DEFINITION OF THE EFFECT OF YARN VIBRATION ON DETECTION AND DETERMINATION OF PHOTODETECTOR DIMENSIONS

Eldar Musayev, İsmail Tekin
e-mail: eldar@uludag.edu.tr *e-mail: itekin@uludag.edu.tr*
Uludag University, Faculty of Engineering and Architecture, Department of Electronics Engineering, 16059 Gorukle, Bursa, Turkey

Keywords: Yarn, defect, optics, optoelectronics, detection, vibration

ABSTRACT

In this paper, it is shown that vibration of the yarn affects the detection. Furthermore, an optical model explaining this situation has been developed. Required system dimensions and related equations to decrease effects of vibration have been obtained.

I. INTRODUCTION

Optical and optoelectronic methods and systems are widely used to detect various parameters of textile products [1, 2, 3, 5, 10]. Among these, systems detecting yarn defects are developed and used in practical applications [6, 7, 8, 10]. The main reasons of such a wide usage range of optical and optoelectronic methods are their high sensitivity and basic structure [4, 10]. In some cases defects cannot be detected by other methods.

LEDs are generally used as light sources in optical defect detection systems. LEDs are wide-angled light sources [4, 9, 10] and since it affects detection of defects, this point must be taken into consideration in the system design.

II. DEFINITION OF THE EFFECT OF YARN VIBRATION ON DETECTION AND DETERMINATION OF DETECTOR DIMENSIONS

Vibration of the yarn is another parameter that must be considered in the design of defect detection system. While it is moving, the yarn slides naturally to right and left perpendicular to the movement direction. This slide affects the photosignal. To decrease these effects, an optimal selection of detector dimensions is required. Let's make some assumptions to develop such a method.

1. The yarn has a circular shape.
2. The surface that the shadow falls on is the light-sensitive surface of the photodetector.
3. LED emits a wide-angled light and light intensity does not change with the angle.
4. We consider the vibration of yarn only on the horizontal axis.

Concerning these assumptions, let's develop a diagram as shown in Fig. 1 where, d is the diameter of yarn, H is the distance between the light source and the detection surface, h is the distance between the detection surface and center of the yarn, Δm is the length of region formed by yarn vibration, Δ is the length of shadow formed by yarn vibration, K_y is the length of shadow formed by the diameter of the yarn, z is the length of the detection surface of the photodetector.

Let's compute the length of detection surface of the photodetector with the help of this diagram. For this computation, let's follow the method given below.

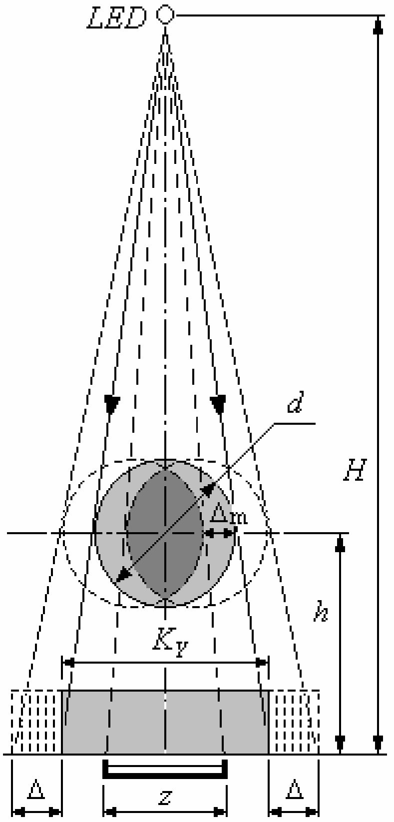

Fig. 1. The diagram expressing effects of yarn vibration.

Yarn vibration causes the shadow formed on the detection surface to slide. However, in spite of all slides caused by yarn vibration, light-sensitive region of the photodetector must be shadowed for an error-free operation of the detector, i.e.

$$z \leq \left(d - 2\Delta_m\right) \tag{1}$$

Considering the above relation and the diagram in Fig. 1, one can write

$$\frac{H-h}{H} = \frac{d-2\Delta_m}{z} \tag{2}$$

From this equation, the length of light-sensitive surface of the photodetector can be computed as

$$z = \frac{H\left(d-2\Delta_m\right)}{H-h} \tag{3}$$

Then, the distance between center of the yarn and light-sensitive surface of the photodetector will be

$$h = \frac{H\left[z-\left(d-2\Delta_m\right)\right]}{z} \tag{4}$$

For example, if *H=50mm, z=1mm, d=1mm* and $\Delta_m=0.2mm$, the distance will be

$$\begin{aligned} h &= \frac{H\left[z-\left(d-2\Delta_m\right)\right]}{z} \\ h &= \frac{50mm\left[1mm-\left(1mm-0.4mm\right)\right]}{1mm} = 20mm \end{aligned} \tag{5}$$

So, the distance *h* which is insensitive to vibrations can be obtained according to the length of light-sensitive surface of the photodetector.

Let's take partial derivative of the equation (4) to determine the effects of the H, z and Δm to the distance h.

$$\Delta h = \frac{\partial h}{\partial H} + \frac{\partial h}{\partial z} + \frac{\partial h}{\partial d} + \frac{\partial h}{\partial \Delta m} \tag{6}$$

After the partial derivation process, equation (6) will take the form of equation (7).

$$\Delta h = \frac{z^2 + \left(H - d + 2\Delta m\right)z + Hd - 2H\Delta m}{z^2} \tag{7}$$

Variation of the distance Δh with H, z and Δm is examined in Matlab using real values of system parameters for d=1mm and d=2mm. Results are shown in Figs. 2, 3 and 4.

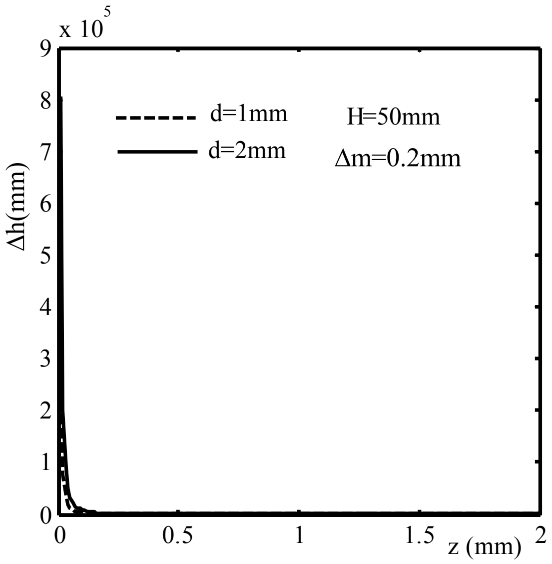

Fig. 2. Variation of the distance Δh with the length of the detection surface of the photodetector (z).

As shown in Fig. 2, yarn vibration decreases while the distance h increases. However, maximum value of the h is limited by the speed of the system. Because, when the distance Δh increases, time constant of the photodetector also increases.

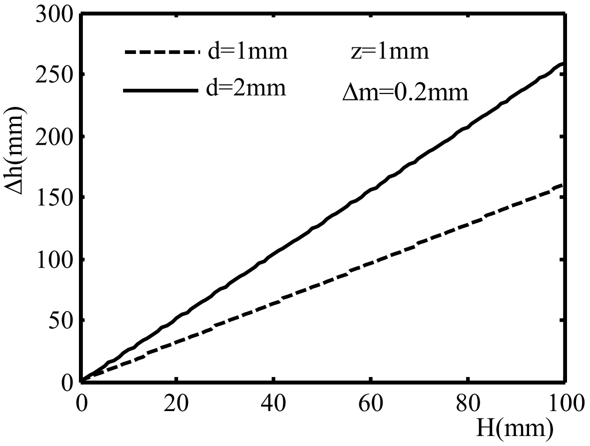

Fig. 3. Variation of the distance Δh with the distance between the light source and the detection surface (H).

As shown in Fig. 3, when the distance H increases, the system dependency to the measured parameters also increases but sensitivity of the system to yarn vibration decreases.

Δm depends to the diameter of the yarn. As shown in Fig. 4, when the diameter of the the yarn increases, the slope of the graphic doesn't change. So, effects of the yarn diameter are easly eliminated in the system design.

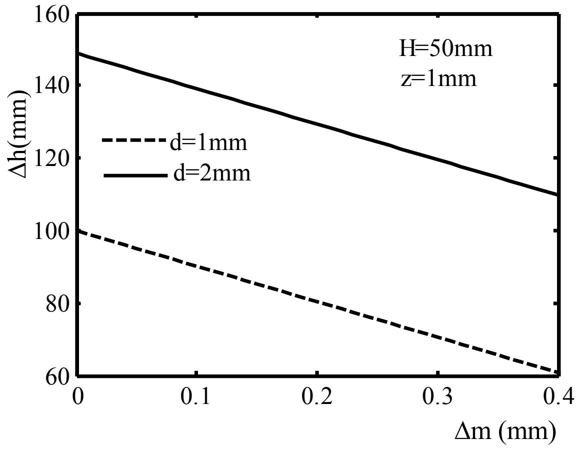

Fig. 4. Variation of the distance Δh with the length of the region formed by yarn vibration (Δm).

III. CONCLUSION

A geometric diagram expressing slides formed by yarn vibration has been developed. With the help of this diagram and concerning maximum slides formed by yarn vibration, required dimensions for the case insensitive to vibrations have been obtained.

An equation expressing the relation between the length of light-sensitive surface of the photodetector and other dimensions has been derived. This equation has been used to compute the distance between the yarn and the light-sensitive surface of the photodetector. Effects of H, which is the distance between the light source and the detection surface, Δm, which is the length of region formed by yarn vibration, z, which is the length of the detection surface of the photodetector, to the distance Δh are examined in Matlab.

REFERENCES

1. Cuo J., Stegmaier T., Tranter J., "Neues Beschlichtungsprinzip für eine ausgerprägte Mautelbeschliehtung", Institut für Textil und Verfahreustechnik (ITV), Melliand Textilberichte, 82(5), Frankfurt, pp.362-364.
2. Elsasser N., Maetschke O., Wulfhorst B., "İplik hazırlık işlemlerinde yoluk liflerinin çalışma davranışları", Institut für Textiltechnik der RWTH Aachen (ITA), Almanya, Melliand Türkiye sayısı, 1, pp.24-28, 1999.
3. Bugao Xu, "An Overview of Applications for Image Analysis to Objectively Evaluate Fabric Appearance", The University of Texas, Textile Chemist and Colorist, 28(5), May 1996, pp.18-23.
4. Musayev, E., "Optoelectronic circuits and systems" Birsen Press, Istanbul, P. 285, 1999 (in Turkish).
5. Ciamberlini, Francini F., Longobardi G., Sansoni P., Tiribilli B., Defect detection in textured materials by optical fitering with structured defectors and self-adaptable masks, Optical Engineering, 35(3), pp.838-844, March, 1996.
6. Barco Vision, ABS detector looks at the yarn from all angle, www.barco.com/vision/sensors systems/
7. Fraden J., Handbook of Modern Sensors, Physics, Designs and Applications, AIP Press, 2 nd. Ed., 1996.
8. Clearex Yarn clearing system for chenille and fancy yarns, Installation and User Handbook, 2.2 Edition-2000, Feb., Iteco Textile, Calenzano, Italy, 2000.
9. Bergh, A. A., Dean, PiJ., "Light – Emitting diodes", Clarendon, Oxford, 1976.
10. Musayev E., "An Optoelectronic Defect Detection Method and System Insensitive To Yarn Speed", Journal of Optics A: Pure and Applied Optics, 6 (2004) pp.721-724.