DOI: https://doi.org/10.53052/9788367652117.09

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ZAPEWNIENIE BEZPIECZEŃSTWA NA OPERACJA CIĘCIA W PRODUKCJI TEKSTYLNEJ Z ZASTOSOWANIEM "SMART GLOVE"

Streszczenie: W artykule omówiono istniejące i innowacyjne technologie w zakresie cięcia materiałów tekstylnych. Proponuje się zastosowanie inteligentnych rękawiczek, które mają za zadanie zapobiegać wystąpieniu niebezpiecznych sytuacji, gdy ręce zbliżą się do krytycznie blisko do ostrza tnącego. Rozważane są różne schematyczne rozwiązania wdrożenia tej innowacji.

Słowa kluczowe: inteligentna rękawica, materiały tekstylne, krojenie

ENSURING SAFETY IN THE CUTTING PRODUCTION OF A SEWING ENTERPRISE "SMART GLOVE"

Summary: The paper discusses existing and promising technologies in the field of cutting textile materials. The use of smart gloves is proposed which perform the function of preventing the occurrence of a dangerous situation when hands approach critically minimal distances. Various schematic solutions for the realization of this development are considered.

Keywords: smart glove, textile materials, cutting

1. Introduction

One of the main risks that arises when working with sewing equipment is injury from moving parts. Many sewing machines have moving parts that can cause serious injuries if the worker does not use them carefully or if there is a human factor of inattention to a particular operation [1]. The latter is especially dangerous when performing a material cutting operation.

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2. Results and discussion

In today's world, the garment industry is constantly evolving due to the introduction of the latest technologies. In particular, cutting tools, such as knives, scissors, and lasers, are constantly being modernized to improve efficiency and safety[1-2].
Classical material cutting technologies are gradually being replaced by more innovative and safer operations. The following trends are observed in the field of material cutting technologies:

1. *Cutting knives and scissors*: Traditional cutting tools, such as knives and scissors are still widely used in large enterprises and in home production. However, their designs are improving. There are already scissors with sensors that can sense the approach of human skin and turn off, reducing the risk of cuts.
2. *Laser cutting:* Lasers are used to cut materials accurately and quickly. This technology reduces material loss and provides excellent edge quality. With the help of microcontrollers, it is possible to program the laser cutting process to automate cutting[2].
3. *Protective gloves*: To protect against cuts when working with cutting tools, special gloves have been developed. These gloves are made of high-strength materials that are difficult to cut, such as duralumin or specialized synthetic fibers.
4. *Software and hardware*: Modern enterprises use software to optimize the cutting process. Such software can analyze the shape and size of the parts to be cut and calculate the most efficient way to position them on the fabric to minimize waste and reduce tool-to-fabric contact time.
5. *Innovative schemes:* In the area of safety and efficiency, a combination of developments in the form of cameras, sensors, microcontrollers, and software to create systems that automatically adjust and adapt to changing production conditions. This approach is especially important when applying the so-called artificial intelligence, which is already being implemented in similar tasks in a different direction.

Summarizing the above, we can conclude that the greatest danger to a garment worker is the technology of cutting materials on belt machines. Examples of such machines are shown in the figure 1.

Figure 1. Belt type cutting machines

Figure 2. Chainmail glove

The real situation at the enterprises of the garment industry indicates the widespread use of traditional mechanical cutting tools, which increases the possibility of injury to the employee. Therefore, the authors set out to develop modern intelligent safety equipment for cutting equipment. A special chain mail glove, which should be used by a cutter, does not meet the conditions of comfortable use when working with a cutting tool. In fact, it represents technologies that were used several centuries ago. There are many similar safety devices on the market (Fig. 2).

Modern advances in sensors and microelectronics make it possible to create a "smart glove" that would be comfortable and intelligent, i.e., allow you to respond to danger in advance and perform certain additional functions.

Several applications have been proposed.

The main challenge in developing such systems is tracking the distance between the cutting surfaces (blade, cutting edge, vibrating or circular saw, etc.) and the worker's hand [3]. There are several solutions for this:

- tracking the position of the worker's hand with a camera and computer analysis of its distance from dangerous parts;
- using a capacitive sensor between the hand and the cutting edges;
- inductive coupling between a special glove on the operator's hand and the cutting tool.

Each of these methods has its advantages and disadvantages. The use of video analysis is very versatile, without the need for protective equipment, but there is a need to "train" the neural network system for a specific equipment configuration. In addition, it is necessary to provide the working city with high-quality circular lighting without shadows, the use of video cameras with very high resolution, as this will determine the accuracy of measurements of the distance of the operator's hand from dangerous equipment. And of course, for a short system reaction time to dangerous events, the processing speed must be very high, using hardware to form an analyzing neural network [4] based on, for example, programmable logic matrices, since the software implementation will have much greater inertia. The cost of such a system would be very high, which would not justify its use in mass production.

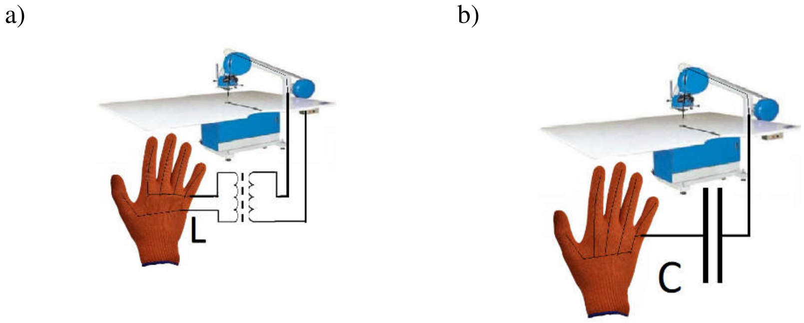

Figure 3. Proposed schemes for the implementation of capacitive and inductive communication

The use of capacitive or inductive communication looks much simpler. These methods require a high-frequency signal from a generator (10^5-10^6 Hz) with an amplitude of several tens of volts to be applied to the metal cutting edge. To form a capacitive connection (Fig.3a), the worker's protective glove must be woven with threads that conduct electric current (metal or preferably carbon). In this case, the cutting edge acts as one of the covers of the sensor capacitor, and the mesh of threads in the glove acts as the other. The amplitude of the voltage (which will be proportional to the distance) can be easily detected by a conventional diode amplitude detector and further processed on a single-chip microcontroller, with a variable frequency warning sound signal output. The amplitude and frequency of the signal should increase with decreasing distance between the cutting tool and the operator's hand.

In the case of inductive communication (Fig.3b), only the glove changes, in which the electrically conductive threads should form the coils of the sensor coil. The signal is then processed as in the case of the capacitive sensor described above. If there is a lot of electromagnetic interference in the shop (created by lighting devices, electric motors of sewing and cutting equipment), it is better to use a synchronous detector instead of a conventional diode amplitude detector, which operates at the excitation frequency with phase accuracy and can detect a useful signal against the background of interference whose amplitude is 1000 times higher than the measured one [3].

The closer the fingers are to the moving tape, the more powerful the generator's sound signal will be (in both proposed implementation schemes). Next, the output signal needs to be digitized for further transmission over the selected communication channel. This operation can be performed by means of a microcontroller, built-in or external ADC [5-6]. The signal level from the ADC is normalized and calibrated by the distance to the tool by software. Due to the fact that there is a lot of sound noise from various working tools in the workshop, the alarm signal will not be heard. Therefore, an indication signal can be realized via the 'blue tooth' channel of communication[3], which is quite simple to implement in the case of microcontroller control of the circuit as a whole.

3. Conclusions

The use of innovative technologies in the light industry allows not only to improve the quality and efficiency of operations, but also to promote employee safety during certain operations. This is especially important when it comes to cutting material. The use of innovative methods, such as a smart glove, helps to avoid cases of employee injury, as well as add certain functions for monitoring cutting parameters.

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