Improvement of the multifilament wire lager for cable production

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Abstract. The article discusses a possible way to solve the urgent problem of cable production - increasing the efficiency of the technological process by modernizing the control system of technological equipment by developing an intelligent system that allows to improve the reliability of the technology as a whole. The stranding equipment for the implementation of the stranding technology has been chosen as the object of the study, namely, a multifilament wire lager. This equipment is used in the production process of manufacturing cable and wire products, in particular the production of cable semi-finished products – strands. The work done on the modernization of the multifilament wire lager due to the introduction of the intelligent control system has resulted in outputs that provide high flexibility of the technology, which shall meet modern quality requirements of finished cable products.

1 Introduction

In the manufacturing technology of cable and wire products, a special place is occupied by the technological operation - stranding, the quality of which largely determines the operational parameters of the finished cable product [1-3].

An integral structural part of any cable and wire is stranded structural elements: a strand, a cable conductor, a core, which ensure the maintenance of the round shape of the finished cable product [4-5].

The high quality of the technological operation under consideration is determined by the efficiency and accuracy of the technological stranding equipment. Depending on the design of the working unit, the technological stranding equipment is divided into: cage-type, disc, tubular, bow-type (litz twisting) and universal (drum twister) stranding machines. Due to the wide variety of types of machines in the technological process, they carry out both twisting of strands, cable conductors, cable and wire billets from bare (elementary wire) and insulated cores, depending on the cable design [6-8].

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Ensuring the efficiency of the stranding process for an element of the cable product is determined by the parameters of the technology: core diameter, number of stranded cores, type of stranding, stranding diameter, stranding pitch, core cross-section, stranded cross-section of the product, size of the pay-off drums with the core, drawing, compression of the stranded product, pulling force, linear speed, requirements for the stranded billet (back-twist stranding / stranding without back-twist), the required performance for a single operation. At the same time, each type of stranding machine specializes in the manufacture of only one specific structural element of a cable product [9-12]. Taking into account the fact that the stranding operation is performed several times during the manufacture of a nomenclature unit of cable and wire products, then solving the issue of improving the efficiency of the technology under consideration is an urgent task.

Multifilament wire lagers of bow-type are of particular interest to us in the study of stranding technological equipment, on which the production of strands for the cable conductor of cable and wire products is carried out (Figure 1).

The strand (Figure 1) is a cable conductor (3) consisting of a plurality of wires (1) stranded together in coils (2). A distinctive feature of the strands is that they are made of copper non-insulated conductor and have high flexibility, due to their design solution. Quantitatively, the cable conductor contains from several strands up to 20-40 pieces, which ensures high requirements for the mechanical parameters of the cable conductor, since each subsequent turn has an increase in the stranding pitch determined by the design of the finished cable product.

Over the years, many domestic and foreign scientists have been engaged in improving the efficiency of the technology of manufacturing cable and wire products: I.B. Peshkov, L.T. Larin, K.A. Bulkhin, Ya.B. Myasejnik, V.S. Bleikman, O.Sh. Akhmedov. However, all of them have not directly considered the issues of expanding the technological capabilities of the multifilament wire lagers and improving the quality of the manufactured nomenclature product, on which the effectiveness of the entire technology as a whole depends.

The growing requirements to the technological process pose a task to the production service of the cable enterprise, not only to master new types of cable and wire products by commissioning new technological equipment, but also by upgrading existing equipment. One of the possible ways to improve the operation of the multifilament wire lagers installed in the production workshops is the introduction of an automation and control system for both a separate stranding machine and the entire technology as a whole [1, 3, 13-15].
In this regard, the main task of our scientific research is determined - to increase the efficiency of the stranding process by modernizing the control system of the multifilament wire lager, through the development of the intelligent system that allows to increase the reliability of the technology as a whole. This is achieved by the formation of archival memory, which includes storage, quick access and use of the information base of the stranding parameters, taking into account the entire period of operation of the equipment, optimization of decision-making and diagnostics of the electromechanical system of actuators to ensure safety control and maintain a high level of trouble-free operation of the investigated stranding equipment [3, 16].

2 Materials and methods

As an object of research, the BM 630D multifilament wire lager has been determined (manufacturer - SAMP, Italy (Table-1) [2].

The structure of the generalized stranding machine (Figure 2) includes: a pay-off (1), a working unit (2), a pull-off device (3), a receiver (4). At the same time, each unit, along with its functional load, performs the main (general technical) and production task: ensuring continuous feeding of billets for their subsequent stranding into the strand with the maintenance of a given parameter of their tension to the working angle (for the pay-off), also the constancy of the angular speed (for the working unit), stability and constancy of the linear speed and pulling force (for the receiver). All the listed operating parameters of the machine are synchronized with the receiving speed of the pull-off device, and are unchanged for the construction length of the finished product [2].

**Table 1.** Technical parameters of the BM 630D bow-type stranding machine (manufacturer – “SAMP”, Italy) [2].

<table>
<thead>
<tr>
<th>External view</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Spool, mm</td>
<td>400-630</td>
</tr>
<tr>
<td></td>
<td>Width, mm</td>
<td>290-475</td>
</tr>
<tr>
<td></td>
<td>Spool bore, mm</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>Spool weight, max, kg</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Max. core diameter, mm</td>
<td>10-178</td>
</tr>
<tr>
<td></td>
<td>Material diameter, mm</td>
<td>0.10-0.70</td>
</tr>
<tr>
<td></td>
<td>Stranding pitch, mm</td>
<td>5.96-62.98</td>
</tr>
<tr>
<td></td>
<td>RPM, max.</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td>Linear speed, m/min</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Type of stranding</td>
<td>bunched</td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>copper</td>
</tr>
<tr>
<td></td>
<td>Cross-section of cable conductor, mm²</td>
<td>from 0.1 to 6</td>
</tr>
</tbody>
</table>

![Fig. 2. Scheme of a generalized stranding machine.](image-url)
In turn, the manufactured strand shall meet the quality requirements of GOST 22483-77. The rejected product is considered to be a cable conductor (CC), which has the following (Table 2) deviations in quality and the presence of shortcomings.

**Table 2.** Types of defects and deviations in the cable conductor quality.

<table>
<thead>
<tr>
<th>Type of defect</th>
<th>Cause of occurrence</th>
<th>Method of elimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>The core or billet is stranded from inappropriate</td>
<td>Stranding machine has been filled incorrectly</td>
<td>To check the diameters of the cores when filling the stranding machine.</td>
</tr>
<tr>
<td>core diameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The stranding pitch does not correspond to the</td>
<td>The stranding pitch is set incorrectly</td>
<td>To set the stranding pitch according to the sketch map by means of gears.</td>
</tr>
<tr>
<td>sketch map</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical damage to the core</td>
<td>The eyelets of the distribution outlet and the die are damaged.</td>
<td>To replace faulty bushings, eyelets, die. To replace the take-up drum. To top up the</td>
</tr>
<tr>
<td></td>
<td>The take-up drum with bent bobbin flanges. The lubrication in the lubrication device</td>
<td>lubricant.</td>
</tr>
<tr>
<td></td>
<td>has run out.</td>
<td></td>
</tr>
<tr>
<td>Core breakage</td>
<td>The traverse on the pay-off drums is littered.</td>
<td>To replace the drum with a bad winding. To adjust the brakes.</td>
</tr>
<tr>
<td>Separate wires stick out on a stranded core.</td>
<td>The stranding pitch is incorrectly selected. The brakes on the pay-off are not</td>
<td>To set the stranding pitch according to the sketch map. To adjust the brakes on the</td>
</tr>
<tr>
<td></td>
<td>configured.</td>
<td>pay-off.</td>
</tr>
</tbody>
</table>

A comparative analysis of the stranding machines for various purposes has shown that double-stranding bow-type machines (maximum linear speed up to 180 m/min) differ the most in performance, followed by single-stranding bow-type machines. Moreover, with one turn of the stranding frame in the double-stranding machines, a two-pitch stranding occurs in the double-stranding machines, and with a single-stranding - one pitch - this explains the high productivity of more than 2 times of these machines, in relation to single-stranding machines.

**3 Results and Discussion**

In addition to the above, the high efficiency of the multifilament wire lager is largely determined by the setting of a given stranding pitch, which depends on many factors:
- The correctness of the choice and the change in the number of turns of the frame of the working unit (Figure 3) relative to the linear speed of the product, which is achieved by the accuracy and correctness of the selection of the gear ratio of the kinematic pair – interchangeable gears.
- Efficient operation of the equipment installed on the stranding machine: pulse counter, frequency converter, etc.

![Fig. 3. The scheme of the multifilament wire lager: 1 – pay-off; 2 - working unit (cradle); 3 - pull-off device; 4 – receiver.](https://example.com)
The solution of the task by developing a special control system (CS) shall ensure, under conditions of high dynamism of the stranding process with sudden changes in workloads, rigid maintenance of the specified technological parameters, reliability of the electric drive (ED) and electromechanical system (EMS), stop accuracy and positioning working unit (cradle) of the multifilament wire lager. The effectiveness of CS integration largely depends on the correct choice of software and hardware: an actuating device (AD), controllers (C), microprocessors (MP), emergency system (ES). At the same time, the AD is assigned the function of converting electrical energy (EE) into mechanical energy (ME), which is necessary for applying external influences with a working EMS and ED, according to the developed control algorithm. In turn, C and MP provide the solution and execution of logical tasks for the entire CS of the multifilament wire lager as a whole [3-8].

The development of the control algorithm and its functionality shall also make it possible to increase the speed of data processing on the input signal and the clarity of setting the control actions on the AD when executing the “Start" (Fig. 4) and “Stop" (Figure 5) Subprograms of the stranding technology. In this case, the commands "Start", "Stop", "Error" are set by the input signal, and the commands "Start", "Stop" are set by the output signal. Block diagrams of the algorithms of the CS subprograms for the modernized multifilament wire lager are shown in Figures 4 and 5.

The electromechanical system of a standard multifilament wire lager includes (Figure 6):

- A pay-off, which has a free running of coils for recoil of copper elementary wires into the stranding.
- Socket, which is an intermediate link between the pay-off and the working unit (cradle), providing the distribution of elementary wires (MM, MT) for laying through the frame in a layer and subsequent stranding of the strands.
- The ED of the working unit, which contains the motors of the stranding frame, the pull-off device and the receiver.

![Fig. 4. Block diagram of the algorithm of the Drive Start Subprogram - "Drive Start".](image-url)
Fig. 5. Block diagram of the algorithm of the ED stop subprogram - "ED Stop".

Fig. 6. Functional diagram: $D_1$ – motor of the stranding frame; $D_2$ – pull-off device; $D_3$ – receiver motor; $D_d$ – weight sensor; $D_n$ – tension sensor; $D_s$ – speed sensor.

The development of the structural scheme of the CS of the modernized multifilament wire lager has been carried out in accordance with the task [17]. As a result, the control structure has been adopted (Figure 7), which has a hierarchy that includes several control sublevels: upper, middle and lower.

Fig. 7. Block diagram of the control system of the upgraded multifilament wire lager.
The lower level has a base consisting of a set of sensors: weight (control of the filling level of the pay-off coils); tension (control of the tension of the elementary wire, as well as the finished semi–finished product - the strand), speed (control of the operation of the motors).

The middle level includes the control of the stranding process, consisting of a control network.

The upper control level is the main one in the developed control system, performing information and computing operations, including a database server, an information archive, and a control device.

The compiled block diagram of the CS of the multifilament wire lager allows to develop a system of forms for entering the necessary data both for a given technology and for the operation of technological equipment - the stranding machine. The effectiveness of the technology is determined by the level of development of the intelligent control system of the multifilament wire lager and the correctness of the choice of technology and equipment parameters, which consist of the following parameters: technical, coil, products, receiver settings, machine settings, etc.

All of the above data is entered into the system manually, according to the production order from the "Data Menu" panel, which is the main screen form (Figure 8).

![Block diagram of the control system of the upgraded multifilament wire lager.](image)

**Fig. 8.** Block diagram of the control system of the upgraded multifilament wire lager.

### 4 Conclusion

The developed CS made it possible to improve the operation of the multifilament wire lager, expanding the technological capabilities and improving the quality of the finished cable semi–finished product - the strand. At the same time, not only satisfaction of the requirements for the automation system has been achieved, but also high flexibility of the technology, which has created favorable conditions for improving the ACS (automatic control system) in accordance with the growing requirements for the quality of cable production technology, which are changing in accordance with the existing operational requirements of cable and wire products.
References

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