Rubbing Cloth Evaluation Method for LCD Panels

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Abstract

In order to stabilize the rubbing process for liquid crystal panels, the authors developed "the sparkling dot area ratio evaluation method". This method quantifies the fiber length dispersion of rubbing cloths, which is a major cause of mura defects. The newly developed method enables quantitative evaluation of rubbing cloths and contributes to the improvement of rubbing process uniformity.

1. Introduction

Rubbing is the process whereby the surface of the alignment layer on a glass substrate is rubbed with a rotating roller covered with a rubbing cloth. The rubbing uniformity affects the image quality of the liquid crystal panel because of the correlation between the arranging force affecting liquid crystal molecules and the rubbing intensity.

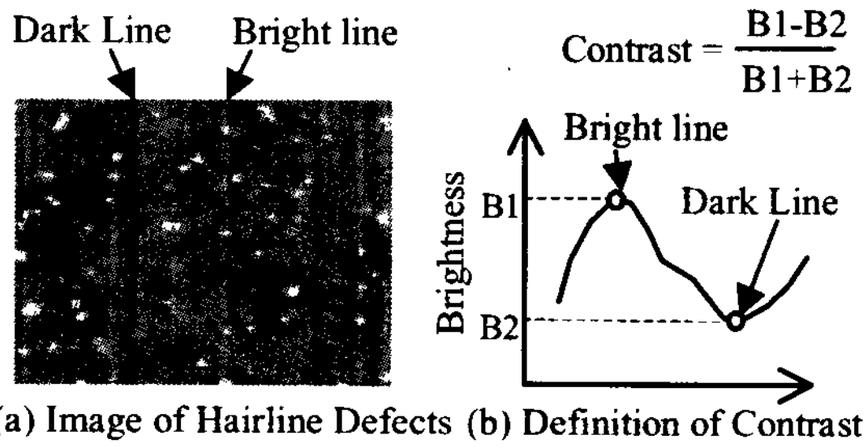
The critical factors for precision rubbing are as follows:

1) Rubbing process and defect analysis
2) Rubbing materials evaluation method
3) Rubbing quality quantitative evaluation method

With respect to the rubbing process and defect analysis, detailed chemical investigations, such as examinations into rubbing-cloth materials, contamination chemistry and rubbing tribology have been performed[1,2,3].

The authors have developed a rubbing quality quantitative method in which contrast is used as a hairline defect evaluation index based on the fact that the human eye can recognize areas in which bright and dark lines provide high contrast, such as the dark mura defects reported in a previous study[4].

An effective rubbing materials evaluation method has not yet been proposed because the critical parameter for rubbing materials has not yet been clarified. Accordingly, in the present study, the authors focus on the quality of the rubbing cloth, one of the key materials in the rubbing process, and attempt to establish a rubbing cloth evaluation method.



(a) Image of Hairline Defects (b) Definition of Contrast
Figure 1: Hair Line quantitative method

Figure 1. Hairline quantitative method.

2. Rubbing cloth evaluation method

The fiber density of the rubbing cloth is 1000 fibers per square centimeter. The dispersion of fiber length affects the rubbing unevenness. Therefore, evaluation of the rubbing cloth requires a rubbing process that is free of mura defects.

Typical mura defects, which are caused by low-quality rubbing cloths, appear as hairline defects, as shown in figure 1(a). Mura defects are recognized by high contrast areas between dark and bright lines. We herein define contrast as follows:

$$Contrast = (B_1 - B_2)/(C_1 - C_2) \cdots (1)$$

Figure 2 shows the magnified surface of a rubbing cloth. The fibers of the rubbing cloth are roughly oriented in the same direction. Hence, when light is irradiated from a tangential direction on a rubbing roller covered with a rubbing cloth, fibers that stand out appear brighter than the average cloth surface. We attempted to quantify rubbing cloth unevenness based

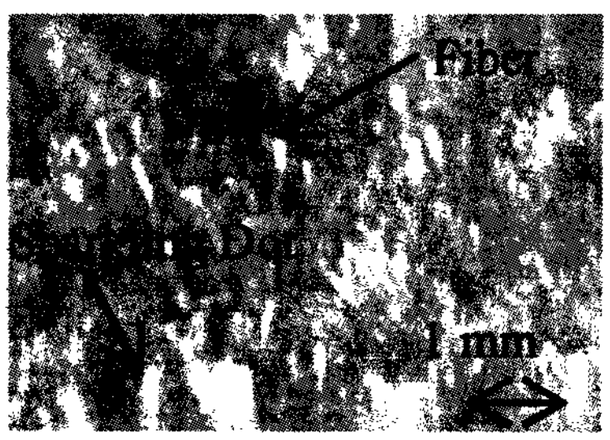


Figure 2. Magnified surface of rubbing cloth.

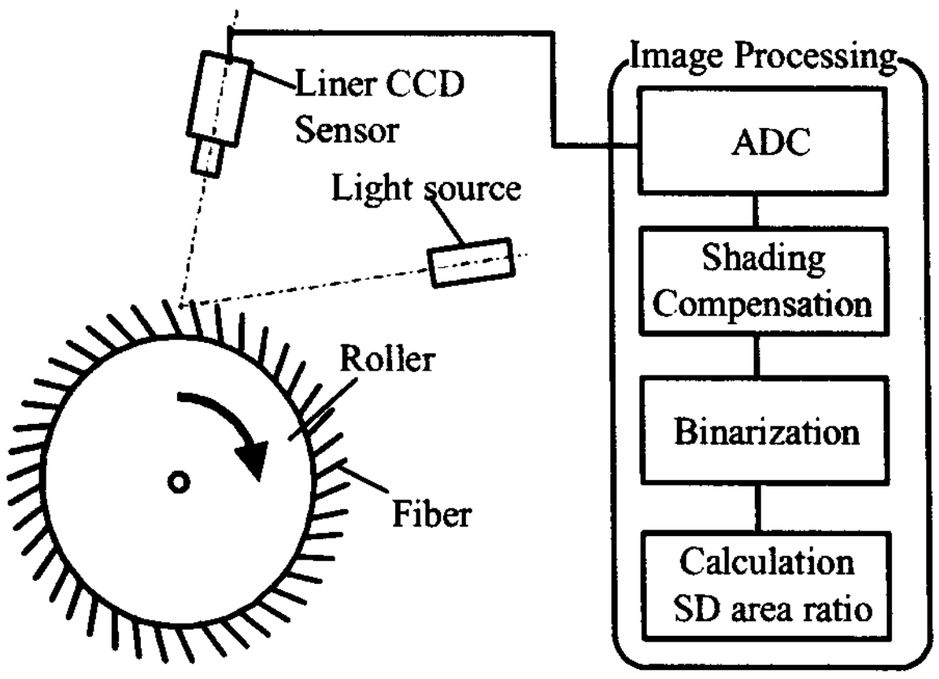


Figure 3. Configuration of the experimental system.

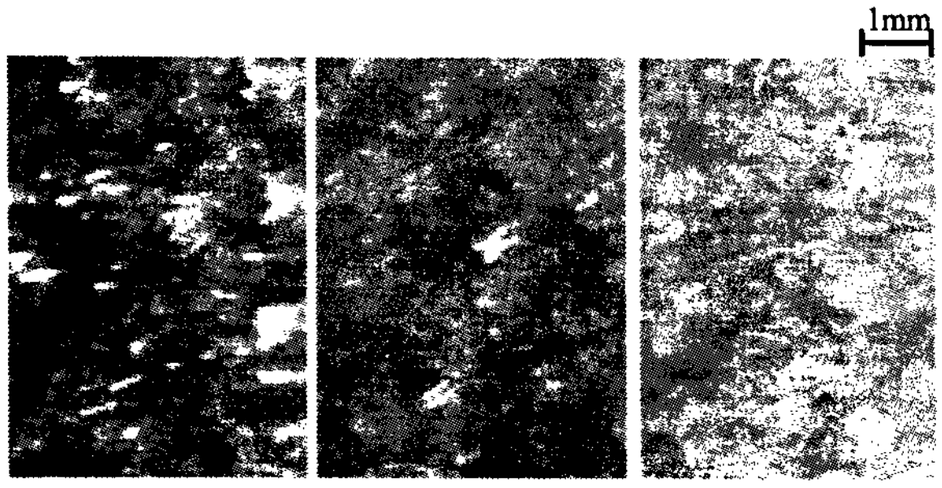
on this "sparkling dot", or SD, area, i.e. the area that appears brighter than the average cloth surface due to protruding fibers.

3. Experimental method and apparatus

Figure 3 shows the experimental system. A linear light from a halogen light source is passed through an optical fiber and irradiated on the rubbing roller surface. First, the circumferential image of the roller is acquired using a linear CCD sensor camera during one rotation of the roller. After a shading compensation process and a binary process, the SD area is extracted. Finally, the SD area ratio, which represents the ratio of the SD area to the entire area of the captured image, is obtained.

4. Results and Discussion

Figure 4 shows the evaluation results for three sample cloths. We confirmed that the SD ratio increases with the unevenness of the cloth surface.



(a) 2.78% (b) 1.31% (c) 0.22%

Figure 4. Cloth images for different SD ratios.

The peripheral velocity of the roller during the rubbing process is more than 50 times the glass substrate feed velocity. This means that the roller rubs each area of the alignment layer numerous times. Hence, the rubbing strength increases in proportion to the total pressure caused by the fibers around the roller. Since a large number of SDs exist on the rubbing cloth, the dispersion of which shows no pattern, the dispersion of the total number of SDs in the circumferential direction is considered to decrease with increasing SD.

Figure 5 shows the summation results for the number of bright spots in the circumferential direction for rubbing cloths having SD ratios of 2.8% and 1.3%. When these two rubbing cloths are compared in terms of dispersion versus mean, the decrease in dispersion is proportional to the increase in the SD ratio. This

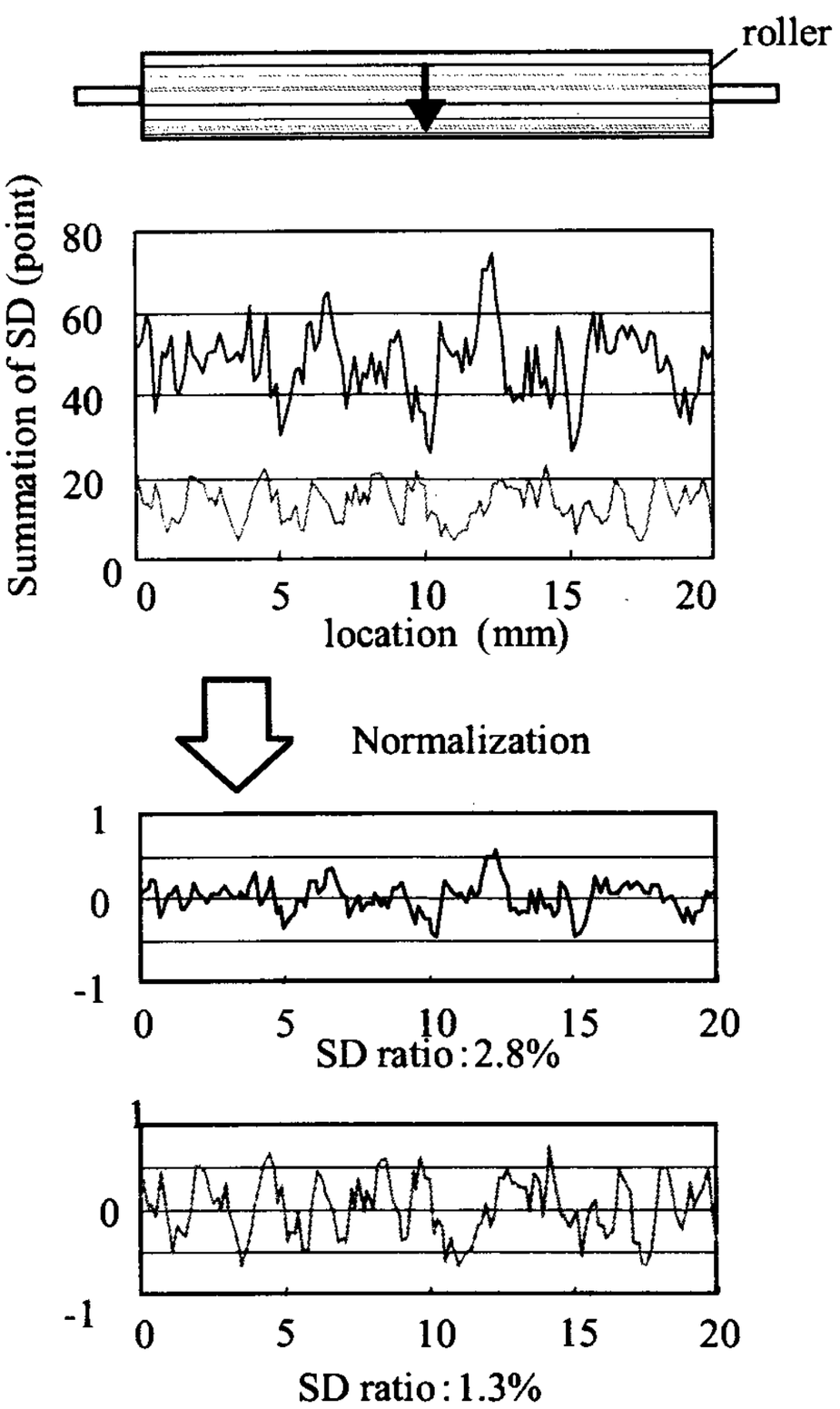


Figure 5. Relationship between BS ratio and dispersion of rubbing strength.

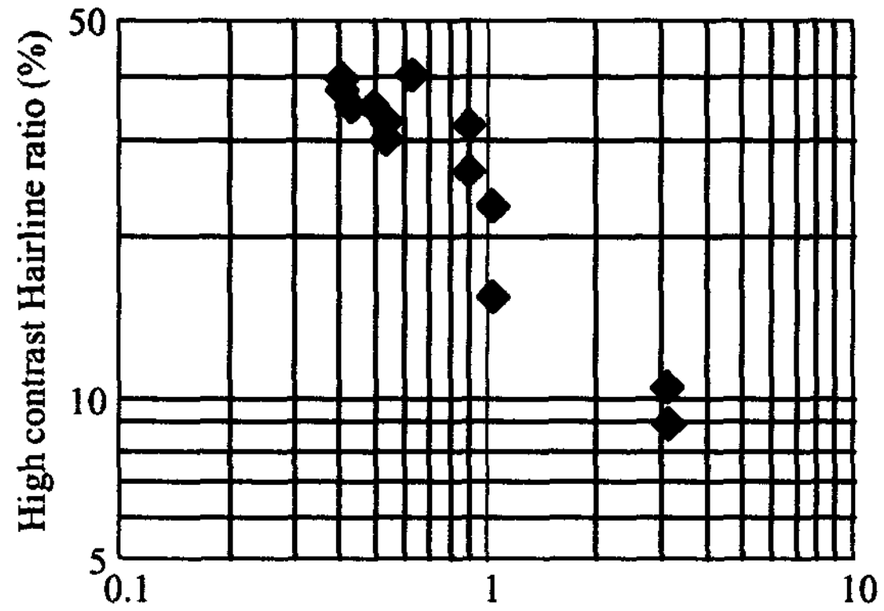


Figure 6. Relationship between SD ratio and high-contrast hairline ratio

result suggests that rubbing cloths of high SD ratio suppress rubbing strength unevenness and lower hairline contrast.

We investigated the relationship between SD ratio and hairline contrast by rubbing unit LC panels with cloths having different SD ratios. Figure 6 shows the experimental results. In evaluating the image quality of the LC panel, we used the ratio of the area occupied by hairlines having a contrast exceeding 0.8% to the entire area occupied by hairlines, i.e. the high-contrast hairline ratio, as the evaluation index for mura defects.

Figure 6 indicates that use of rubbing cloths of SD ratio and high contrast hairline ratio enable quantitative evaluation of rubbing cloths.

5. Conclusion

In order to achieve quantitative evaluation of rubbing cloths, a novel evaluation method was developed which evaluates the rubbing cloth quality based on the relationship between the unevenness of the cloth surface and the number of protruding fibers, referred to herein as sparkling dots. The validity of the method reported herein is confirmed by experimental results.

6. References

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