DESIGN OF HANDHELD DEVICE FOR MONITORING OF INDIVIDUAL SPINDLE SPEED IN SPINNING MACHINE USING WIRELESS TECHNOLOGY

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Abstract

In textile spinning mills, the quality of yarn depends on twist and hence needs to be monitored continuously in online. Ring spinning machine is used to produce yarn in textile industries, twist of yarn has been calculated by measuring spindle speed, measured at the common drive shaft and delivery speed of yarns is measured at front roller. Here, individual speed variation of spindle caused due to looseness or tightness of belt cannot be monitored separately. In this paper, the problem has been addressed by providing a hand-held device to the operator, which can measure individual spindle speed by Hall Effect sensor. Through wireless technology, the handheld device receives delivery speed from machine mounted controller unit which measures delivery speed. Handheld device will then calculate twist based on individual spindle speed and common delivery speed received from machine mounted unit. This device is highly needed in the industries, so that quality, production and maintenance can be improved.

Keywords: Dynamic C, Ring spinning machine, Twist, Rabbit microcontroller.

I. Introduction

In Textile Industries, Ring spinning machine converts the roving into yarn. Quality of the yarn depends on twist. The twist depends on spindle speed and delivery speed of Ring spinning machine. In ring spinning machine, it is essential to monitor twist, spindle speed, delivery speed and to logg the same on each and every machine
in the spinning mill. This paper involved designed and development of a handheld instrument and a machine station with the help of Rabbit core modules (microcontroller) and wireless technology are proposed for twist and speed monitoring. To measure spindle speed and delivery speed two different speed sensors are employed. A proximity sensor is mounted on common shaft in ring spinning machine to measure delivery speed. This proximity sensor is coupled with machine station. A Hall Effect sensor is employed in the handheld instrument to measure individual spindle speed. Delivery speed sensor signal is transmitted to the handheld device using wireless technology from machine station. Then twist is calculated in the handheld instrument.

The handheld unit is designed as a data logger. It also stores and calculates the twist/meter, twist/inch, spindle speed, delivery speed and average speed. The necessity of such device is highly needed in the industry, for the quality of yarn produced and maintenance purposes. There are approximately 1000 spindles to be checked regularly for about 20 machines in a day. Such a handheld device makes the task at hand easy.

II. Mechanism of Twist

Twisting is an important process in stable yarn, twine, cord and ropes. Twist is introduced into the solid yarn to bind the constituent fibers together, giving the yarn sufficient strength and ensuring the yarn's continuous length. Fibre strand twisting is done on a roving rig, rotor rotating ring assembly. To twist and wind the strand on the box, there should be two rotating components (the spindle and traveler, or flyer and bobbin). The winding rate from the drafting system shall be equal to the distribution rate. As the winding on the packet's diameter varies continuously throughout the process, the difference velocity between the two elements also needs to be constantly varied. Since the supplied rate is constant, the winding product should be kept constant on diameter and the difference in speed between the two spinning components. On a roving frame, this is accomplished by constantly changing the bobbin speed and keeping the flyer steady, where only the single rotates at a constant rate as a ring spinning, and the yarn drags the traveler around the rings. The required speed difference between the spindle and the traveller is balanced automatically due to the frictional force between the ring and the traveler.

For calculating twist roving and ring spinning

\[ \text{Twist/cm in the roving} = \frac{\text{flyer speed}}{\text{delivery rate in cm/minute}} \]

\[ \text{Twist/cm in the yarn} = \frac{\text{spindled speed in rpm}}{\text{delivery rate in cm/minute}} \]

\[ \text{Twist insertion to the yarn when the spindle is stationary, Length of the yarn wound per revolution of traveller} = \pi d \]

\[ \text{Turns/cm due to winding} = \frac{1}{\pi d} \]

Where
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Twist insertion to the yarn when the traveller is stationary:

\[
\text{Turns /cm due to over end unwinding} = \frac{1}{\pi d}
\]

Twist insertion on the yarn when both spindle and traveller rotate in opposite direction:

The length of the yarn wound per minute and twist/cm can be calculated:

Length of yarn wound per minute = \(\pi d (N_s + N_t)\)

Twist per cm due to winding = \(-\frac{N_t}{\pi d} (N_s + N_t)\)

Where

\[N_s\] - Spindle speed in rpm
\[N_t\] – traveler speed in rpm

Twist insertion onto the yarn when the spindle leads the Traveller:

In ring spinning, both the spindle and the traveler rotate in the same direction.

Length of the yarn wound on the cop per minute = \(\pi d (N_s - N_t)\)

Both the spindle and the traveler rotate in clockwise direction. Turns/cm in the yarn = \(\frac{N_t}{\pi d} (N_s - N_t)\)

The winding rate should be equal to the delivery rate.

Length of the yarn delivered (cm/min) = \(\pi d (N_s - N_t)\)

during over-end unwinding one turn of twist is inserted for every unwound of coil.

Turns/cm for unwinding = \(\frac{1}{\pi d}\)

Total twist present in the yarn after over-end unwound = \(\frac{N_t}{\pi d} (N_s - N_t) + \frac{1}{\pi d}\) = \(\frac{N_s}{\pi d} (N_s - N_t)\).

III. Measurement Setup

The existing embedded controller for measuring twist is consists of micro controller, Keypad, display and Power supply unit. Two proximity sensors are used to measure the delivery speed and spindle speed. These two sensors are connected with the micro controller through wired connection.

Both the delivery and spindle speeds are measured on the common shaft to calculate the twist. This entire setup is fixed in a machine station. Need a controller for each machine to measure the twist. Ring spinning machine consists of approximately 1200 spindles and it is difficult to identify any speed variation due to belt looseness or tightness in any one of the spindles as shown in Fig.1.

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The online individual spindle twist is monitored in ring-spinning machine using the measurement setup as shown in Fig.2. It measures the individual spindle speed and common delivery speed. The common delivery speed is transmitted through RF module. The hand held device also contains RF module that receives the delivery signal and directly senses the individual spindle speed. The formula for individual spindle twist calculation is given below.

\[ TPI = \frac{SS}{FRS \times FRD \times Pi} \]

Where

- \( TPI \) = Twist per inch.
- \( SS \) = Spindle Speed in rpm.
- \( FRS \) = Front roller Speed in rpm.
- \( FRD \) = Front roller Diameter in mm.
- \( Pi \) = 3.14

**Fig. 1:** Individual speed variation of the spindle caused due to looseness or tightness of belt

**Fig. 2:** Twist measurement setup.

### IV. Design of Handheld Unit

The handheld device designed with the following units:

- a. Sensor
- b. Microcontroller
- c. Wi-Fi module
- d. Keypad
- e. LCD
- f. Data logging

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Battery backup.

**Hall Effect sensor**

When a current-carrying conductor is put in a magnetic field, a voltage perpendicular to both the current and the field is produced. The element Hall is the basic sensor of magnetic fields. To render the performance available for most applications, it needs a signal conditioning. The electronics needed for the signal conditioning are amplifier level.

![Diagram](image1.png)

**Fig. 3:** Effect on the conductor, when no magnetic field

![Diagram](image2.png)

**Fig. 4:** Effect on the conductor, when magnetic field present

![Diagram](image3.png)

**Fig. 5:** Hall Effect Sensor Setup

The 3.Fig. Display the basic Hall Effect Sensor theory. It shows a thin sheet of semi-conductive material (Hall element) through which a current passes through. The links at the output are perpendicular to current direction. When there is no magnetic field (Figure 3.), the current distribution is uniform, and no potential difference is seen throughout the output. The magnetic field (B) perpendicular is present as shown in Fig.4. On the present the Lorentz power is exercised. This force disrupts the current distribution, resulting in a potential (voltage) difference across the output. The

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voltage is the voltage of the Hall. The magnetic field and current interactions are shown in equation form as equation \( VH = I \times B \). Hall Effect Sensors can be applied to many sensing device types. When the quantity (parameter) to be sensed includes or can integrate a magnetic field, the function is performed by a Hall sensor. Fig. 5 displays the Hall Effect Sensor configuration.

![Hall Effect Sensor Configuration](image)

**Fig. 6:** Hall sensor output amplifier circuit

IF HS 52 pin details [IV]
1- Output., 2- Vcc., 3- Ground., 4- Ground.

The amplifier must be a differential amplifier, so that the Hall voltage can only amplify the potential difference. In the presence of a one gauss magnetic field, the Hall voltage is a low-level signal of the order of 30 microvolts. This low-level performance includes a low-noise amplifier, high input impedance and reasonable gain. Using standard bipolar transistor technology, a differential amplifier with those characteristics can be easily integrated with the Hall element. Compensation of temperature is easily integrated too. The Fig.6.show hall sensor signal conditioning circuit. It has two operational amplifiers. First one is a comparator and the other one is a voltage follower. The comparator has two inputs. Hall sensor output is given to inverting input and reference voltage is given to non inverting input of the comparator. Whenever a pulse is present at the Hall sensor output, the comparator produces a low output voltage. A reverse biased LED connected at the output of the comparator glows to indicate that a pulse is present in the Hall sensor output.

**Wi-Fi Technology**

In order to send the delivery speed to handheld device needs any one wireless medium, this one is achieved by Wi-Fi technology. Wi-Fi, a popular name for 802.11b, is one of the IEEE standards-compliant wireless systems included in the 802.11 series. The serial port C is provided in the micro controller for communication with the host system. C coding is written for serial communication using dynamic C software. We can communicate with the computer through this serial communication.
port. The saved data of individual spindle speed, delivery speed, twist/inch, twist/meter can be transferred to the computer and the print out of each spindle’s information can be taken.

**LCD Module**

![LCD Module Diagram](image)

*Fig. 7: LM08200 [8 x 2, 1/16 MUX]*

Pin details.

1-Ground, 2-Vcc, 3-Vo, 4-RS, 5-R/W, 6-E, 7 to 14-DB0-DB7, 15 & 16-LED BL A&K.

The LCD model LM08200 (8 characters x 2 lines, 1/16 multiplexer shown in Fig.7) is used for interfacing with the micro controller to display the required parameters. The LCD module consists of total 16 pins, out of which 8 pins are data bus lines (DB0 to DB7). Pin numbers 15 & 16 are used for LED backlight anode &cathode [VIII].

**V. Results and Discussion**

RCM -3100 (microcontroller) contains a number of parallel I/O ports and serial ports. Some of these ports are used for the handheld device operations. Six data lines from Parallel port D and one data line from parallel port G, totally seven lines are used for LCD module, four data lines parallel port F and two data lines from parallel port G, totally six lines are used for key pad module and serial port C used for RS 232 communication. RF module (DM1800) is interfaced to the RCM 3100 with some standard ports and the Hall Effect sensor is connected to parallel port F. The schematic of developed controller is shown in Fig.8.
Keypad Module Interfacing

The membrane keypad is in 2 x 4 matrix format. It has six lead wires arranged in two rows and four columns. The six leads are connected to the microcontroller ports PG6, PG7, PF4, PF5, PF6. The two rows of the keypad leads are connected to PG6 and PG7 ports configured as an output port through software and the four columns leads are connected to PF4, PF5, PF6, PF7 ports configured as an input port using dynamic C software. The keypad operations are developed by the following software development.

Dynamic C software is used for programming. The dynamic C embedded software is user friendly and it has more features compared to other embedded software.

All the libraries developed within the software, for example timer and counter do not need initial basic operation, and the software itself does all the operations. C coding is written for keypad interfacing module and interface to the micro controller using this software. The algorithm for the software development is given below.
a. Configuring the parallel port F as input port (for 4 columns).
b. Configuring the parallel port G as output port (for 2 rows).
c. Set output port G6 as high, output port G7 as low.
d. Read the parallel port F4 to F7 if any one key is pressed in the first rows.
e. Set output port G7 as high, output port G6 as low.
f. Read the parallel port F4 to F7 if any one key is pressed in the second rows.
g. Configure each key for our required application.

**Sensor Module Interfacing**

Sensor module is interfaced to micro controller port PF1and PF3. The pulses of spindle speed are given in to port PF1 and the pulses of delivery speed are given in to port PF3. The spindle speed pulses are given to the signal conditioning circuit and converted in to the TTL output. The hall sensor normally gives some DC voltage. When an object crosses the hall sensor voltage increases by some mV range. That voltage is compared with standard reference voltage using the signal conditioning circuit.

The Fig.9 shows the developed handheld device for twist and speed monitoring. Dynamic C software is used for programming. The algorithm for the software development is given below.

a. Configuring the parallel port F1, F3 as an input.
b. Read the port F1, F2.
c. If the above ports low means count the pulses.
d. If the above ports high means wait until port is low.
e. If the status is low, count the pulses and continue up to one second.
f. Speed in rpm = Number of pulses x 60 sec.
g. If the status is high, remain in normal mode.

**LCD Module Interfacing**

The LCD module consists of 16 pins. The upper four data lines DB4, DB5, DB6, DB7 are connected to output port of the microcontroller PD0, PD1, PD2, PD3 respectively and register select pin is connected to PD6 port and enable pin is connected in to PD7 port. Dynamic C software is used for programming. The algorithm for the software development is given below.

a. Configuring the parallel port D as output port.
b. Check the mode whether data mode or Command mode.
c. Basic LCD initialization according to reference manual.
d. Select the display mode as either 4-bit mode or 8-bit mode.
e. Send the character nibble by nibble.
f. Upper nibble first and lower nibble second.
g. Display the parameters.

**RF Module Interfacing**

Dynamic C software is used for interfacing RF module with microcontroller as shown in Fig. 10. That is called as a firmware. General technical characteristics include data rates of 250 kb/s in 2.4 GHz and 20/40 kb/s in 868/915 MHz, 16 channels in the 2.4 GHz ISM band, 10 channels in the 915 MHz ISM band and one channel in the European 868 MHz band, CSMA/CA channel access, Fully handshake protocol for transfer reliability, extremely low duty-cycle ability, Beaconless operation available, Support for low latency devices and Star or Peer-to-Peer network topologies supported.

![RF module interface with micro controller](image)

**VI. Conclusion**

Individual speed variation of the spindle caused due to looseness or tightness of belt cannot be monitored separately in the existing embedded controller used in ring spinning machine. The above problem has been solved by providing a hand-held device to the operator, which has been developed in this paper. It can measure individual spindle speed using the Hall Effect sensor with improved signal conditioning circuit. Through wireless technology, the handheld device receives the delivery speed from the machine mounted controller unit, which measures the delivery speed. The developed handheld device has calculated the twist based on individual spindle speed and common delivery speed data obtained from the Machine mounted unit. This advanced technology has been implemented in this paper for ring spinning machine to calculate the twist.

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