of material in a mould, it puts the net in the mould which has been put in the first layer of material. So it achieves to product multiple boards in one line at the same time, improving the production efficiency and saving the cost greatly [9].

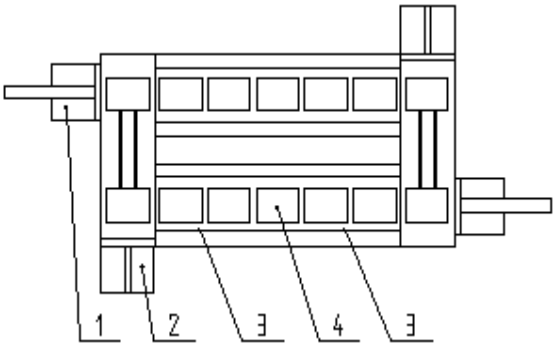

Fig. 1. The schematic diagram of the production line. 1-the pushing forward device, 2-the traversing device, 3- the required processes, 4-the mould.

2.2. The Choice of the Hardware for the Control System

The sound-absorbing board production line has massive actuators. In order to meet the requirement of keeping stable when running separately and harmonious when running as a whole, it divides the controlled objects into two parts according to their functions. One part is called the main line, which completes the cycling moving of the moulds and the other part is called the subsets, which complete the required processes introduced above [10]. The main line is the key of the line, and its controlled objects are the most complex, which includes the stamping mechanism and the lifting mechanism besides the moving moulds mechanisms, so this part chooses large-scale PLC the Mitsubishi Q series PLC Installed the QD70 positioning module as the control core. The subsets' action is simple slightly, so this part chooses three FX 3U series PLC as the control core [11]. It achieves the communication between the two parts by the external wiring. The Schematic diagram of the hardware structure is shown in the Fig. 2.

2.3. The Design of the Software for the Control System

For making it convenient to debug and repair the production line, the control system is divided into two modes-the mode of automatic control and the mode of manual control [12].

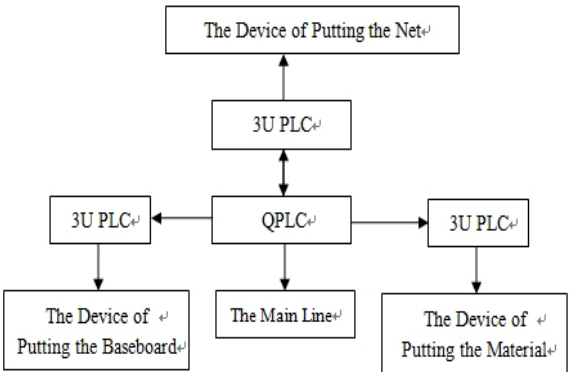

Fig. 2. The Schematic diagram of the hardware structure.

When choosing the mode of automatic control, the system relates the subsets in turn. After finishing relating all the subsets, the main line and the subsets run together in accordance with the established process. The stopping turn of the subsets is the same to the relating turn. That is the subsets related first will be stopped first while the subsets related afterwards will be stopped afterwards. Whether the subsets are related or not, the main line completes its all actions, which makes it convenient to run without the materials and clean the moulds [13].

If the mode of manual control is chosen, the users can not only control every actuator separately, but also control every subset. It is in favor of the separate test and repair, increasing the flexibility of the operation [14]. In order to ensure safety, many normally closed contacts are added the output section in the program of the mode of manual control, avoiding the possibility of false action.

3. The Development of the Fault Diagnosis Module

The technology of fault diagnosis is a comprehensive technology, it involves multi-disciplinary knowledge, such as modern control theory, signal processing, artificial intelligence, statistics, pattern recognition, electronic technology, applied mathematics and so on [15].

To improve the reliability of the system, the control system should be able to watch the working status and distinguish the fault signals, ensuring to handle and prevent the faults in the first time [16].

In recent years, the touch screen shows more and more powerful advantage in many aspects of the industrial field, such as monitoring and acquisition of the data, controlling and processing of the front-end data [17]. The line adopts the Industrial Personal Computer of KUNLUN TONGTAI, whose model is MCGSSTPC1516H, high performance integrated

industrial control computer with embedded low power CPU as the core, which has excellent electromagnetic shielding property and humanized operation interface [18]. In the control system, users can watch the machines' working status and control their action instead of buttons and indicator lights.

3.1. The Grading Treatment of the Faults

The control system of the sound-absorbing board production line adopts the grading treatment to the different faults, instead of adopting the emergency shutdown.

According to the degree of the importance of the actuators and the consequence after the faults happening, the faults are divided into three grades: the general grade, the alarm grade and the key grade, constructing the fault tree [19]. For example, when the machine of putting the net doesn't has the signal about finishing putting the net persistently, the fault mainly is the net is bending slightly, which has little influence on the subsequent process, so this kind of faults is defined as the general grade, whose treatment is going on to run after waiting for some time; the fault that the sensor of the baseboard in place hasn't the signal belongs to the alarm grade, which can be solved after being handled quickly, so this kind of faults doesn't need to stop the production. However, when the faults belonging to the key grade happen, the line must be stopped to handle them. The faults of the key grade all are related to the moving of the moulds, which can lead to the consequence of the hitting each other of moulds or damage cylinders if ignoring these faults.

3.2. The Fault Prevention System about the Automatic Control Mode

In order to simply the operation, it usually only consists of one starting button and one stopping button in the traditional automatic control mode [20]. But the system of the sound-absorbing board production line is very huge. It has high risk to run automatically before checking carefully, even causing irreparable consequence.

In order to prevent accidents from happening, in the automatic control mode, the messages needing to be checked are all shown on the touch screen, such as the checks about the external conditions of the moulds and the main line, the monitor of the correct positions of the air cylinders, punching machines and the electric motors [21]. With the appropriate self-locking program in PLC, it ensures that a trouble free start and it cannot be conducted under false positions, realizing the effects of shielding the false operation and ensuring a safe start. Fig. 3 is the safe start program segment and the commentary about Fig. 3 is listed in the Table 1.

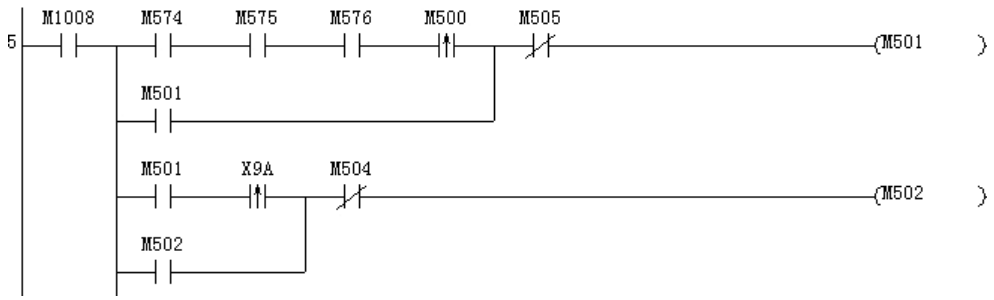

Fig. 3. The safe start program segment.

Table 1. The commentary about Fig. 3.

Name	Commentary
M1008	The service bit of automatic operation
M574	The confirmation bit of checking the position of the mould
M575	The confirmation bit of checking the status of the main line
M576	The confirmation bit of checking the status of the subsets
M500	The flag bit of confirming the automatic start
M501	The service bit of starting the automatic operation
X9A	The starting button
M504	The flag bit of stopping The automatic operation
M502	The flag bit of starting the automatic operation

3.3. The Treatment of the Faults Through the Program

Although the three-dimensional modeling and simulation software's wide use brings a great convenience to the post process and assembly, some unforeseen problems often happen in the actual debugging [22]. In this case, if re processing and assembling parts, it will increase the cost and production cycle greatly. According to the actual fault that occurs in debugging, the control system of the sound-absorbing board production line chooses to improve the process through the program, realizing the zero cost on faults' elimination.

As the lubricant supply is not timely or the verticality precision of the guide is not high enough, the lifting mechanism occasionally can not lift the board successfully, which can be solved through operating the lifting mechanism again. Therefore, the control system increases the program segment of operating the lifting mechanism again to solve this fault. The corresponding program is shown in Fig.4 and the commentary about Fig. 4 is listed in the Table 2. The specific implementation process is: firstly, start the timer T82 when executing the command of starting the lifting mechanism; secondly, judge whether the board is lifted to the highest position. Stop the T0 and do the next step of the process when the board is lifted to the highest position. However, if it is not, stop the T82 and fall the lifting mechanism, at the same time, the counter C0 pluses one; thirdly, compare the count of C0 and the number TWO. Return to step one if the C0 is smaller, or alarm and shut down.

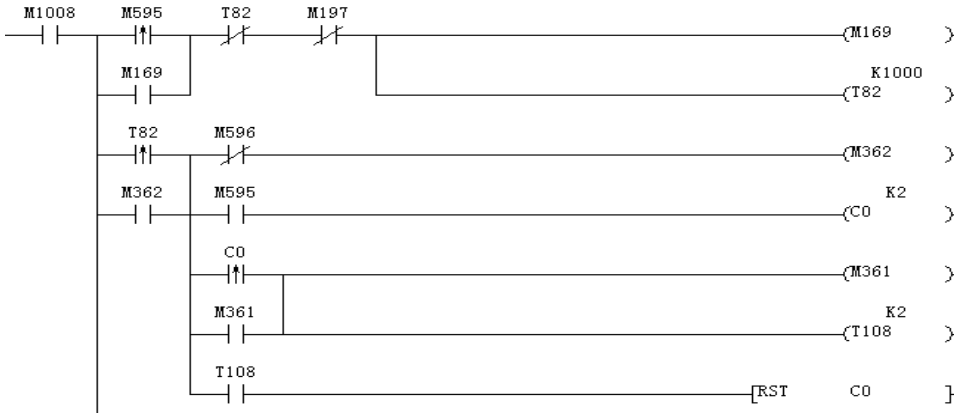

Fig. 4. The program segment of operating the lifting mechanism again.

Table 2. The commentary about Fig. 4.

Name	Commentary
M1008	The service bit of automatic operation
M595	The flag bit of starting the lifting mechanism
M197	The flag bit of that the lifting is finished successfully
M169	The service bit of starting the lifting mechanism again
M596	The flag bit of that the board is lifted to the highest position
M362	The flag bit of starting the lifting mechanism again
M361	The limiting bit of the number of the lifting operation

4. Conclusions

The article introduces the specific application of PLC in the control system and fault diagnosis of the perlite sound-absorbing board production line, achieving automatic production of the sound-absorbing board and completing the real-time monitoring and fault diagnosis.

The fault diagnosis module uses the function of the function of logical judgment of PLC, and the diagnosis method designed has good results in the actual operation, which has good guiding significance to other places.

Acknowledgements

This article is supported by the Hebei Province Natural Science Fund Project 'The research on the theory and method of the integration design about the control system of continuous power and power management of the zinc-air battery based on active balance', whose number is E2013202230.

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Sensors & Transducers Journal (ISSN 1726-5479)

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The 2008 e-Impact Factor is 205.767

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