DESIGN OF A CONTEMPORARY MEASURING SYSTEM FOR READING THE TREAD'S TENSION IN A NEEDLE

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Abstract: *In the sewing industry, one of the main quality criteria is the quality of the seam. The criterion for qualitative stitching is the interweaving of the threads (top and bottom) to take place in the middle of the materials being processed. One of the main factors that determines the way in which threads are intertwined is the tension of the upper thread. In modern sewing companies, the maximum tensile strength of the upper thread is manually adjusted by a disc brake. The adjustment is based on the experience and flair of the machine operator or technologist. This creates conditions for the influence of the subjective factor on the quality and productivity of sewing. Therefore, the purpose of the present work is to create a computer-integrated measuring system for determining the thread's tension in a needle which meets contemporary requirements for speed, ability to process information flows, communication and mobile applicability. In addition, it is proposed to use a specialized servomotor to run the machine. This creates conditions to study and analyze the relationships between speed, acceleration, torque of the machine mechanism and the thread's tension in a needle.*

Keywords: *the tread's tension in a needle, contemporary measuring system*

1 INTRODUCTION

Quality assurance and quality control is a complex area of the apparel industry. Quality assurance is not quality control, but quality control is an aspect of quality assurance. Quality assurance builds quality into each step of the manufacturing process [1]. Therefore, it is especially important to study the influence of the quality of stitching on the quality of the sewing product [2]. From the literature review it can be concluded that this issue has not been sufficiently investigated. One of the main factors influencing the quality of the stitching is the tread's tension in a needle.

In modern sewing companies, the maximum tensile strength of the upper thread is manually adjusted by a disc brake. The adjustment is based on the experience and flair of the machine operator or technologist. This creates conditions for influence on the quality and productivity of sewing by the subjective factor. Therefore, it is necessary to carry out many preliminary studies to define the nature and magnitude of the tensile strength [3] of the upper thread at specific technological parameters (composition and structure of the textile material, number of treated layers, type of stitch formation, etc.). In this regard, studies have been conducted on monitoring and control of industrial sewing machines research on thread tension behavior in lockstitch machines [4]. Research has also been done on the determination of the sewing thread friction coefficient [5].

The power tension of the upper thread is calculated by complex physical laws, as the sum of:

- the tensile forces of the thread to the disc brake;
- the tension of the thread from the disc brake;
- stretching the thread from the brake to the material.

In the light of the foregoing, it is necessary to investigate this tension with specialized equipment which takes into account the total tensile strength of the upper thread. This in turn necessitates the creation of a modern, fast-acting computer-integrated measuring system for measuring the total tensile force of the upper thread of a sewing machine.

The literature overview reveals that attempts to create systems for automatic process control have been made [6]. The automatic process control ensures that a certain degree of tension (preset) of the upper thread is maintained continuously. This makes it possible to avoid the influence of the subjective factor during the stitch formation process. The problem originates from the fact that the intensive development of electronics and information technology has outpaced the development of technologies in the sewing industry. That is, systems for automatic maintaining the tensile strength of the needle thread have been created [6], but they work with preset required values for that force. The optimal levels of these values need to be established beforehand so that they can be assigned to automatic control systems [7-9]. However, research in this area has not been comprehensive enough yet.

It is necessary to determine the optimum tensile strength values for different working conditions and different textile materials in advance. This is precisely the task that sewing technology professionals are facing. Therefore, it is of importance to carry out a number of investigations and analyses to determine the optimum values of the upper thread tension when sewing different textile materials (TM), different number of layers and types of seams. In this one can determine the values to be set in the automatic control of the process. In this sense, it is particularly important to look for a method for measuring the total tread's tension in a needle under different technological conditions. Globally, many elite companies have conducted research in this area, but their studies are commercial or confidential. Different types of thread voltage sensors are proposed in [10]. There is no proposal for a measuring system for determining the tread's tension in a needle. In [11], a computer-integrated measurement system has been proposed that has the following characteristics: high level of interactivity; universality and modularity; polymorphism and inheritance; communication; industrial applicability. At the time of its creation, the system proposed in [11] met the real needs of the sewing industry. The rapid development of electronic equipment and computer technology, however, determine the insufficient communication of this system [11] at the present stage. The global development of industrial technologies today defines the need for faster action, greater ability to process information flows and mobile applicability [8, 9, 12].

2 DISCUSSION AND ANALYSIS

The purpose of the present work is to create a computer-integrated measuring system for determining the thread's tension in a needle which meets the contemporary requirements for speed, ability to process information flows, communication and mobile applicability.

2.1 Conditions to execute the experiment - requirements for the measurement system

In formulating the conditions and methods for studies the thread's tension in a needle, the principles of the morphological method for the analysis and synthesis of methods are applied [13]. An analysis of the technological features of stitch formation shows that it is necessary to study and analyze the relationships between speed, acceleration, torque of the mechanism of the machine and the thread's tension in a needle. It is particularly important that the measurement is synchronized with the rotation of the main shaft. In addition, the principle of measurement with the measuring system must make it possible to carry out studies concerning all types of stitches, all types of processed textile materials and all types of thread used.

2.2 Results

In light of the above, this work proposes the use of a specialized servomotor to run the machine. The functional diagram of the servomotor is given in Figure 1. This creates conditions to study and analyze the relationships between speed, acceleration, torque of the machine mechanism and the thread's tension in a needle.

Figure 1 Functional diagram of a servomotor

The block diagram of the servo control for speed and position control is given in Figure 2. The application of the servo control allows to establish the effective operating modes (values of the thread's tension in a needle for certain speed and acceleration of the machine mechanism at a given needle number, type of thread and the processed textile materials (TM), number of layers of TM, type of the stitch line, etc.).

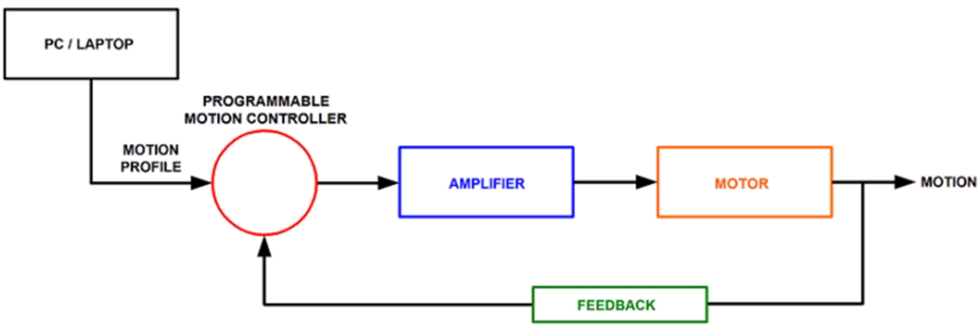

Figure 2 Structural diagram of servo control for speed and position control

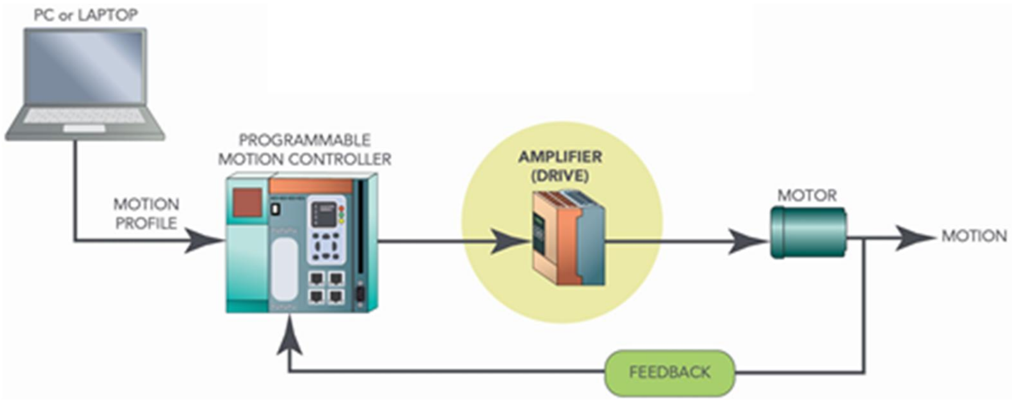

Figure 3 Functional scheme of servo control for speed and position control of mechanisms

Figure 3 shows a functional scheme of a computer-integrated information-measuring system for determining the tensile strength of a needle thread.

The system shown in Figure 3 includes the following modules: personal computer, PLC of Siemens, capacitive sensor Rothschild, module to convert the signal from the capacitive sensor Universal Transducer Interface (UTI), inductive position sensor Servo Motor Incremental Encoder, Servo Motor with Servo Control ELAS DA2.

The system configuration created has the following distinctive features:

- Modern high level of interactivity provided by industrial software TIA Portal and ET 200SP.
- TIA Portal of Siemens is a fully integrated automation portal. This is a software package that makes process automation more efficient.
  Here, many of the basic features are readily available in one software package. The TIA portal includes the following features: networks configuration, drives and I/O stations, PLC programming, programming of security applications, migration of STEP7 projects, design of HMI panels, simulations, data management and online diagnostics.
- SIMATIC ET 200SP has a compact design that saves up to 50% of the space required compared to older Siemens controllers.
- The interaction of the ET 200SP with other components allows to reduce the commissioning time by about 20%.

In general, the system is characterized by contemporary communication and industrial applicability. Communicativeness enables the inclusion of additional measuring and control modules and sensors. Profinet DP provides system development in a vertical and horizontal hierarchy. Industrial applicability is a characteristic that is necessary for the application of the research and methods obtained from the result of scientific work in engineering practice.

The elements that make up the computer-integrated system for measuring the thread's tension in a needle are given in Figure 4.

Figure 4 Method of measurement with the selected sensor

The modules of the proposed system have the following characteristics:

- Sensor (position 1) – Model 100P D72186 AMPHEHOL, produced by "Rotchild" Zurich, Switzerland [9]. The converter is a capacitive type selected with non-rotating guides.
- Converter UTI Smartec (position 2). It provides interaction for many types of sensor elements, in this case capacitors. It has a resolution and linearity of up to 14 bits and the calibration is automatic. The output signal is compatible with the inputs of the microcontrollers.
- Incremental sensor for position feedback (position 3) - RTC70S8. The maximum number of impulses generated per revolution reaches 6000 ppr. A highly reliable photoelectric device guarantees long life, high noise resistance and a wide temperature range.
- Programmable logic controller SIMATICS7 (position 4) -ET200Sp /SIEMENS/.
- PC with environment TIA - Portal installed (position 5).

The choice of the processor and the controller type is related to the tasks that are to be solved, as well as to the great number of factors involved in the research process. Optimizing the PLC selection is always associated with a priori resource reinsurance. The principle of measurement of the created measuring system provides possibilities for its universal application in measuring the thread's tension in a needle for different types of sewing machines. The method of measurement with the selected sensor is given in Figure 4. The overall view of the measuring system is given in Figure 5.

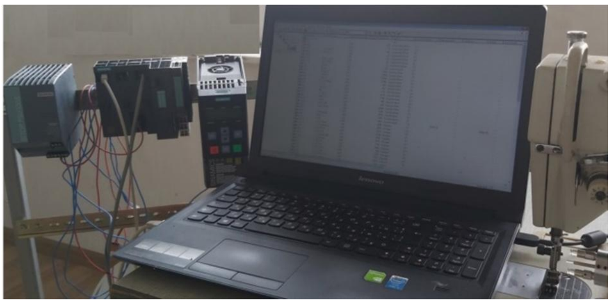

Figure 5 An overall view of the measuring system for reading the tread's tension in a needle

A mechanical force is applied at the sensitive end of the capacitive sensor, resulting in a change in its capacity. In this case, mechanical force is created by the upper thread, which moves in the process of stitch formation. With high-speed sewing machines, the thread moves with great acceleration. It is the measurement system that helps to achieve high accuracy in measurements. The working range is from 0 to 1000 g.

The selected sensor is based on the conversion of mechanical deformations. Mechanical deformations change the dielectric constant of the sensor. Both transformations are linear. The sensor connects to the meter which is a precision measuring bridge. Changing the force in the range from 0 to 1000 g affects the measuring bridge and produces a proportional voltage from 0 to 5 V at its output, which, after conversion, is fed to the computer processing system.

Specific software has been created to perform measurements using the method shown in Figure 6.

The measurement is synchronized with the rotation of the main shaft. The tensile strength of the upper thread when rotating the main shaft from 0 to 360° is determined. The characteristics of the created measurement system allow to measure the values of the effort over a preset time interval up to milliseconds.

Through the Profinet communication interface (Figure 6), the data from the measurements and transformations of the tension of the needle thread are transferred to a database of the computer 5. This allows subsequent processing in Windows environment and Excel tools for research, analysis and mathematical modeling.

3 CONCLUSION

Measuring technological parameters is a challenge for any scientist. All researchers are faced with a difficult choice - to look for hard-to-reach and expensive equipment or to design such equipment themselves. This article offers a modern solution for measuring an important technological parameter in the sewing industry.

A contemporary computer-integrated information-measuring system for measuring the thread's tension in a needle in sewing machines has been created.

The created configuration of the information-measuring system meets the contemporary requirements for speed, ability to process information flows, communication and mobile applicability.

The proposed system creates conditions for research and optimization of the thread's tension in a needle at different technological parameters work and different types of TM in the sewing industry.

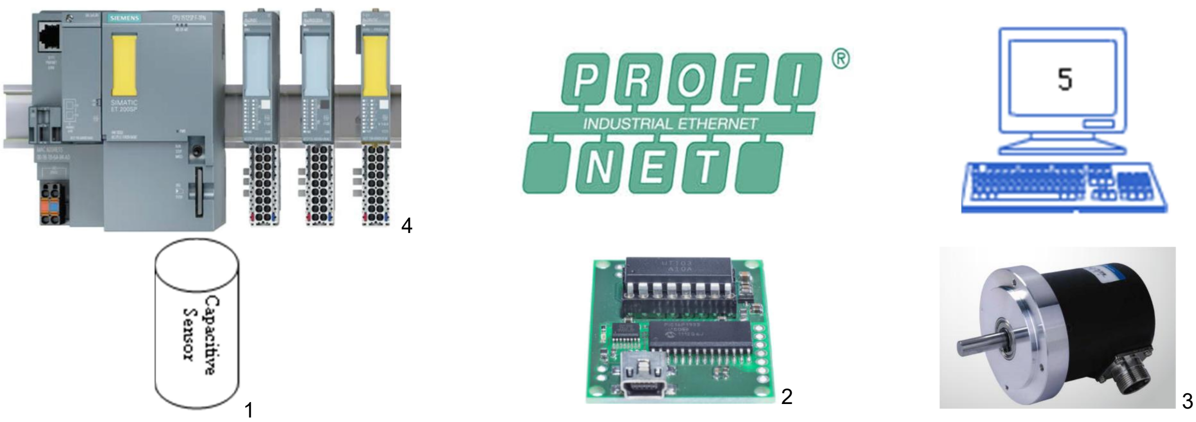

Figure 6 Elements constructing a computer-integrated system for measurement of tread's tension in a needle

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