Paper:

Application of Fuzzy Inference Method in Printing Pressure State Expectation System

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To solve a problem in determining the printing pressure of printing machine for real-world liquid crystal display panel (LCD) production, a Printing Pressure expectation system is proposed based on a fuzzy inference method. In real-world LCD panel production, the recognition of printing pressure conditions and its control is a very important and difficult factor that influences the product quality. It is usually performed by skilled engineers, whose performance highly depends on his tacit knowledge. In the proposed system, a fuzzy inference method is employed to solve the problem. Images of the printing area are observed with cameras, from which abstract features are extracted with image processing. The output of the system is the state of printing pressure, which is divided into 3 states: EXCESSIVE PRESSURE (EP), GOOD PRESSURE (GP), and LOW PRESSURE (LP). Based on the abstract features, the state is estimated with fuzzy membership functions. The shapes of membership functions are determined based on the sampled glasses obtained in actual LCD production line. The experiments are performed with the 2000 glasses that are also printed with actual printing machines, of which the result is compared with that of skilled engineers. It is shown that the proposed system outperforms the quality of skilled engineers. The developed system is installed in actual production line, and it is expected to increase the product quality and production speed, as well as to cut off production costs.

Keywords: fuzzy inference method, fuzzy membership function, printing pressure control, feature abstraction, image processing

Fig. 1. G7 PI printing machine.

1. Introduction

The PI (Polyimide Coat) Coating and TOP (Top Coat) Coating are the most important processes in liquid crystal display (LCD) panel production. A PI/TOP coater machine is a type of printing machine as shown in **Fig.1**. The machine moves a table stage or a printer roll to print a PI film pattern that is engraved on the roll onto the surface of a glass according to the request from a production process.

As one of the most important abilities of a PI/TOP coater machine, it must be able to print a film with a thickness of 750±100Å for TN (Twisted Nematic) type, or 1100±150Å for MVA (Multi-domain Vertical Alignment) type. It depends on the control of printing pressure, which directly influences the quality of LCD.

Printing pressure can be controlled by adjusting the gap between the printing roll and the substrate on the table using printing gauges as shown in **Fig.2**. It is usually done by a skilled engineer, whose performance highly depends on his tacit knowledge.

On the other hand, due to many mechanical factors, a printing pressure does not stay fixed after the gap adjustment, which causes the variations in thickness of a printed film. Detection of such changes and quick adjustment in online processing is the objective of our research.

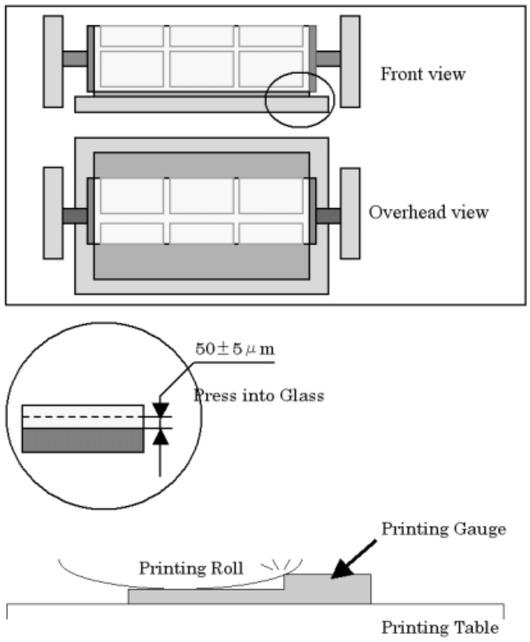

Fig. 2. Printing pressure control method.

In conventional production processes, an experienced engineer has to pick a sample glass from a printing machine at periodic intervals, and assess the film's thickness by watching the printed pattern with his own eyes. This examination process should be done offline. To make matters worse, as picking a glass from a printing machine is a very difficult task in a clearing room of class 1000, it often happens that a sample glass will be damaged during the process. That is, the examination process is one of the main factors which could make a production line slow. Moreover, in current, cutting-edge LCD production, the size of a mother glass becomes very large (1870×2200mm), while its thickness is very thin (0.6-1.1mm). Therefore, it would be impossible or costly to pick such a large but thin glass from a printing machine for examination purpose.

Furthermore, the examination of a printed pattern by a skilled engineer does not depend on only his experience, but also on various factors such as a surrounding environment and his health condition.

To solve the above-mentioned problems for reducing production cost as well as getting highly reliable examination results, we propose an online examination system that can check printed patterns without stopping production lines, and warn the operators of the printing machine when it detects the abnormalities of printing pressures. We also propose a fuzzy inference method for estimating the state of printing pressure.

This paper is organized as follows: Section 2 proposes the structure of examination system, and Section 3 discusses how a skilled engineer's examination process can be emulated. Based on the discussion, a fuzzy inference method is proposed in Section 4, followed by the experimental results that are performed in an actual LCD panel production plant in Section 5.

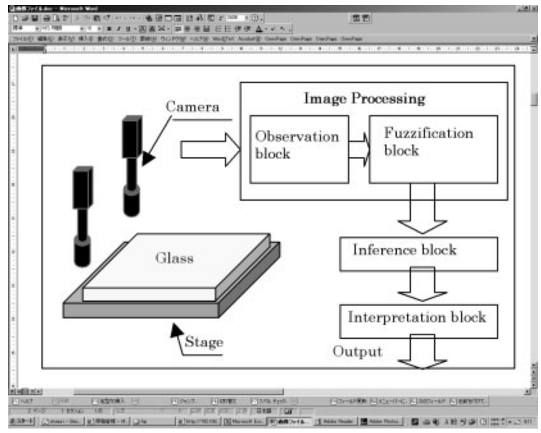

Fig. 3. Outline of printing pressure examination system.

2. Printing Pressure Examination System

The outline of a printing pressure examination system proposed in this paper is shown in **Fig.3**. The system can determine the printing pressure conditions in real-time by monitoring the edge area of printed patterns. The system has two CCD cameras to acquire images of the edge area. We use two cameras considering the problem of the balance of printing roll in mechanical. That is, using two CCD cameras can make it easy for a transfer robot that sets up a glass on the stage to align glasses always on the same position. Furthermore, the redundancy of two input image patterns can reduce errors in estimating the printing pressure.

The obtained images are sent to image processing unit, which consists of observation block and fuzzification block. The image processing unit extracts features from the images, based on which inference block infers the current state of printing pressure with using fuzzy inference method.

The details of each block is described in the remain part of this section.

2.1. Observation Block

The role of observation block is to observe the image of printed film's edge area on the surface of a glass, and to extract features. The range of luminosity variation and the actual distance variation are selected as features, which is determined according to skilled engineers' advices.

The specification of the cameras used in the proposed system is;

- Magnification: 3 × diameter,
- Image area: (V) 5mm × (H) 5mm,
- Coaxial fall LED camera light.

The lights of the cameras are projected on the engraving edge area on a printer roll, the pattern edge area on the surface of a glass, and their joint area, from each of which the illuminance distribution over the printed film is obtained with image processing techniques. The further details of this process are described in Section 3.