P2-9 An Optical Measuring System for the Surface Roughness of Glass Wool Papers

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1. Introduction

Glass wool papers have been used as a dust proof paper mainly in semi-conductor factories and as an impregnation paper for sulfuric acid in a storage battery; the latter is used mainly in cars. When the paper is used as an impregnation paper, a surface flatness is the most important factor since an electric power depends largely on the flatness. The flatness depends on the manufacturing process. In the present paper, we developed an optical system for measuring the flatness automatically.

2. Method and System

Scattered light can reveal an information on a surface roughness if a spot size of the irradiation area, ϕ in diameter, is chosen properly. Figure 1 shows a sensor head of the system. A semi-conductor laser was used as a

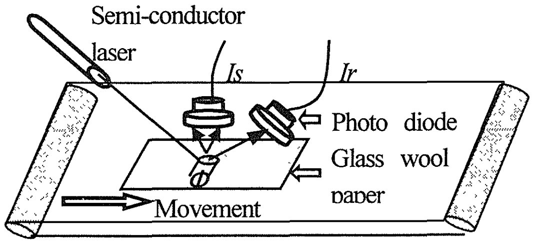

Fig. 1 Sensor Head.

light source and two silicon photodiodes were used as light receivers. One of the photodiodes was used for the scattered light intensity, I_s, and the other was used for the reflected light intensity, I_r. Scattered light intensity will increase and, on the contrary, reflected light intensity decrease with an increase of surface roughness. The ratio of I_s/I_r will then increase drastically with an increase in roughness. Another major reason for using I_s/I_r is that it does not depend on the color of the glass wool paper and, thus, the ratio will depend only on the surface roughness.[1]

Both the light intensities, I_s and I_r, were amplified and digitized into 256 degrees by 8 bits A/D converter. These values were then used for an estimation of the surface roughness.

The degree of roughness R can well be estimated by means of a standard deviation,[2]

$$R=[\{\Sigma(x_i-a)^2/n\}]^{1/2}. \qquad (1)$$

Where, x_i is a sample datum of I_s/I_r, a is the mean value and n is the total number of samples. Each sampling datum was obtained by moving the glass wool paper with a velocity of 2cm/s as shown in figure 2. The sampling rate was 20 Hz; each sampling datum was obtained at an interval of 1mm. The measurements were done over a period of 5.5s for each piece of glass wool paper. The standard deviation and the mean value for each glass wool paper were then obtained by 110 sampling data.

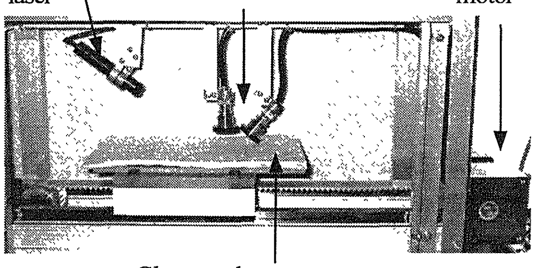

Fig. 2 Photograph of the System.

3. Results and Discussion

Figure 3 shows a relation between the ratio, I_s/I_r, and the dimension on the sheet for some irradiation spot sizes. It was found from the comparison with a microscopic observation

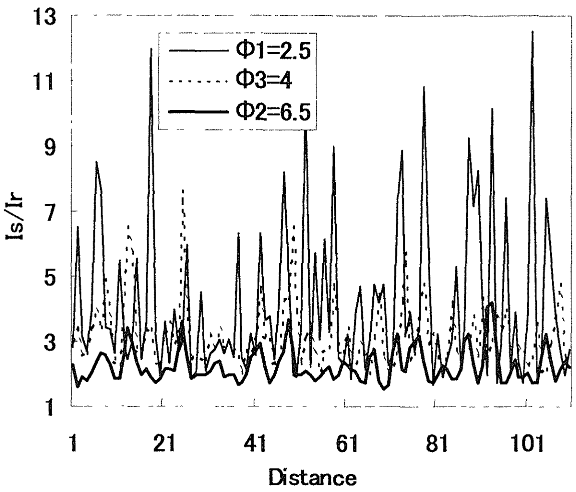

Fig. 3 I_s/I_r for Some Irradiation Spot Size.

that the change of I_s/I_r represented an exact envelope of the surface when an irradiation spot size was chosen appropriately. Further, as was expected, the standard deviation increased with a decrease of the irradiation spot size. It was concluded that the optimum spot size was about half of the surface roughness and the optimum distance between each irradiation spot was a few tenth of the roughness.

Table 1 shows the standard deviation for 20 paper samples obtained under the optimum conditions just mentioned above. The roughness of these samples increased roughly with the product number, #1~#20. The classification of the roughness into these 20 groups has been done by human eye observation, which has, heretofore, been done in practical settings. As shown in this table, the classification by the optical method agreed quite well with human eye observation.

#	*1*	*2*	*3*	*4*	*5*
R	0.05	0.04	0.05	0.06	0.06
#	*6*	*7*	*8*	*9*	*10*
R	0.08	0.14	0.14	0.16	0.16
#	*11*	*12*	*13*	*14*	*15*
R	0.25	0.25	0.27	0.28	0.27
#	*16*	*17*	*18*	*19*	*20*
R	0.29	0.29	0.37	0.36	0.62

Table 1 Standard Deviation for 20 Paper Samples. The sample number for each value was 110.

4. Conclusion

An optical system for measuring surface roughness has been developed for use in manufacturing plants. The ratio of scattered light intensity to reflected light intensity agreed well with the practical envelope of the surface when the probing spot size was about a half of the surface roughness and each sampling was done at an interval of a few tenth of the roughness. Further, the standard deviation of the ratio agreed well with the degree of the surface roughness. The system has now been used successfully in practical settings.

Acknowledgement

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Reference

1.J. Chen, et al., Rev. Laser Engr. Vol. 26, No. 10, p. 744, 1998

2.N. Takai, Pre. Eng. Vol. 64, No. 10, p. 1304, 1998