Detection of Yarn Tension in a Ring Spinning Frame

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The textile industry relies heavily on the precise control of yarn tension in ring spinning frames to ensure the production of high-quality yarns. Maintaining consistent yarn tension is crucial for achieving uniform yarn properties, reducing defects, and improving overall production efficiency. This abstract describes an advanced approach to measure yarn tension in a ring spinning frame using the latest sensors and data analytics. The aim is to enhance the quality and consistency of the spun yarn while minimizing downtime and waste. This proposed paper is used to detect the yarn breakage and it can be identified by sensors. It reduces labour charges, and it can be easy to identify the breakage by glowing of LED in which slot the breakage will happen.

Keywords: Yarn tension, Machine vision, Yarn breakage, Infrared, Yarn swing, Indicator.

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1. Introduction

India is the historic textile producing nation, with textile in general and cotton in particular serving as the country's primary industries. One of India's biggest and oldest industries is textile production. India's textile industry is self-sufficient and autonomous, with a wide range of products and flexibility. The structured mill sector and the unorganised decentralised sector are the two broad groups of the textile industry. The mills are the organized part of the textile industry. It might be a composite mill or a spinning mill. A spinning mill is one in which the spinning, weaving and processing operation are all done under one roof. The most serious problem with ring spinning is end breakage, which occurs when the peak tension of the yarn surpasses the resilience of its weak points. The rate of yarn end breakage has a big impact on how efficiently rings are spun. As a result, it is crucial to assess yarn tension in order to increase ring spinning's quality and productivity. Fiber drafting, twisting, spinning, and wrapping are characteristics of the yarn creation process known as ring spinning. The most serious problem with ring spinning is end breakage, which occurs when the peak tension of the yarn surpasses the resilience of its weak points. The rate of yarn end breaking has a significant impact on the production effectiveness of ring spinning [1]. As a result, it is crucial to assess yarn tension in order to increase ring spinning's quality and productivity. Fibre drafting, twisting, spinning, and wrapping are characteristics of the yarn creation process known as ring spinning [2-3]. The thread's traveller and guide are both passed through by the drafted roving's strands before being coiled around the bobbin by the high-speed revolving spindle [4]. In the yarn-ballooning zone, top- and bottom-ballooning tensions Tq1 and Tq2; winding tension Tw; and upstream tension Tfare the four different forms of yarn tension. Real-time yarn tension measurements allow for the identification of the causes of breakage and abnormal yarn tension during ring spinning changes [5-7].

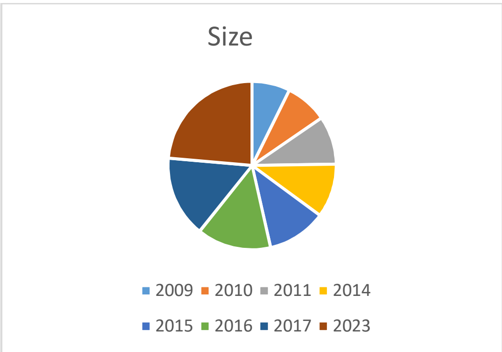

Figure 1. Ratio of yarn industry

As of 2017, India's textile industry was worth 150 billion US dollars. 842000 rotors and more than 50 million spindles have been installed in 3400 textile mills. The value of the textile industry's output is 7%, and its exported revenue are 15%. The cotton industry is one of the greatest employers in the nation, directly employing more than 45 million people. The states about the tension of the materials, when the yarn is moving in the frame. They would manually set the tension of the material what they are using. By mistake if the thread or yarn moving in the frame increase the speed of moving. There may be a chance of increase in the tension of the thread moving. It may lead to the breakage of the particular yarn moving in the frame. So it's necessary to know about the tension of the materials. Table 1. shows the tension of the materials that were used in the spinning mills.

Table 1. Tension of materials

YARN TYPE	TENSION
Woollen material	3.90
Cotton material	5.44
Silk material	10.30

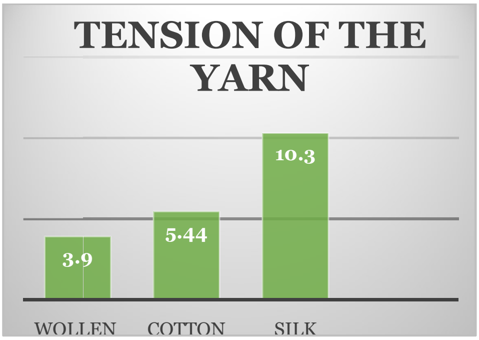

Figure 2. Data of Tension

2. Existing Method

S. Bhattacharyya, et.al [1] published a paper in a methodology of common knowledge while spinning, the tension of the yarn varies in various zones. The twisting zone in ring spinning is where the yarn tension is maximum. It is situated there, halfway between the ring traveller and the lappet guide. Because of the traveler's rotation, tension is produced in the yarn that is ballooning and Z. X. Tang, et.al [2] published a paper in a methodology of an experimental investigation of yarn tension in simulated ring spinning. One important element that has an impact on a ring spinning system's effectiveness is yarn tension. H.P.Jia [3] distributed a study in a method to employing yarn tension managing in the yarn manufacturing process. This article suggests a technique for managing yarn tension that will enhance soft winding machine performance while maintaining yarn quality and increasing output. The proposed approach eliminates the tension regulating and machine speed trade-off that arises in conventional systems by adjusting stress levels, as shown by a comparison of the outcomes with the conventional system. H.Banitalebi and M. Rafeeyan [4] published a paper in a new way for measuring tension in stationary and moving wires without contact. In this study, a non-contact technique based on wire lateral vibration equations is presented form easuring instantaneous tension in a wire. An eddy current transducer is used to measure the string's lateral vibration, and the data is then transferred to a computer M. Bracewell, K. Greenhalgh [5] published a paper in a methodology of dynamical measurement of the balloon in motion. Air drag on an expanding yarn and the balloon's establish in ring spinning. The quantity of energy used and the volume of yarn generated, as well as the tension of the yarn and ends-down (yarn breakage), are related. A computer collecting data system was used to monitor yarn tension during testing with cotton and wool yarns at various balloon heights and with varying yarn lengths inside the balloon. A laser Doppler vibrometer (LDV) was used to detect yarn tension. Using machine vision technology to assess product features, is widely employed in the textile sector. Wang et.al presented an optical method for autonomous vehicles monitoring yarn micro tension on this basis. A line laser can be used in a winding machine to illuminate the moving yarns and an image-capturing line scans industrial camera. However, the mathematical model has a number of shortcomings, such as the failure to account for the influence of other factors during motor operation developed a transverse frequency-based yarn-tension detection technique. While non-contact detection is possible, the results are sporadic and distinct [8-10]. It is difficult to meet real-time tension detection requirements in production. The technologies are equally unsuited for on-site operation in the spinning field since they completely depend on computer software to process visual data. Real-time detection must be accomplished using high-performance CPUs and a higher tension sampling rate before being applied to control systems. [11-13]. Because it directly affects the requirements of the finished product, measuring tension of the yarn is essential during the textile manufacturing process, the productivity, and the subsequent processing [14-17]. Significantly, IR sensors are used in a variety of industries due to the quick development of rotating gadgets. Additionally, the yarn tension using IR sensor explored that possesses great properties such as highly reliable, greater sensitivity, quick reaction time, great anti-interference capacity, small size, low cost, and more, making it a solid choice to adapt to current textile manufacturing[18-19].

3. Objective of the Proposed Method

- To detect whether there is an end breakage in the yarn.
- To indicate the breakage area with an alarm and display the place where the yarn is broken

4. Block Diagram

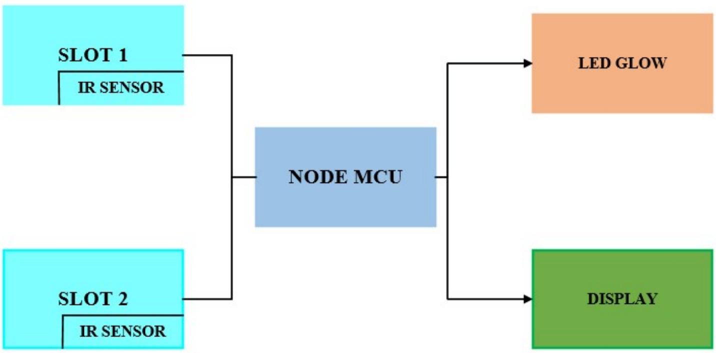

Figure 3. Block Diagram

The block diagram for our proposed system is shown in Figure 1. The IR sensor is used to detect the breakage of yarn. Here, two IR sensors are used. The one IR sensor is denoted as slot1 and another IR sensor is denoted as slot2.If there is a breakage in yarn denoted as slot1 and another IR sensor is denoted as slot2. If there is a breakage in yarn due to high stress the signal which is connected to NODE MCU will indicate by glowing led and it will be displayed in the LCD display that the breakage is in slot1 or slot2.If there is no breakage in both slots it shows the message as good.

4.1 Limitations

When there is a yarn detection in the slot needs manual checking. It takes time to find the detection in the slot. So there is a continuous manpower needed. It affects the overall performance and accuracy.

5. Flowchart of the Proposed System

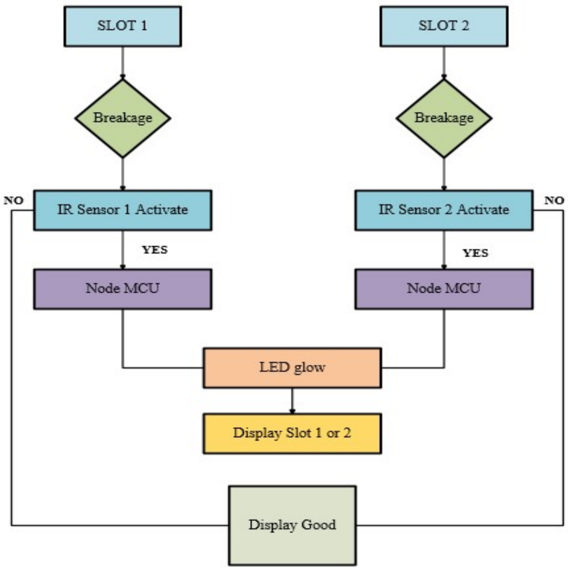

Figure 4. Flowchart

The breakage in the yarn is continuously monitor by using infrared sensor. A technical device known as an infrared sensor emits light to identify surrounding objects. The Infrared sensor may detect both motion and the temperature of an object. If the breakage is happened the IR sensor detect that there is a breakage is happened as shown in Figure 2. The information is passed to NODE MCU is anopen source firmware and development kit that help us to prototype and led starts to glow and the led display in which slot the breakage is happened as shown in Figure 3 and Figure 4. If there is no breakage the led will display the slot is good as shown in Figure 5.

Table 2. Components and Quantities

COMPONENTS	QUANTITY
IRSensor[4649]	2
NODEMCU	1
LED	1

6. Hardware Setup

The Hardware components setup for the project and its components are described below. The hardware is placed in wooden cardboard in order to prevent the damage of electrical equipment by the external factor. In Figure 5. and Figure 6. shows the breakage of yarn in which slot occurs. In figure 7. shows there is no breakage of yarn.

When breakage in slot 1

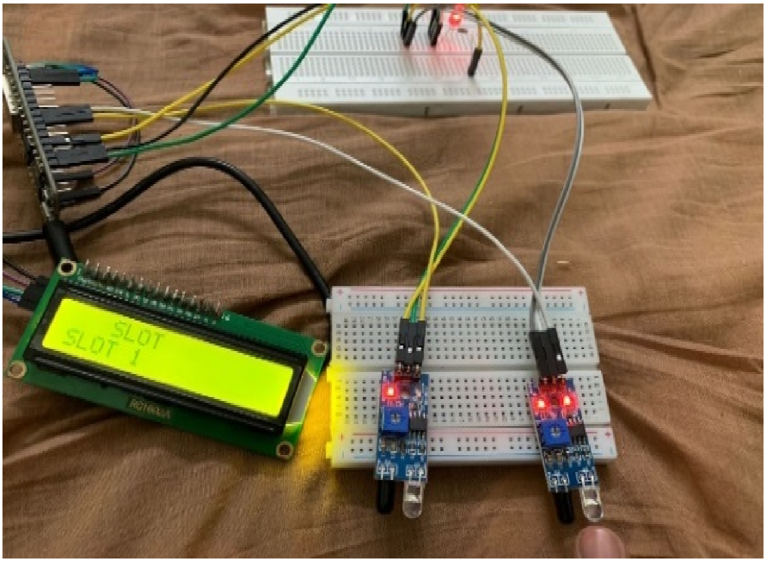

Figure 5. Output of slot 1

When breakage in slot 2

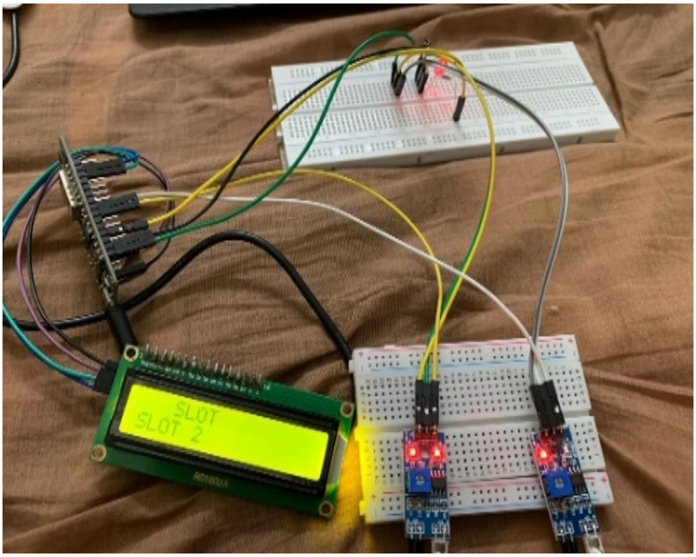

Figure 6. Output of slot 2

No breakage of yarn

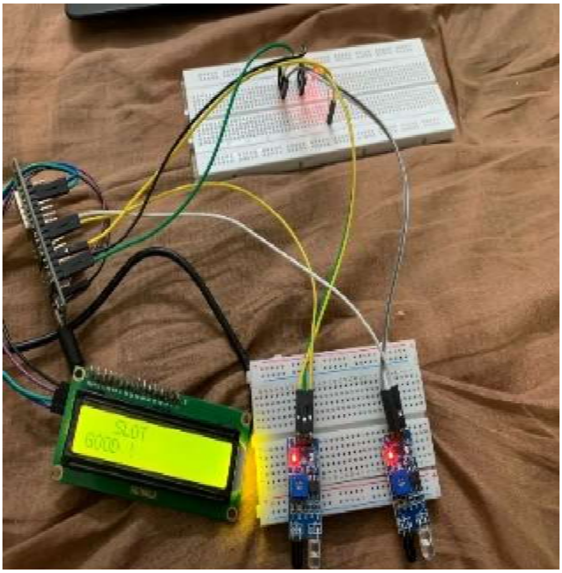

Figure 7. Output of no breakage

6.1 Components Description

NodeMCU is an open-source LUA based firmware developed for the wifi chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e., NodeMCU Development board. It supports serial communication protocols i.e., UART, SPI, I2C, etc. Using such serial protocols, we can connect it with serial devices like I2C enabled LCD display, Magnetometer HMC5883, MPU-6050 Gyro meter + Accelerometer, RTC chips, GPS modules, touch screen displays.

7. Experimental Setup

7.1 Setup in the field

The ring spinning frame with motor is shown in figure. 8. In the ring spinning frame the fibre bundle flows a path between the drafting system and yarn take up on the cop. After drafting the fibre is twisted into yarn structure by a whirling spindle.

The sensor will be placed at the centre of plate. The experimental setup of our project is placed on the silver plate when there is end breakage or slag in the yarn it displays in which slot breakage occurs. Table 3. shows the measurement of Yarn tension while running.

Figure 8. Existing method in the Industrial field

Table 3. Measurement of Yarn tension

TENSION	OUTPUT
T>25 in slot 1	slot1
T>25 in slot2	slot2
T<25	good

8. Result

Table 4. Result Table

Tested Hour	SLOT 1	SLOT2
1hour	Good	Good
4hour	Good	Bad
12hour	Bad	Good

Therefore, it is tested our product in the yarn industry and the results were mentioned in the table.4. And it was placed our product in the steel slot which was located under the yarn. Due to no breakage in the yarn the LCD display good in both the slot. In case of any breakage in the yarn the LCD will display at which slot the breakage is happened.

9. Conclusion

In this proposed paper, a tool for measuring yarn tension in a ring spinning frame is established. We monitored the dynamics of yarn tension as it crossed over the thread guide using sensors connected to a ring spinning frame. Additionally, we analysed the yarn tension in a ring spinning, where a number of factors affect yarn tension. The breakage of yarn was being sensed using the IR sensor and display the slot at which the breakage is occurred. The result was displayed in LCD. It is easier way than the manual checking. Thus, the proposed system gives a better solution for monitoring the breakage in the yarn using IR sensor. Finally, to examine the characteristics of the yarn tension fluctuations in the ring spinning frame.

References

[1] S. Bhattacharyya, S. Mondal, and S. Pal, "Measurement of yarn tension and its on-line monitoring," Indian J. Fibre Textile Res., vol. 28, no. 4, pp. 418–422, Dec. 2017.

[2] H. Banitalebi and M. Rafeeyan, "A new approach for non-contact measuring of tension in fixed and moving wires," Int. J. Adv. Design Manuf. Technol., vol. 5, no. 4, pp. 51–57, 2013.

[3] Z. X. Tang, X. G. Wang, W. B. Fraser, and L. J. Wang, "An experimental investigation of yarn tension in simulated ring spinning," Fibers Polym., vol. 5, no. 4, pp. 275–279, Dec. 2019.

[4] Liu, X.; Miao, X. Analysis of yarn tension based on yarn demand variation on a tricot knitting machine. Text. Res. J. 2017.

[5] Ali, M.; Ahmed, R.; Amer, M. Yarn tension control technique for improving polyester soft winding process. Sci. Rep. 2021.

[6] H. P. Jia, "Implementing the yarn tension control in the process of yarn," Foreign Textile Technol., vol. 12, no. 1, pp. 31–35, Dec. 2011.

[7] Fang, B.; Long, X.; Sun, F.; Liu, H.; Zhang, S.; Fang, C. Tactile-Based Fabric Defect Detection Using Convolutional Neural Network with Attention Mechanism. IEEE Trans. Instrum. Meas. 2022.

[8] Zhang, L.; Liu, C. Robust Low-Rank Analysis with Adaptive Weighted Tensor for Image Denoising. Displays 2022.

[9] X, Q.Y., G, X.Q., Current Situation and Outlook of Yarn Tension Measurement and Control Technology, In: Cotton Textile Technology, 2011.

[10] Nutting, T., Kinetic Yarn Friction and Knitting, In: Journal of the Textile Institute Transactions, 2020.

[11] Chen, X.L., Mei, S.Q., Chen, X.B., Non-contact measurement of yarn tension in spinning process, In: Applied Mechanics and Materials, Trans. Tech. Publ., 2015.

[12] G.M. Bracewell, K. Greenhalgh, Dynamical analysis of the spinning balloon, J. Text. Inst. 44, 2020.

[13] Xu, Q., Mei, S.Q., Zhang, Z.M., Measurement method of yarn tension based on CCD technology, In: Advanced Materials Research, Trans. Tech. Publication,2021.

[14] Behera, B., Subramanian, S., Garg, A., Opto-electronic measurement of spinning tension, 2019.

[15] Guo, M., Sun, F., Gao, W., Theoretical and experimental study of color-alternation fancy yarns produced by a double-channel compact spinning machine. In: Textile Research Journal, 2019.

[16] Tang, Z.X., Fraser, W.B., Wang, X., Modelling yarn balloon motion in ring spinning, In: Applied mathematical modelling, 2007.

[17] H. P. Jia, "Implementing the yarn tension control in the process of yarn," Foreign Textile Technol., vol. 12, no. 1, pp. 31–35, Dec. 2011.

[18] Zhao, B.; Cong, H.; Wu, G. Construction and system realization of the yarn tension model of fully-fashioned flat knitting fabric. Text. Res. J. 2021.

[19] Batra SK, Ghosh TK, Zeidman MI. An integrated approach to dynamic analysis of the ring spinning process: part i: without air drag and Coriolis acceleration. *Text Res J* 1989; 59: 309–317.