

Optical Sensors for Control in Textile Industry

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Abstract: The proposed paper presents optoelectronic sensors for detection of a lack of thread in two types of textile machines. Possible reasons for this failure may be thread breaks or running out of material in the supply bobbin. The application of this method results in a rapid and timely stop of the workflow and reduces the time for restoring the operation of machines. This leads to an increase in labour productivity and product quality.

Keywords: optoelectronics, textile machinery, production control

I. Introduction

An important issue in textile industry is stopping the machine or the relevant working place in case of thread break[1][2]. This is specifically important for doubling machines, where the thread speed can reach 1200 m/min or 20 m/s. In particular, in weaving and knitting looms, the most difficult task is finding the base of a broken thread, since the number of threads ranges from hundredths to several thousands. All breakers, used until now, can be separated in two main groups:

- main breakers of mechanical and electromechanical type;
- optoelectronic sensors[3].

The main breakers of mechanical type are relatively simple but their security is too low, since during operating conditions in weaving workshops, their contacts can hardly be kept clean and thus relative low contact resistance can hardly be achieved. In the cited article, two types of optoelectronic sensors are discussed, applied to doubling and weaving machines..

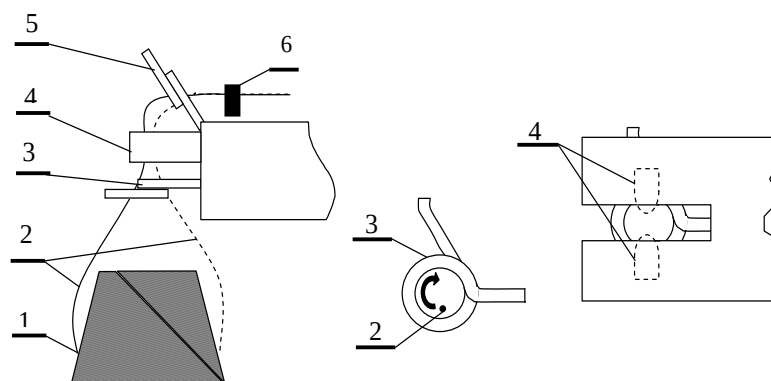
II. Presentation

The doubling machine collects the threads from several (up to 4) bobbins into one, and if one of them breaks, the relevant working place must be turned off as soon as possible. If stopping is delayed, a large amount of defective yarn needs to be unwound from the collecting bobbin, which causes loss of time and material. The tendency for increasing the working places up to 104 per machine as well as the high speed of thread movement makes the issue of control in case of thread break of primary significance[4][5]. Older models of doubling machines are equipped with mechanical breakers, which have satisfactory performance in low thread speed. Thus, at mechanical breaker speed performance of 0.5 s and thread speed of 5 m/s, the defective already doubled yarn will be about 2.5 m. Placing piezoelectric detectors, which react to the vibrations of the sliding thread, can provide the required speed performance but due to the different pressure, applied from the thread unwinding from the bobbins, such detectors give false signals that stop the working place even in case of sound thread.

The described device uses an optoelectronic sensor, which achieves contact-free tracking and speed performance greater than the requirements of the doubling machine manufacturers.

The principle of operation of the device is described in Figure 1:

Figure 1: The principle of operation of the device is described



When bobbin 1 unwinds, component thread 2 goes around the entire internal surface of thread guide 3 and for one revolution it passes twice between optoelectronic pair 4. Then, passing through thread guide 5 and electromagnetic scissors 6, thread 2 is rolled on a common bobbin, which is not shown on the drawing, together with the other component threads. Optoelectronic pair 4 consists of an infrared diode (ILED), powered by a currency generator (CG) due to temperature instability of these elements Fig. 2.

The so-lighted phototransistor (PT) generates photo electric current in its collector circuit in such a way that half of the input voltage is applied on it. In this mode of operation it is sensitive to the possible maximum to any changes in the beam of light that falls on it from the infrared ILED.

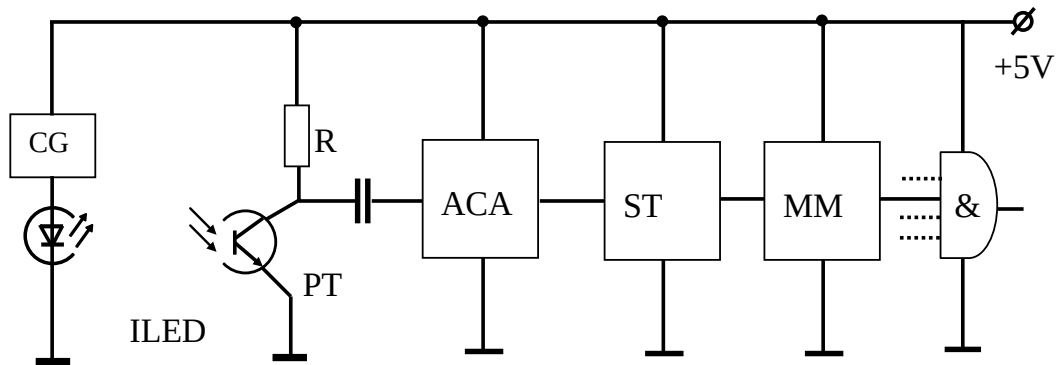
Thread 2 is made of material, which absorbs the infrared radiation, and therefore, when it passes between the optoelectronic pair, the phototransistor receives an impulse, which is processed by an electronic circuit, which contains a Schmitt trigger, a monostable multivibrator and a logic circuit.

When bobbin 1 unwinds, its diameter changes from 0.3 m up to 0.07 m, while the thread speed is constant due to the uniform peripheral speed of the receiving bobbin surface, and it is 20 m/s. This leads to changes in the pulse frequency rate, which is

$$(1) \quad v = \frac{2V}{\pi D}$$

whereas V is the speed of thread movement and D is bobbin 1 diameter. Calculated according to (1), the minimum pulse frequency rate is , and the maximum . The periods corresponding to these frequencies are and , respectively.

Figure 2



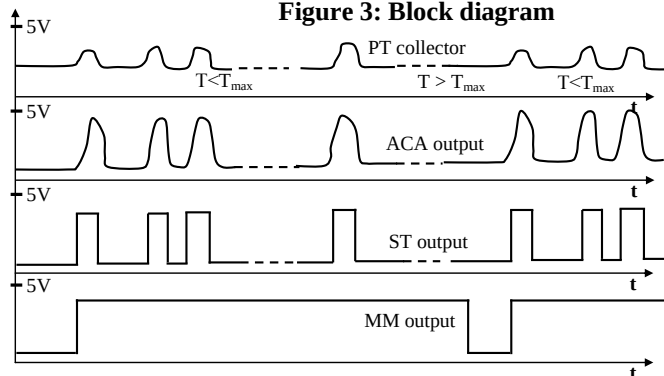
The monostable multivibrator (MM) is operated on the front line of the input impulse, irrespective of the status at the output. Its time constant is to be selected greater than T_{max} for safety purposes and given the above quantities, its optimum value, as determined through tests, is $T_{mm} = 30ms$. The time diagram in Fig. 3 shows the shape of output impulses of four of the main elements of the device.

The MM output is connected to a logic circuit, which allows stopping the working place in case of breaking of one of the component threads, tracked by other devices of this kind. In case of thread break, the logic circuit puts into operation electromagnetic scissors for cutting all of the remaining threads so that the end can be found more easily and less material would be wasted. The scissors speed of performance is about 10 ms and together with the MM time of 30 ms, the total time is 40 ms. The threads travel a distance of about 0.8 m for this time, and as compared to about 10 m when using mechanical detectors, this is a much better performance. Practically, experience shows that the length of the non-doubled end is also shorter due to the following reasons.

Experience shows that 90% of breaks appear when the thread ends, and in such cases it does not make a rotating movement but only “slips unnoticed”, thus simulating a break.

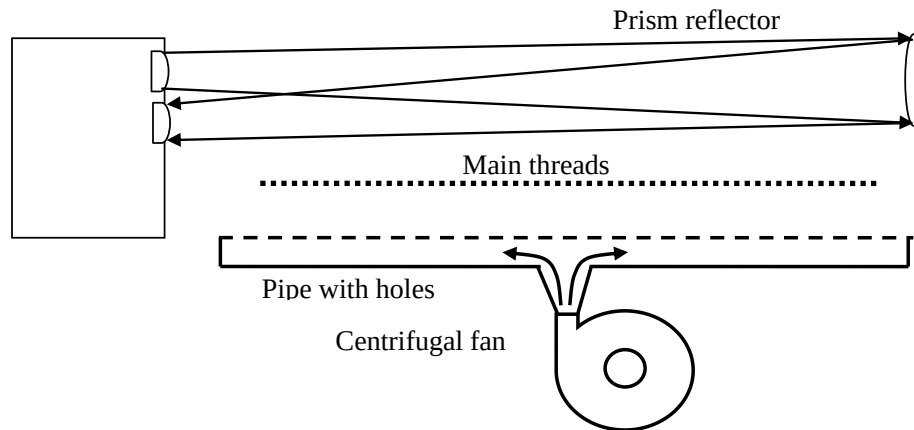
The electromagnetic scissors are placed at about 0.4 m away from the optoelectronic pair, thus reducing the length of the non-doubled end with the same length.

Figure 3: Block diagram



The designed optoelectronic main breaker operates contact-free, and for the purpose a parallel beam of infrared light is being used. To allow the broken thread to cross the beam of light below or above the main threads, a pipe is fitted with holes perpendicular to the direction of their movement (Fig. 4). Compressed air is flown into the pipe, which blows all main threads. If one of them breaks, it goes out of the plane and crosses the beam of infrared light. The reduction in the intensity of the beam of infrared light, due to absorption by the broken main thread, is detected by the electronic device and this initiates a signal for stopping of the weaving loom.

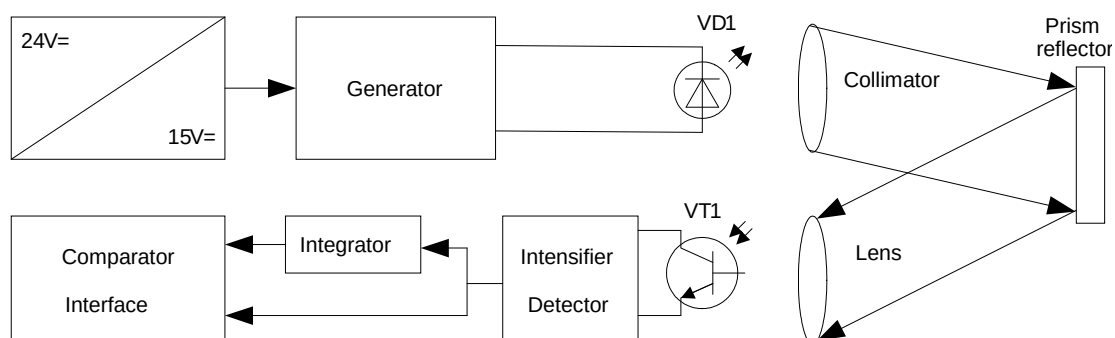
Figure 4



In case of main thread break, the thread crosses the infrared beam of light, taken by the flow of compressed air, and this instantaneous drop of infrared light intensity leads to drop of the average value of voltage after the Intensifier and the Detector. Due to the inertness of the Integrator, the directly fed voltage is lower, the comparator drops out of its balance for some time and thus gives a signal for a broken main thread. In case of gradual change of the voltage after the Detector due to wearing out of LED, change in the rate of transmittance of the so-created opto-coupler, etc., the voltage after the Integrator remains always lower and does not change the normal work of the device.

The optical part of the device consists of lens-collimator, which transform the divergent beam of infrared light, emitted from LED, into a parallel beam.

Figure 5: The electronic circuit



This beam is reflected by a reflector with micro-pyramids for full internal reflection and falls into the lens, which focus the reflected beam of light on the phototransistor. A filter is fitted between the lens and the phototransistor, which holds the white light and lets through the infrared light. The distance between the system collimator-lens and reflector may be changed from 0.5 m up to 6 m, depending on the diameter of the reflector. The minimum thickness of the main threads is 0.3 mm.

The time diagram in Fig. 6 shows the shape of the impulses and the constant current constituents in the outputs of the different elements of the device:

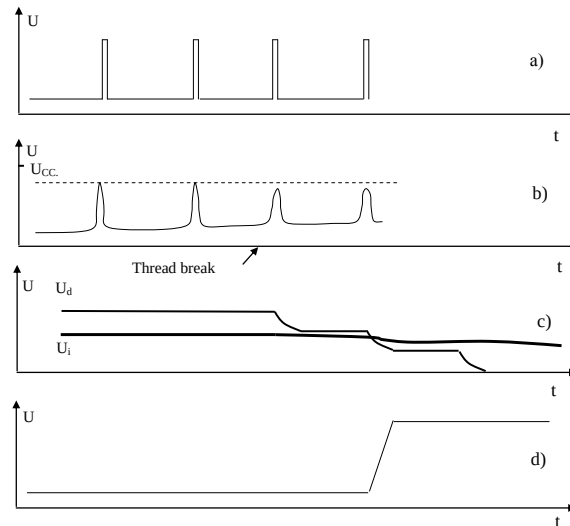
Figure 6: The time diagram

Fig. 6 a) and Fig. 6 b) show the voltage in LED and the intensified voltage, received by the phototransistor at the output before the detector. After rectification of the so-received signal, Fig. 6 c) shows the two voltages U_d and U_i , and U_i is adjusted in the device setting process to be lower than U_d . In case of thread break, the thread crosses the infrared beam in two spots (in two directions) and the drop of the beam intensity leads to a corresponding drop of the amplitude of the impulses as well as of their mean values U_d and U_i . The greater time constant of RC integrating circuit in the Integrator transforms the status of the Comparator, thus registering the thread break (Fig. 6 d)). In case of gradual change in the levels of U_d and U_i due to objective factors, such as wearing of LED, soiling of the optical system, etc., the two voltages are changing but not leading to false operation of the device. The difference $\Delta U = U_d - U_i$ is determined by means of tests as a compromise according to the level of hum noise around the particular machine.

Conclusions

1. Two types of contact-free optoelectronic sensors are offered, which are tested and implemented in actual conditions.
2. The first sensor – optoelectronic pair (Fig. 1) 4 is self-cleaned by the moving thread.
3. In the second sensor, accumulation of dust and fibers on the optics leads to simultaneous reduction of the level of both voltages U_d and U_i but it does not affect its operation.

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