A Direct Reading Spindle Speed Meter

A. R. KALYANARAMAN & U. SRIDHAR
South India Textile Research Association, Coimbatore 14

Received 8 July 1976; accepted 10 August 1976

A simple, inexpensive and direct-reading spindle speed meter has been designed and fabricated. The accuracy and reproducibility of measurements made with the meter are comparable to those obtained with the stroboscope. The potential industrial applications of the meter, besides its use in spindle speed measurement, are indicated.

Measurement of spindle speed is in fact the measurement of the state of health of the textile industry. The spindle speed is directly related to the production and the machine efficiency and is a measure of modernization of the mill. In view of this, one need not overemphasize the utility of a meter designed to measure the spindle speed. Several types of spindle speed meters are available. Mechanical torque type meters are well known. They have the disadvantage that in the process of measurement, they load the spindle; since, for the measurement, they have to have physical contact with the spindle itself. The other type of instruments are generally based on the stroboscopic principle, i.e. synchronization of a pulsed light with the spindle speed, so that when there is perfect synchronization, the rotating spindle appears stationary. This requires careful adjustment of the pulse period of the light pulses so as to synchronize it well with the rotating spindle, and hence very high stabilization circuitry is needed. For accurate measurements, expensive electronic components have to be used. This paper describes another method of tracking the spindle; it helps in measuring the traveller speeds also. The method is based on electromagnetic pulse generation and measurement. The main advantages are:

1. The method of measurement used is direct and simple; no adjustment is required;
2. The instrument is inexpensive;
3. The accuracy and reliability are good.

Principle

A soft iron piece moving in a magnetic field causes a disturbance in the field. If the soft iron piece itself forms a rotating object (as in the case of a spindle), it causes a disturbance in the magnetic field placed nearby. For every rotation, an electromagnetic pulse is produced and the electromagnetic pulse period holds information about the speed of the rotating object, i.e. the pulse period is equivalent to the time taken for the object to rotate once. This pulse is picked up and after several electronic manipulations is indicated through a meter.

Description of the Instrument

The schematic diagram of the instrument is shown in Fig. 1.

Probe — This picks up the electromagnetic signal from the revolving object at the rate of one signal per revolution.

Amplifier and shaper — The generated pulse will be usually weak in strength and hence before further handling it has to be amplified. Shaping of the pulse helps to design a suitable method of measurement. The noise is also amplified and the next stage is so designed as to discriminate against noise.

Trigger and differentiator — The trigger is of Schmitt type. It also shapes the signal into a square pulse. The threshold voltage of triggering is set at 3 V so as to discriminate against spurious noise around. The noise may have originated outside and picked up by the probe along with the signal or generated inside the electronic circuitry. The triggering voltage has to be set, depending upon the situation under which the trigger is used.

The differentiator chops off half the trigger output and sends the pulse to the next stage.

The timer — The pulse time has to be suitably measured so as to give the spindle speed. The timer used is a monostable multivibrator. This gives out constant width pulses as set by a choice variation of resistor and capacitor combination or variation of resistor alone, depending upon the range of measurement. This combination is arrived at by setting a rotary range switch. The multivibrator is triggered by the shaped pulse of the previous stage.

In the present version, the range switch has eight stages and each stage corresponds to a variation of 2500 cycles per minute.

Pulse shaper — This shapes the output of the monostable, so that it could be easily measured by the meter employed. The square pulses of the monostable multivibrator are shaped into pulses of constant amplitude rising from zero voltage level. This is the input to the meter.

Meter — The meter reads the average direct voltage of the incoming constant amplitude constant width pulse.

![Fig. 1 — Spindle speed meter: Schematic diagram](image-url)
pulses. The present meter is calibrated to read 0 to 2500 in 50 equal stages. The least count is 50. The accuracy in the lowest scale is ±25 rpm. The accuracy could be further improved by increasing the size of the meter dial or by digitizing the whole operation.

The meter in the present form could read up to 0 to 20,000 rpm in an eight-step scale. If necessary, the measurement could be stepped down to small ranges or stepped up to higher ranges by a suitable change in the timing circuit.

Measurements and Discussion

The reliability of the instrument has been tested on several regular working ring frames in different mills. The spindle speeds are measured using this instrument as well as with the stroboflash. Each observation was made three times and two observers estimated the speeds independently. The details for three speeds are given in Table 1. The stroboflash readings are juxtaposed.

The data given in Table 1 indicate that the tachometer clearly brings out spindle to spindle speed variation accurately. The difference observed between two readings may be due to the limitations of the inherent methods of construction of the instruments. Also, the least counts of the scales of the two instruments are fairly high and hence the difference noted here is not very significant. The variations observed are mainly due to the fluctuations in voltage of the input electrical mains. However, the overall mean speeds are equal.

Table 2 gives the variance analysis of the observations. The coefficient of variation is around 1% for both the instruments; this is quite satisfactory. The results of significance tests are given in Table 3. The in-between variation of the instruments is not significant. Also, the F ratio between the two instruments for the two observers is not significant. Thus, the spindle speed meter described could effectively replace the stroboflash in measuring the spindle speed. Also, the input signal can be electromagnetic, photovoltaic or photoelectric.

The meter is inexpensive and easy to assemble. The measurement is direct and simple and no adjustment is needed.

Applications

(1) Depending upon the signal strength, the Schmitt trigger could be modified to respond to signals even at a distance.

This method of electromagnetically tracking a non-uniformity on a magnetic material could be effectively made use of to true the break drums of any rotating object to be machined. If the tools are properly connected, the response could monitor the tool at the right place, so that automatic shaping of objects to very high tolerances could be achieved. Thus, this method has potential application in heavy machine industry.

(2) The meter could be modified to measure speeds and could be effectively used as a speedometer. In certain situations, it could be used as a production meter also. The meter could be easily digitized.

(3) The pulse generator can be electromagnetic, photovoltaic, photoresistor, ultrasonic or microwave. The electromagnetic method may be employed for tracking speed in photographic industry. Ultrasonic or microwave methods may have application in such cases where the rotating object is moved inside a covered case. The speed could be estimated without opening the case.

(4) To make the instrument handy, a pocket battery model is available, which could be used to make on the spot check of spindle speeds, drawing frame speeds, etc.

### Table 1 — AVERAGE SPEEDS MEASURED WITH THE ELECTRONIC METER AND STROBOFLASH

<table>
<thead>
<tr>
<th>Spindle No.</th>
<th>Electronic meter</th>
<th>Stroboflash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observer 1</td>
<td>Observer 2</td>
</tr>
<tr>
<td>4</td>
<td>11686</td>
<td>11624</td>
</tr>
<tr>
<td>8</td>
<td>11604</td>
<td>11604</td>
</tr>
<tr>
<td>12</td>
<td>11664</td>
<td>11664</td>
</tr>
<tr>
<td>16</td>
<td>11564</td>
<td>11454</td>
</tr>
<tr>
<td>20</td>
<td>11770</td>
<td>11760</td>
</tr>
<tr>
<td>28</td>
<td>11676</td>
<td>11780</td>
</tr>
<tr>
<td>32</td>
<td>11850</td>
<td>11910</td>
</tr>
<tr>
<td>36</td>
<td>11810</td>
<td>11810</td>
</tr>
<tr>
<td>Mean</td>
<td>11810</td>
<td>11810</td>
</tr>
</tbody>
</table>

*The readings are the averages of three independent observations by each person.*