Ensuring the reliability of the technological equipment of the cable company through the use of renewable energy sources

V.V. Tsypkina[1] *, V.P. Ivanova[1]

[1]Tashkent State Technical University named after I. Karimov, Tashkent, Uzbekista

Abstract. To date, a "green" transformation of the industry is being carried out in the global energy sector, which will inevitably affect the decline in the level of consumption of natural energy resources, as well as the accompanying high financial and technological risks. The article discusses the issues of accelerating the possible energy transfer, in relation to enterprises producing cable and wire products. The analysis of possible methods and technologies that are aimed at making the transition and increasing the energy efficiency of cable machines is carried out. Improving the efficiency of technological processes will increase the profitability of the cable industry, as well as obtain significant savings in electrical energy. The solution of the task is focused on the use of an additional unit included in the electromechanical system of technological equipment having increased alternating loads (runout). The theoretical possibility of carrying out the improvement of cable machines has been studied by developing a mathematical model describing the physics of the process that ensures the energy efficiency of the proposed method. It is noted that the application of the considered method is possible not only for cable units and machines, but also for technological equipment with a certain shock load.

Introduction

The "green" economy is essentially a new trend, which until recently was a fashionable trend in the economic policy of any developed state. It should be noted that recently this direction has formed the basis of measures for the global green transformation of the economies of states whose policies are focused on the growth of welfare and social equality, while significantly reducing natural (environmental) risks and environmental deficits [1]. In the near future, the "green" economy will become an integral part of many industries and services.

The use of "green" technologies in the industrial sector is usually focused on increasing the energy and resource efficiency of the production process, which is inextricably connected with changes in energy and transport infrastructures operating on a low-carbon basis. The use of renewable energy sources in industry will eventually lead to a "green" transformation of the entire industrial sector, which will inevitably affect the decline in the level of consumption of natural energy resources, as well as the reduction of concomitant high financial and technological risks.

The orientation of "green" technology to individual elements of the economy with structural adjustment will eventually lead to a way out of the current environmental crisis in the world. Therefore, industrial enterprises shall play a leading role in solving the current environmental situation by introducing "green" technologies into the production process, given that in developed countries businesses own copyrights to most "green" technologies [2].

One of the ways to introduce "green" technologies is the "ecological modernization" of the production infrastructure. However, it is impossible to solve this problem at the global level, which means that it is necessary to consider a point orientation to separate technological equipment. The work on the modernization of the working mechanisms of production machines in the long term implies a complete restructuring of all production technological chains and the creation of a "green" transformation of the enterprise. Thus, this direction is relevant for every country, for every region and for every company.

Given the existing interconnections to the decarbonization process, the economy of any state is not ready for the introduction of clean energy, because the percentage of its production is not high enough, while the share of electricity worldwide in the structure of production costs will grow to 20-30% [3]. For instance, the forecast for the production of steel by electrometallurgy in the period 2050-2070 is 50-70%, the rest relates to the hydrogen method and electrolysis production. At the same time, the cost of electricity for the production of one ton of steel will be 3.5-4 times higher than at present. This suggests that the economies of the states will not be ready for this growth.

Currently, there is an active integration of environmental factors with the management strategy of companies in the world. Some large manufacturers, for example BMW (Germany), when concluding contracts with steel suppliers for volumes of more than €20 million tons per year, focus only on the purchase of "green" steel [3]. The introduction of "green" technologies into other industries is becoming a stable trend, which is accompanied by the use of both

*Corresponding author: veronika.tsipkina@yandex.com

fundamentally new approaches and modernization of technological equipment installed at enterprises in order to increase the unit capacity of the main equipment.

The "green" transformation of the cable industry is also of great importance, because the technological process of cable and wire products manufacture includes a large number of energy-consuming technological equipment: melting, drawing, extrusion and stranding equipment, the work of which shall be focused on improving the reliability of its operation and reducing the cost of finished products through the introduction of innovative technologies.

Methods and technologies to improve the reliability of cable equipment.

The conducted research of the Association "Electrocable" (Moscow) shows that the cable industry is currently in a stage of intensive growth [4], which is ensured by the introduction of innovative scientific developments that have found their application both in the process and in the development of new designs of cable and wire products using modern materials. All these aspects have allowed the industry to maintain a high technological level. At the same time, most cable companies have technological equipment, the average service life of which lies in the range from 5 to 20 years. The program of technical re-equipment of the enterprise is carried out as part of the development of new types of products and is implemented through the purchase of modern technological lines. In relation to the established technological park of cable machines, due to the impossibility of its abrupt renewal, measures are being taken to modernize them by improving the design of equipment and technology operating at the enterprise [5, 6, 7, 8, 9].

One of the possible ways to solve the problem of modernization of technological equipment is the introduction of alternative energy sources, i.e. the "energy transition" from the existing system to the innovative one due to renewable energy sources (RES), which is based on the creation of a flexible energy system of both a cable enterprise and a cable machine by organizing "smart networks" that allow optimizing electricity consumption and to increase the efficiency of RES application in the manufacturing technology of cable and wire products [9].

Wires and cables are always in great demand in the economy of any state. At the same time, the traditional manufacturing technology is based on the use of copper, less often aluminum conductors, which make up the cable nomenclature of various purposes. Engineering and technical services are constantly working to improve both the operational characteristics of cable products, as well as strength, flexibility, mass, corrosion and chemical resistance, fire resistance, electromagnetic compatibility, etc. [10].

The technology of manufacturing cable products is based on standard technological operations, which are usually performed on cable machines with high energy intensity. Therefore, the issue of improving the efficiency of equipment is the main task, the solution of which will create great opportunities to improve the energy efficiency of technology and reduce the cost of finished products. The introduction of alternative energy sources will improve the reliability of the equipment and will contribute to reducing energy consumption and cost of finished cable products.

The results obtained

Scientific research in the field of using alternative energy sources at cable enterprises was carried out on technological machines with an increased level of vibration and shock load, namely:

- stranding equipment – general stranding machines, braiding machines, armoring machines, "Drum twister" stranding machine, rigid stranding machine, cable armoring line, cable screening line;
- rewinding equipment;
- cable production waste recycling lines;
- hydraulic presses for cable aluminum sheathing.

As an object of research, the type of general stranding machines was determined, which strand both the current-conducting conductors and the workpiece of cables and wires from insulated cores (Fig.1).

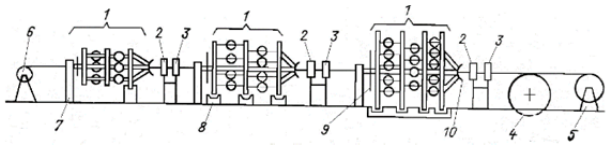

Fig. 1. General stranding machine:
1 — carriage – stranding pay-off; 2 — calibers; 3 - sealing rollers; 4— pull-off device; 5 — take-up device; 6 —fixed pay-off device; 7 — support stand; 8 — support roller; 9 — unscrewing device; 10 — distribution socket

The composition of the working part of the stranding machine (Fig.1) contains units that have a certain technological load and provide quality parameters of the finished product, namely:

Carriage …..…….. 4 pcs.
Wheel-type pull-off device……...……..1 pc.
Take-up device ……..……...1 pc.

The choice of the stranding machine loading option is made depending on the production task, i.e. the type of core strand (insulated, bare) of the cable product order, taking into account technological factors:

- number of core strand;
- core cross-section;
- dimensions of the pay-off drums with a core;
- requirements for the strand workpiece (back-twist stranding / stranding without back-twist);
- required performance of this operation.

At the same time, for machines of this type, the energy consumption level is taken in the power range

(Table 1) according to the equipment passport, and the actual power consumption depends on the multitasking of the equipment, i.e. the use of additional options in the technology: a taping head, a scroll, etc.

Table 1. Power consumption of the stranding machine

Working unit	Quantity, pcs.	Full maximum power, kW	Actual power consumption, kW
Carriage	4	300	250
Take-up device	1	15	10
Wheel-type pull-off device	1	110	100
Total:		**425**	**360**

It should be noted that the discrepancy in the values of the full maximum power and the actual power consumption of the upgraded cable machine directly depends on the volume of work and the level of equipment load. According to the equipment passport, the range of the initial loaded wire in the carriage is for the wire diameter in the range of Ø 35-300 mm^2. Depending on the design of the cable product, the carriages of the stranding machine are loaded with coils with wire, and depending on the number of wires in the layer of the workpiece (conductive core), the amount of load and the number of unused working carriages are determined. Thus, the power consumption of the stranding machine has a maximum value at full load of all working carriages with a wire diameter of Ø 300 mm^2 and a minimum value at Ø 35 mm^2, as well as not fully loaded carriages (to 80%, 60%, 40%, 20%, 0%). Therefore, when calculating power consumption, the average load of technological equipment is taken, taking into account the carriages that are not involved.

The improvement of the operation of the stranding machine (Fig.2) by installing additional units with alternative energy sources will create conditions that allow accumulating additional energy with its return to the power system of technological equipment. Thus, to ensure an increase in the level of reliability of the equipment both in the event of a power outage in the workshop, and the return of stored energy from the batteries to the electromechanical system, which will increase the energy efficiency of the upgraded cable equipment.

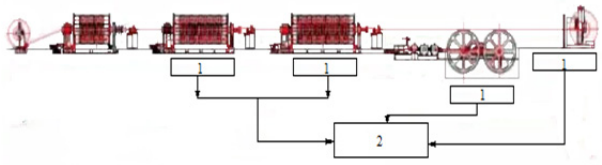

Fig. 2. Block diagram of an improved stranding machine: 1 - unit with alternative energy sources, 2 – accumulating battery

The presented functional diagram of the improved stranding machine (Fig. 2) explains the experimental part of the scientific research conducted at the Departments of "Electromechanics, Electrical Technology" and "Electric Machines" of TASHSTU (Tashkent, Uzbekistan) and JV LLC "HPS" (Navoi, Uzbekistan). According to the results obtained, an application for a patent of the Republic of Uzbekistan for a utility model has been filed. The solution of the research task is focused on the use of an additional unit included in the electromechanical system of technological equipment – a stranding machine with increased alternating loads (runout).

As a result of the research work carried out, the theoretical possibility of improving cable machines was studied by developing a mathematical model that describes the physics of the stranding process of the workpiece of a cable product (conductive core, core).

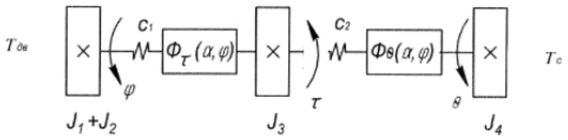

Fig. 3. Dynamic model of a stranding machine

The equation of motion of the stranding mechanism was compiled by developing a dynamic three–mass model (Fig. 3), where J_1+J_2 are the moments of inertia of the first carriage; φ is the generalized coordinate of the first carriage, J_3 and J_4 are the moments of inertia of subsequent carriages; τ and θ are redundant generalized coordinates of subsequent carriages. The results of solving the mathematical model are shown in Fig. 4.

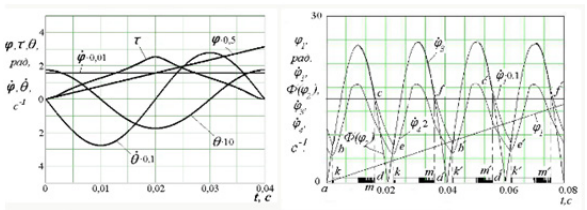

Fig. 4. Results of solving mathematical models

The verification of the adequacy of the mathematical model of the improved stranding machine was based on the comparison of the results of experimental studies with a working cycle that meets the requirements of technology and regulatory documentation for cable equipment operating at the JV LLC "HPS" (Navoi, Uzbekistan).

Conclusion

The research work carried out to improve the energy efficiency of the stranding machine by upgrading it by installing working mechanisms in the electromechanical system: carriages, pull-off and take-up devices, additional units assembled on the basis of alternative energy sources allowed to draw the following conclusions:

The results of the experimental part are shown in Table 2.

Table 2. Stranding machine modernization results

Working unit	Quantity, pcs.	Energy efficiency	
		kW	%
Carriage	4	0,83-1	2,5-3
Take-up device	1	5,33	0,8
Wheel-type pull-off device	1	1,36	1,5
Total		**7,52-7,69**	

1. The introduction of an additional unit into the electromechanical system of the stranding equipment made it possible to ensure the reliability (in 1,5 times) of the technological equipment of the cable enterprise through the use of renewable energy sources.

2. The application of the considered method is possible not only for cable units and machines, but also for technological equipment with a certain shock load.

References

1. Towards a "green" economy: ways to sustainable development and poverty eradication. UNEP report, 2011. p.17.
2. World Economic and Social Survey 2011. The Great Green Technological Transformation. UN Department of Economic and Social Affairs. New York, 2011. P. IX.
3. S. Zinchenko. New challenges of green transformation. https://gmk.center/opinion/novye-vyzovy-zelenoj-transformacii/
4. M.V. Tretyakov, 79th GENERAL MEETING OF THE PARTICIPANTS OF THE ASSOCIATION "ELECTROCABLE", Magazine "Cables and wires", No. 2 (394) 2022.
5. V. Tsypkina, D. Madrakhimov, Method of resource saving of cable production recycables E3S Web Conf., Rudenko International Conference “Methodological problems in reliability study of large energy systems” (RSES 2019), E3S Web of Conferences 139:01058, Follow journal, DOI: 10.1051/e3sconf/201913901058, License CC BY, https://doi.org/10.1051/e3sconf/201913901058
6. V.V. Tsypkina, A. A. Ivanov, Development of generalized requirements for the modernization of the electric drive of cable drawing machines // Universum: Technical sciences. 2017. No.4 (37). URL: https://cyberleninka.ru/article/n/razrabotka-obobschennyh-trebovaniy-k-modernizatsii-elektroprivoda-volochilnyh-mashin-kabelnogo-proizvodstva (Reference date: 31.07.2022).
7. N. Pirmatov, V. Ivanova Improving Energy Efficiency of Drawing Equipment through Energy and Resources Saving, ISSN: 2350-0328International Journal of AdvancedResearch in Science,Engineering and TechnologyVol. 6, Issue 3, March 2019, https://www.researchgate.net/publication/
8. V.P. Ivanova, B.E. Yakubov, Development of an information model of a resource-saving drawing method // Universum: Technical sciences. 2017. No.3 (36). URL: https://cyberleninka.ru/article/n/razrabotka-informatsionnoy-modeli-resursosberegayuschego-sposoba-volocheniya (Reference date: 31.07.2022).
9. I.B. Peshkov, Actual problems of the domestic cable industry, Magazine “Cables and Wires”, No. 5 (391) 2021.
10. Yu. Svetikov, Modern trends in the development of cable production, Magazine “Components and Technologies”, No. 8 '2007. file:///G:/SOFT/sovremennye-tendentsii-razvitiya-kabelnogo-proizvodstva.pdf