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Performance study of optical sensor for parameterization of staple yarn

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ABSTRACT

This work deals with the development of a low cost high resolution yarn characterization unit with optical sensor. The developed system can measure yarn average diameter, diameter variation over length, variation of yarn mass, yarn faults, number of hairs at specific distances from yarn core, mean absolute deviation and coefficient of variation in a single run. The most lucrative feature of the newly developed instrument is one hundredth times lower cost and 8 times higher resolution than the existing one. The sensor signal is fed to a high speed data acquisition system and custom made software to get yarn parameters when the yarn is passed in front of the sensor by mechanical setup. The output of the system is compared with the output of the widely used Tester for the said purpose. Moreover, unlike the standard tester, the newly developed instrument is able to furnish absolute mass and diameter of the yarn in real unit. These important parameters certainly give two important estimates for judging the final look of the fabric. The repeatability of results is insignificant in 0.5% level. Calibration is done by taking a standard wire. Jute and cotton yarns of different tex values are tested with the instrument and results are reported. FFT is also performed to provide equivalent frequency response of diameter/mass profile. It seems to be more significant representation of the parameters under consideration.

1. Introduction

Fibers are the basic building blocks of a yarn which is the fundamental unit of woven fabrics. To ensure the quality and look of fabric there is need of yarn characterization unit which can monitor different attributes of yarn. Irregularity is to judge variations in the yarn parameters and unevenness measures the mean variation in linear density.

To detect the unevenness, electronic capacitance testers are most widely used in industry till date. It identifies the unevenness of mass per unit length. But, mass may vary due to variation in diameter or variation in hairs of the yarn. The indication of yarn faults thus obtained with the existing instrument is not conclusive about the cause of mass variation and needs to be addressed. Moreover, the capacitive measurement suffers from poor resolution (8 mm) which fails to identify short length faults frequently available in the staple yarn. Also, the capacitive sensor output is prone to vary because of ambient humidity or temperature change. To eradicate these affects, Carvalho et al. [1,2] took attempt to increase the resolution by eight times with much higher cost. They further included some new parameters like integral deviation rate (IDR), Fast Fourier transform (FFT) response, Deviation rate (DR) and spectrogram to characterize the yarn. They also devised an integrated system with capacitive sensor for mass measurements and optical sensor for hairiness measurement. Comparative studies [3–5] were performed by the same research group for yarn diameter and mass variation with 1 mm resolution. They found high statistical correlation between diameter and linear mass of the yarn for which it was possible to find yarn mass and infer variations in yarn diameter and/or vice versa. Yarn hairiness [6] is the measure of the protruding fibers extended over the yarn surface. Carvalho et al. also developed a system [7] to identify yarn hairiness along two orthogonal direction. They got strong statistical correlation between the results in each direction. They developed Yarn System Quality [YSQ] where simultaneously yarn hairiness, mass, irregularity and diameter can be measured [8]. Using coherent optical signal processing with a single photodiode, the same team was able to quantify yarn irregularities associated with diameter variations [9]. Guha et al. [10] used image processing to evaluate yarn hairiness expressed as hair length and hair area indices for static yarn image. Kuzanski [11,12] reviewed important measuring methods to determine yarn qualities and proposed automatic method of yarn image processing and analysis. Carvalho et al. presented idea [13] to automatically quantify yarn

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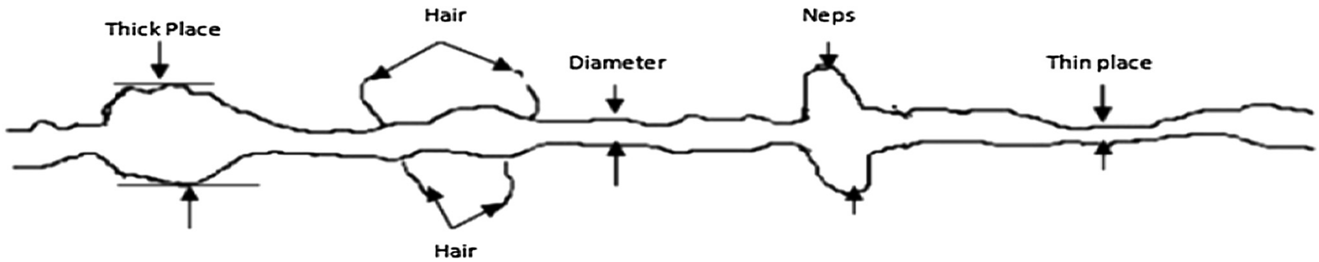

Fig. 1. Yarn configuration.

production characteristics like snarl length, number of cables, fibre orientation, cable orientation, etc. In the work of Fabijanska [14], popular thresholding methods were reviewed and tested on images presenting yarn of different hairiness. Fabijanska and Strumillo [15] developed image analysis algorithm for quantifying yarn hairiness with hair area index and hair length index. Sengupta et al. [16–19] developed low cost yarn parameterisation unit by image processing. The main drawback related to characterisation by image processing was its slow speed. With this history in mind the need of devising a low cost unit based on optical sensing was

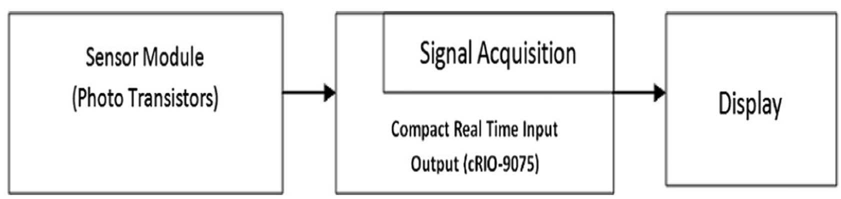

Fig. 2. Block diagram of optical sensing.

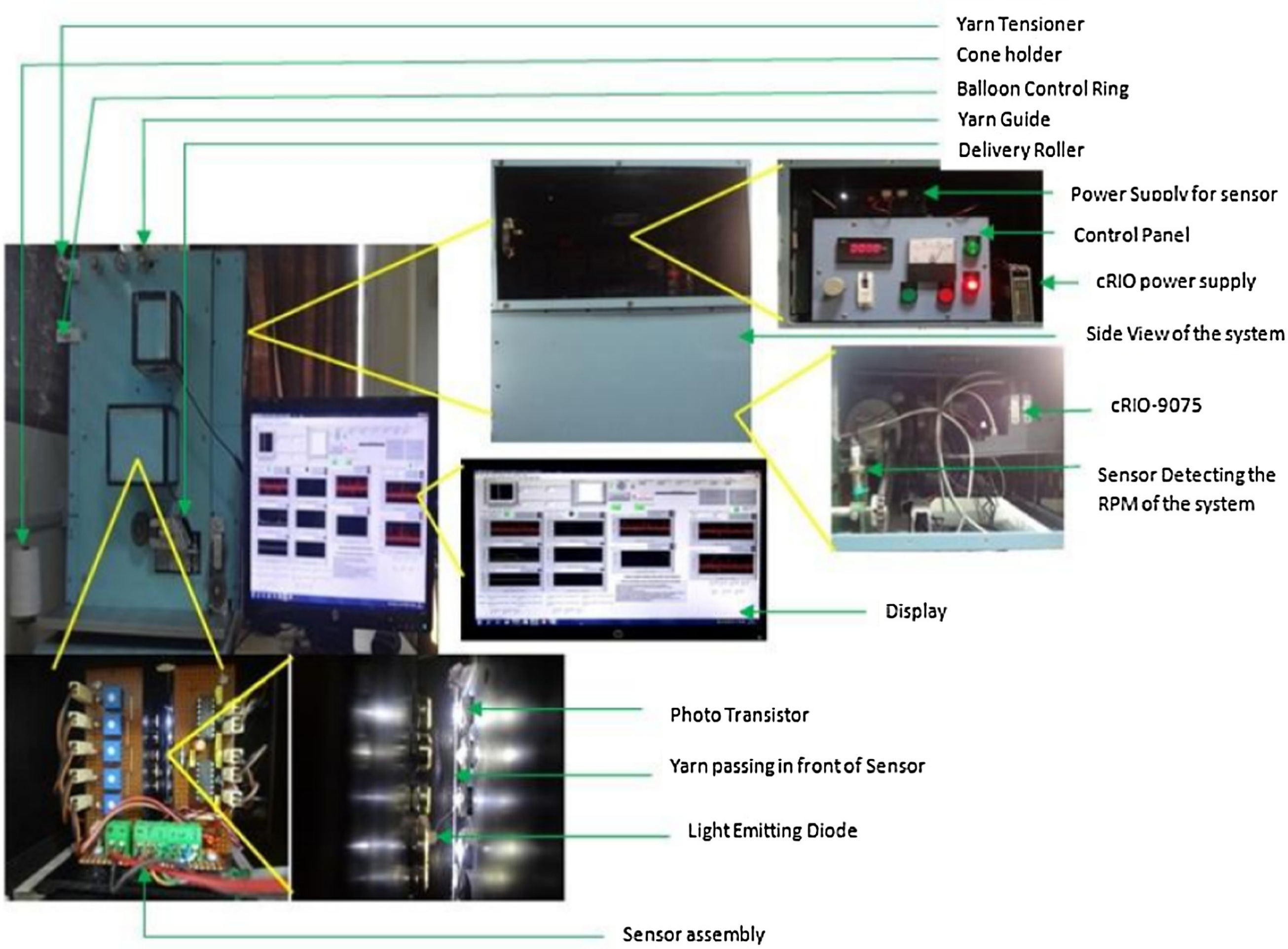

Fig. 3a. Yarn characterization unit.