Programmable Logic Controller for the process of manufacturing eyeglasses based on Program-Based Commissioning Method

Pannawit Jungmanotham and Wudhichai Assawinchaichote
Department of Electronics and Telecommunications Engineering
Faculty of Engineering
King Mongkut's University of Technology Thonburi
126 Prachauthit Rd., Bangmod, Thungkru, Bangkok 10140, THAILAND
E-mail : etnies_p@hotmail.com, wudhichai.asa@kmutt.ac.th

Abstract: In the manufacture of eyeglass lenses, the temperature control system is one of the most essential production processes. The disqualified and poor adhesion of the film can be appeared on the lenses during the manufacturing process, such that the negative result may affect the users' experiences and create dissatisfaction of users as well. Moreover, the production time can also be wasted without any benefit. In this regard, the main contribution of this research is to develop an extra verification for controlling the temperature during production process by utilizing the technologies of Mobile Application together with Programmable Logic Controller (PLC) based on Program-Based Commissioning Method. According to the simulated machine, the results have been found that this proposed method can minimize the possibilities of the product defects, and reduce production time. In addition, this proposed technique may be applied to other production processes as well.

Keywords-- **Mobile Application, Programmable Logic Controller, Temperature Control**

1. Introduction

Nowadays, the competition of industry is quite intense while the product quality and trustworthiness are highly expected from customers. Thus, this proposed research mainly focuses on the optical lenses manufacturing since the optical lenses are commonly used in these days, for example, to correct near-sightedness, long-sightedness or astigmatic. The optical lenses are also enhanced with an ability to adjust the color when exposed to the sunlight in order to protect the eyes from UV ray. The optical lenses manufacturing thus has been constantly developed in order to increase quality of the products as a whole. Traditionally, lenses used to be made of glasses. However, due to its weight and fragility, lenses are mostly made of Plastic (Polymer), which is highly used among other materials. This is because Plastic (Polymer) has similar qualification as glasses, but has lighter weight and higher durability. Plastic (Polymer) then has been widespreadly used in the industry.

Photochromic lenses are optical lenses which can change their color when exposed to sunlight. Lenses can be darken or lighten depending on their exposure to Ultraviolet (UV) radiation. Photochromic lenses contain Silver chlorine compound that transforms when UV light hits on lens, and darken the lenses correspondingly. The lenses also have reversible reaction, which will gradually return to their original state when UV light disappears. The crucial process of lenses production is to generate heat to lenses (or so-called "Annealing process") in order to enhance the cohesiveness between the Primer film and Photochromic film, which can be displayed in layers of Photochromic lenses in Figure 1.1

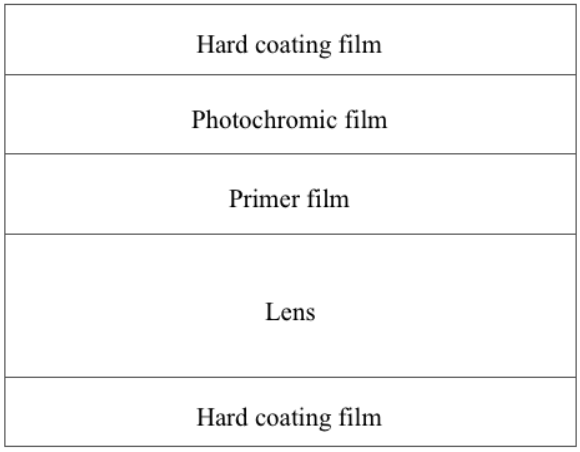

Figure 1.1 Layer of Photochromic lens

The poor adhesion of Primer and Photochromic film is one of the key factors that the lenses are disqualified. It can take place when the heat generated towards the lenses which is not precise in at Annealing process. In other words, if the temperature used during the production process is changed, then the poor adhesion of the films can be occurred as shown in Figure 1.2.

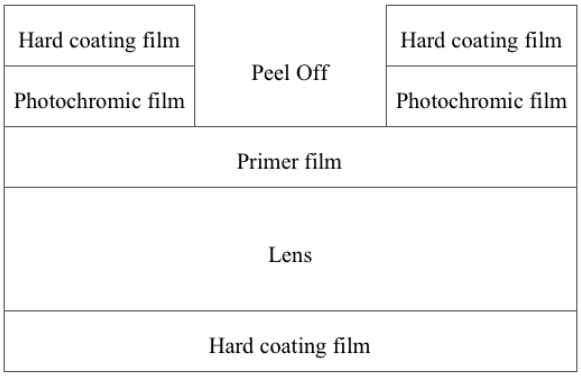

Figure 1.2 Photochromic film and Hard coating film peel off

Therefore, the objective of this research is to develop the lenses verification processes in order to decrease the number of under-qualified lenses and reduce production time by using Programmable Logic Controller (PLC), together with Mobile application through Wifi connection.

2. Methodology

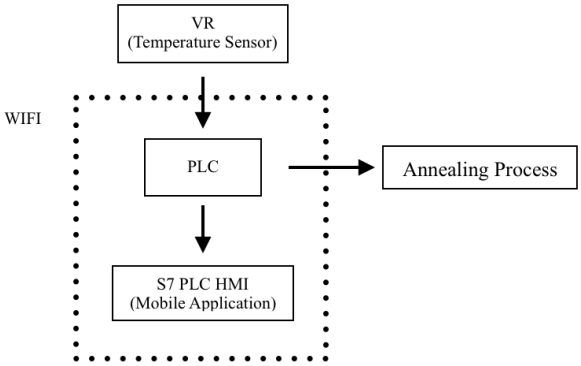

Figure 2.1 Block diagram

In this research, our main focus is on the temperature in lenses production. Nevertheless, as the test temperature is relatively high and it is quite hard to control the temperature to the desired level, Variable Resistor (VR), then, is utilized to control a change in resistance instead of temperature sensor as shown in Block diagram in Figure 2.1. In doing so, the VR is connected to PLC, through an analog signal, in order to adjust the temperature to our focus range. As a result, the desired temperature is in a range between 80.5 – 84.5 degree of Celsius. The Totally Integrated Automation(TIA) is used for ladder diagram programming.

For a mobile application that has been tested in this research is S7 PLC HMI. It can be downloaded via Google Play. In order to connect a mobile phone with PLC, IP address of both mobile phone and PLC need to be set in same wifi loop so as to examine the temperature in Annealing Process. The temperature can be displayed on a mobile phone. When the temperature goes over the default, an indicator will be shown on S7 PLC HMI application.

3. Hardware and Software used in the proposed system

A. PLC Controller : Siemens S7-1200 CPU 1214C DC/DC/ Relay

The S7-1200 CPU 1214C DC/DC/Relay is a compact, small controller. The compact design for small automation system can be implemented as a simple or advanced functionality, for example, HMI, Logic and networking as shown in Figure 3.1. TIA (Total Integrated Automation) is a programming software.

Figure 3.1 Siemens S7-1200 CPU 1214C DC/DC/Relay

The specifications of Siemens S7-1200 CPU 1214C DC/ DC/Relay are

- Analog input : 2 inputs, 0-10 V
- Digital input : 14 inputs, 24 VDC
- Digital output : 10 inputs, 5-30 VDC
- Voltage range : 20.4-28.8 VDC

B. Mobile Application: S7 PLC HMI

The S7 PLC HMI can communicate with PLC via Wifi. This application can be monitored and alarms the set point: set name and choose Type of PLC. Figure 3.2 is shown how to configure the IP address to be the same as PLC IP address (192.168.1.55).

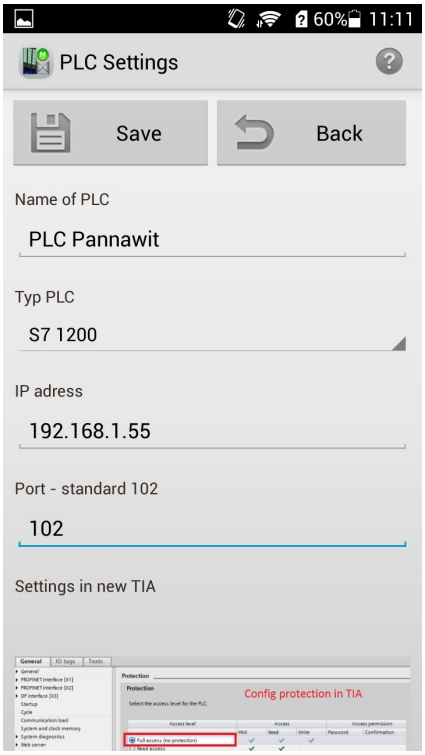

Figure 3.2 S7 PLC HMI application

C. Variable Resistor

This project uses variable resistor (VR) instead of Temperature sensor since VR can control the resistance. The resistance (R) is a direct variation with the potential difference. Normally, the output from temperature sensor used in industrial is the value of resistance or voltage.

D. TIA : Totally Integrated Automation Program

The Totally Integrated Automation is used for ladder diagram programming. The Totally Integrated Automation also uses to construct a ladder diagram program, including Boolean logic functions.

4. Experimental and Result

Firstly, the development of lenses production using S7 PLC HMI through WIFI connection is as shown in Figure 4.1. The production process development will start off with "Appearance check" by visual inspection by using light to find scratch on the lenses before entering Annealing process. This will help decrease the number of defective lenses. In such cases that the scratches or other scraps are found on the lenses, they will be sent to "Stripping of coating film" process to wash off all the coated films and re-enter the Photochromic lenses production again.

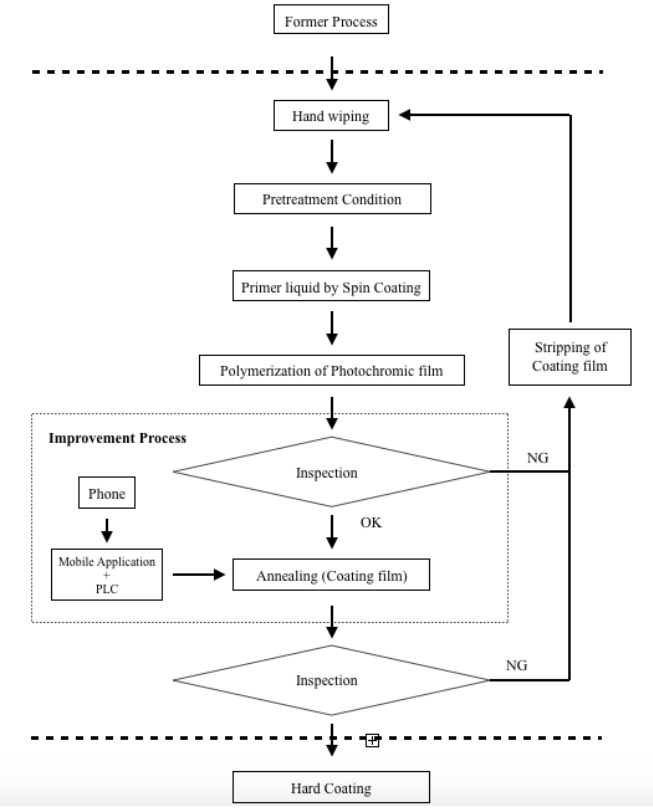

Figure 4.1 Flow chart for improvement Photochromic lens process

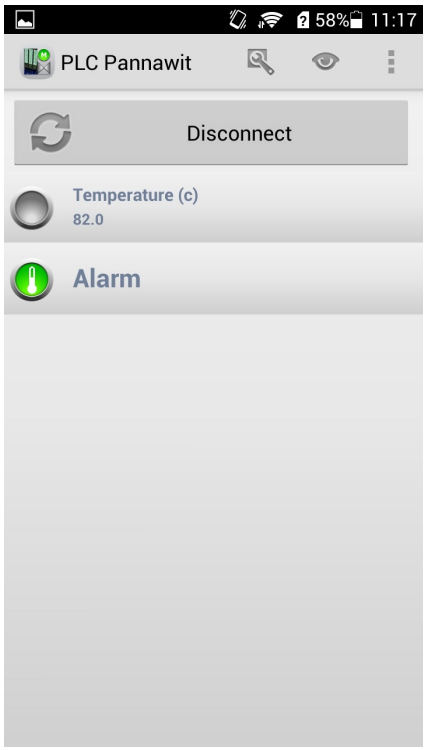

Figure 4.2 Normal status shown in application

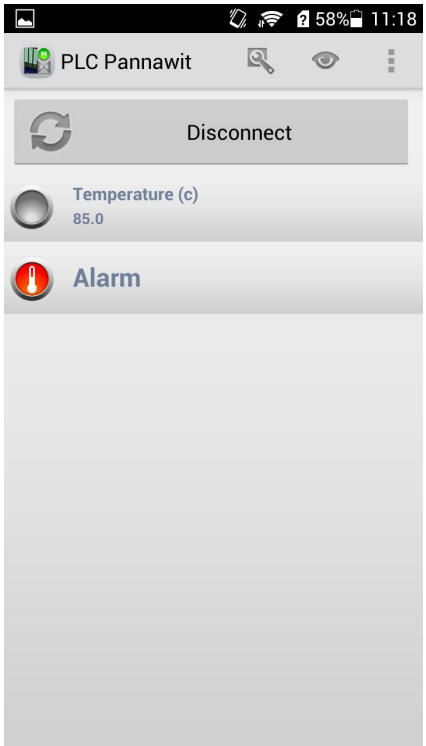

Figure 4.3 Alarm status shown in application

Secondly, the PLC and S7 PLC HMI is connected through WIFI in order to verify the temperature during Annealing process by adjusting VR. The default

temperature will be set to 82.5 ± 2 degree of Celsius. The status is shown as a normal when tested in set temperatures (80.5 - 84.5), which is shown in Figure 4.2. Notification is sent to mobile phone when temperature has been changed to more or less than the default temperature shown in Figure 4.3, so the user will be promptly notified, and able to fix the problem.

5. Conclusion

Annealing Process is an essential process during Photochromic lenses production since it generates heat towards the lenses. This proposed research has developed the technique for the lenses production processes by applying PLC as main controller to control the temperature, while monitoring them through WIFI connection with application S7 PLC HMI. Once the temperature used during the production process is more precise, and well controlled, it will help reduce the poor adhesion of Photochromic lenses. This process can also apply the other production processes as well.

References

[1] Erdal Irmak, Ilhami Colak, Orhan Kaplan, Ali Kose, "Development of a real time monitoring and control system for PLC based elevator", *Proceedings of the 2011-14th European Conference on Power Electronics and Applications (EPE 2011*), pp. 1-8, Aug. 30 2011-Sept. 1 2011.

[2] Gitta Septiani, Rivon Tridesman, Estiyanti Ekawati., "Design and Implementation of Biodiesel Washing Automation System with Set of Sensors and Programmable Logic Controller Device", *2015 International Conference on Sustainable Energy Engineering and Application (ICSEEA)*, pp. 35-41, 5-7 Oct. 2015.

[3] T.Jerry Alexander, "An Implementation of Mobile Control Room Environment in Android Platform for Industrial Applications", *2015 International Conference on Circuit, Power and Computing Technologies (ICCPCT)*, pp.1-4, 19-20 March 2015.

[4] Mrutyunjaya Sahani, Susanta Kumar Rout, Arabinda Mandal, "Remote monitoring in Home Automation using low cost microcontroller", *2014 International Conference on Communications and Signal Processing (ICCSP)*, pp. 925-929, 3-5 April 2014.

[5] G.Sathishkumar, M.Prabu, 2015, "Real time PLC based control systems using wireless sensor networks", *International Journal of Advanced Technology in Engineering and Science*, Volume No 03, Special Issue No. 01, pp.1009-1014. March 2015.