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# Increasing the Reliability of Cable Lines by Improving the Technology of Manufacturing Cable Products

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**ABSTRACT:** The article deals with the issues of increasing the reliability of power supply to active consumers by improving the technology of manufacturing cable products. The modern transmission and distribution process for the end consumer is based on the technologies of a new generation of power supply systems for end consumers. The issues of efficiency of cable lines operation, increase of their productivity, throughput and search for failures are considered. Analysis of technical literature, calculations to improve the technology of drawing, as well as the results of mathematical modeling and experimental studies that were carried out at the Department of Electrical Machines of Tashkent State Technical University, made it possible to obtain a good result in improving the electrical conductivity of the current-carrying core.

## I. INTRODUCTION

The increasing need for high-quality and reliable transmission of electrical energy for the end user requires the use of technical developments using new technologies and electrical equipment (electrical appliances), which allow to reach the level of high-tech enterprises and form a class of active consumers oriented towards the new energy-consuming world [1]. At the same time, one of the main places in the process of transmission and distribution of electric energy belongs to modern technologies that are aimed at using new generations of end-user power supply systems [2]. The analysis of functional and technological conditions for the use of advanced technologies and equipment, carried out among active consumers, shows that the use of fundamentally new technical systems makes it possible to provide reliable and safe power supply, and technological achievements of an industrial nature will create conditions for highly efficient transmission of electric energy with minimal losses [2].

## II. LITERATURE REVIEW

Currently, the electric power industry is focused on the use of new types of cabling and wiring products (CWP), designed for various voltage classes, having high throughput and ensuring strict compliance with modern operational requirements due to the specifics of large cities: high density of buildings; reduction of vacant areas within the city; infrastructure development; high requirements for electromagnetic compatibility of high-voltage electrical networks with technosphere installations and communication networks, permissible levels of exposure to electromagnetic fields generated by overhead power lines per person, etc. [3].

In this context, it has to be said that the efficiency of the operation of cable lines (CL) is largely determined by the correct choice of the method and means of searching for fault locations (Fig.1). The expediency of the method is determined primarily by the stage of work. Many are carried out with disconnecting the line, reducing the transient resistance at the fault location and the completion of the transition resistance of the insulation. Analysis of famous works by Heaviside, A. Waters, M. Wilheim, R. Rüdenberg, A.K. Mann, D.R. Carson, K.M. Polivanov, N.I. Grodnev, V.V. Platonov, V.S. Dementiev, A.D. Drozdov, V.F. Bykadorov et al. [5, 6, 7, 8] made it possible to create conditions and the basis for the development of fault detection methods of various physical nature, but the solution to the problem of fast and accurate fault detection in circuits in the CL has not been found.

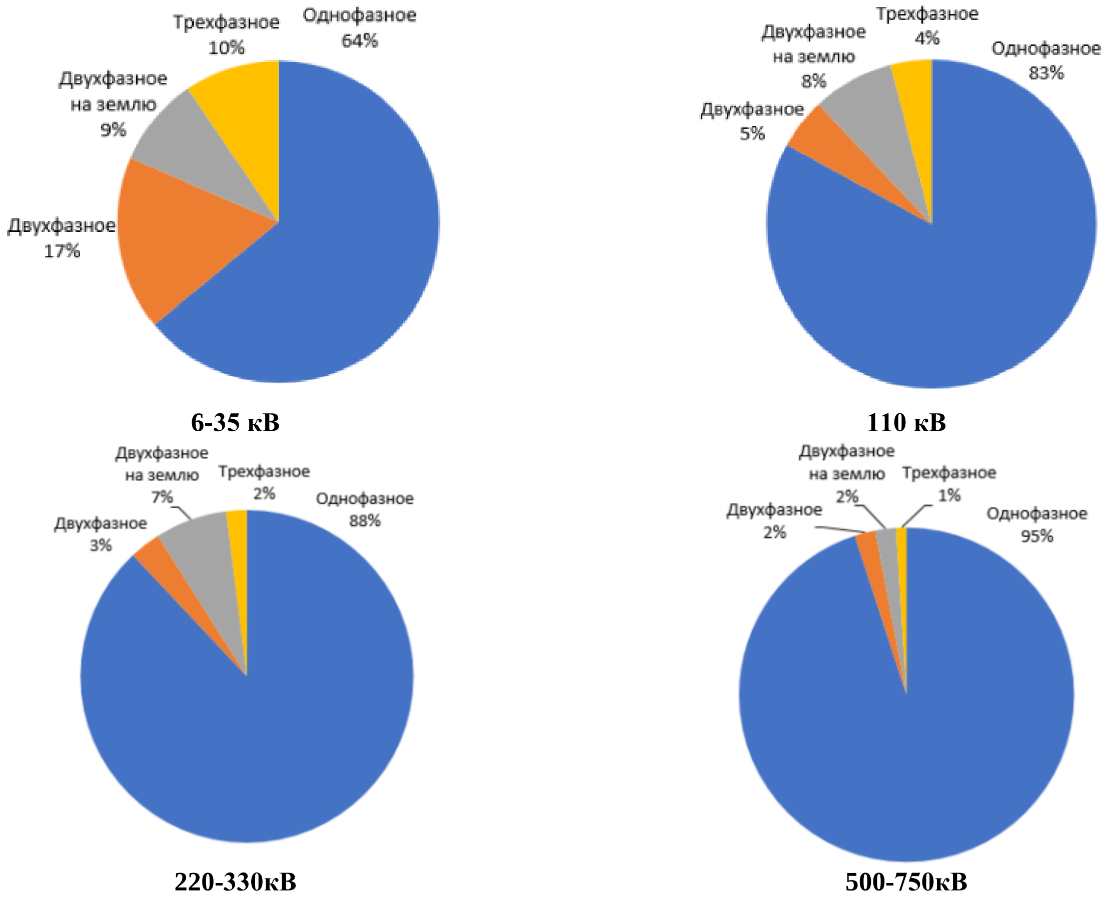


**Fig. 1 Ratios of different types of CL failures**

| | |
|---|---|
| Однофазное | Single-phase |
| Трехфазное | Three-phase |
| Двухфазное на землю | Two-phase to ground |
| Двухфазное | Two-phase |

To date, the search for failures in the CL is carried out as follows:

1. Switching off the CL, in case of fault detection. If the failure is not established, the insulation shall be completed;
2. By means of special devices, the distance to the fault location shall be identified;
3. Identification of fault location on the track. Further, with the help of a very complex technology, repair and restoration work shall be carried out.

## III. MATERIALS AND METHODS.

Currently, many methods are used to search for faults in CL (Fig. 2). The theory of fault tracing is based on the physical processes that occur in the line. Diagnostics of the work is carried out by connecting diagnostic devices.

The increase in the conductivity of CL, taking into account world experience, can be achieved by replacing existing cable products with new, improved designs capable of ensuring operational reliability in combination with high throughput. Based on previous studies [9, 10, 11], thermal insulation modes of power cables determine their working life. Considering the issue of improving the cable design, the most common way is to regulate the permissible operating temperature of

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the conductive core by making changes to the technological process of manufacturing cable products, namely, replacing technological equipment with new ones, introducing new cable designs and structural materials and, accordingly, developing new, advanced technologies with a set of certification measures.

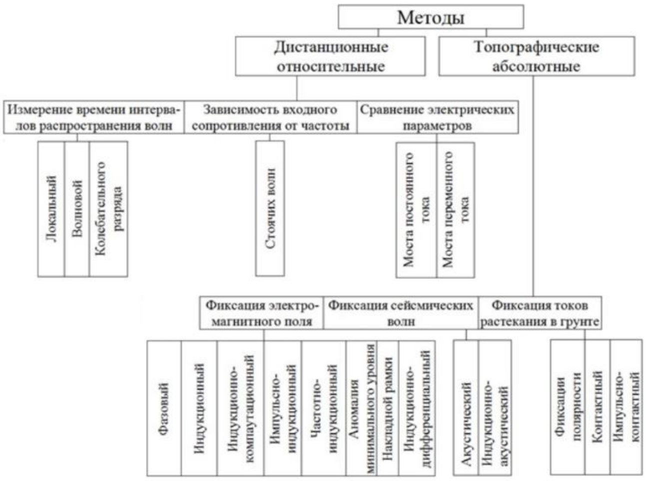


**Fig.2. CL fault tracing methods**

| | |
|---|---|
| Методы | Methods |
| Дистанционные относительные | Remote relative |
| Топографические абсолютные | Topographic absolute |
| Измерение времени интервалов распространения волн | Time measurements of wave propagation intervals |
| Зависимость входного сопротивления от частоты | Dependence of the input resistance on the frequency |
| Сравнение электрических параметров | Comparison of electrical parameters |
| Локальный | Local |
| Волновой | Wave |
| Колебательного разряда | Oscillatory discharge |
| Стоячих волн | Standing waves |
| Моста постоянного тока | DC Bridge |
| Моста переменного тока | AC Bridge |
| Фиксация электромагнитного поля | Electromagnetic field fixation |
| Фиксация сейсмических волн | Seismic wave fixation |
| Фиксация токов растекания в грунте | Fixation of spreading currents in the ground |
| Фазовый | Phase |
| Индукционный | Induction |
| Индукционно-коммутационный | Induction-switching |
| Импульсно-индукционный | Pulse-induction |
| Частотно-индукционный | Frequency-induction |
| Аномалия минимального уровня | Minimum level anomaly |
| Накладной рамки | Overhead frame |
| Индукционно-дифференциальный | Induction-differential |
| Акустический | Acoustic |
| Индукционно-акустический | Induction-acoustic |
| Фиксации полярности | Polarity fixation |
| Контактный | Contact |
| Импульсно-контактный | Pulse-contact |

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All this is very time-consuming and entails long and large financial costs. Considering the fact that cabling and wiring products are one of the most expensive elements of any electric power system, the issue of pricing in its design occupies a special place, being a very important economic aspect of the choice of cable line parameters.

Cable design improvement is a process that requires solving a complex production task related to the development of a new technology, as well as the design of components and cable fittings for subsequent installation and operation.

At the Departments of "Electromechanics and Electrotechnology" and "Electric Machines" of the Tashkent State Technical University, a complex of works has been carried out to develop and introduce an improved drawing method into the production process of cabling and wiring products, which provided an increase in the carrying capacity of the current-carrying part of the cable product by reducing the ohmic resistance of the current conductor [13, 14]. This is achieved by reducing the number of passes along the drawing sequence and reducing the degree of fractional deformation [9, 12]. Compliance with the technology has a great influence on the quality of the drawn wire [9, 12].

The impact of external friction forces, caused by the drawing force ($P_z$) in the deformation center of the technological tool on the contact surfaces, cause additional shear stress and, accordingly, additional shear deformation of the inner layers of the metal due to the influence of cold plastic deformation (Fig.3). This affects the main properties of the drawn product - conductive core: changes in the electrical (increase in ohmic resistance) and mechanical (deterioration of plasticity, increase in stiffness) properties of the substance [9, 12].

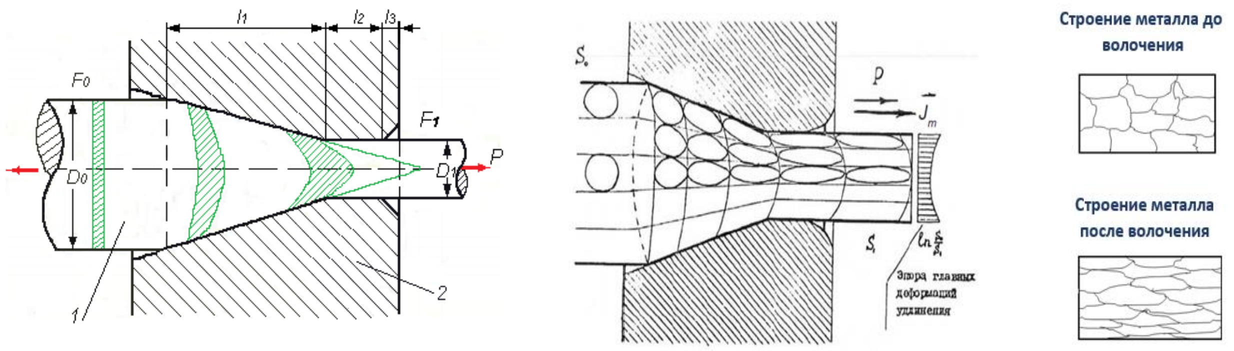


**Fig. 3. Scheme of metal deformation when drawing a solid round profile in a drawing die: where, 1- wire; 2 – drawing die [9, 12].**

| | |
|---|---|
| Строение металла до волочения | Structure of the metal before drawing |
| Строение металла после волочения | Structure of the metal after drawing |
| Опора главных деформаций удлинения | Support of the main elongation deformations |

The presence of drawing forces leads to a change in the microstructure of the drawn wire by compacting it (Fig.3). Thus, as a result of the drawing process, various types of deformations occur in the processed object (conductive core), leading to a proportional change (decrease) in the cross-section of the drawing object and microstructure, which is a negative fact that worsens the property of the drawn metal (change in electrical and mechanical parameters, namely an increase in ohmic resistance and an increase in stiffness. Cold plastic deformation (drawing) in a drawn wire is accompanied by a change in the microstructure of the metal, as a result of which randomly oriented grains before deformation acquire an ordered orientation, tending to be located along the line of action of the applied external force ($P_z$) [9, 12]. According to the technology, in order to restore the necessary electrical and mechanical properties lost as a result of cold plastic deformation, the drawn wire is subjected to heating (annealing) to a certain temperature to restore the equilibrium structure of the metal (restructuring).

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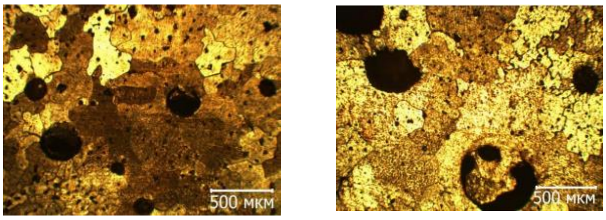


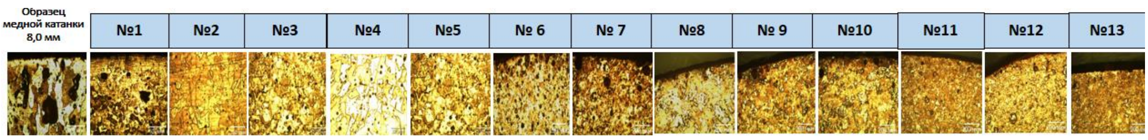

**Fig.4 Microstructure of a prototype copper wire with inclusion, the samples are obtained as a result of an experiment conducted at the FE LLC "NAVOI CABLE CONNECTOR" [9;12].**

An analysis of the technical literature allowed to conclude: with an increase in the total degree of deformation $\varepsilon$ during drawing up to 25-30%, the strength characteristics of copper increase intensively, and the ohmic resistance also increases [9, 8]. Experimental studies of the selected samples at the FE LLC "NAVOI CABLE CONNECTOR" showed (Fig.4) that with a decrease in the diameter of the wire, the ohmic resistance of the sample increases — this is inextricably linked with an increase in the number of passes along the standard drawing sequence, i.e. an increase in the fractional deformation of the grain structure of copper [9, 12, 13,14].

## IV. RESULTS

During the analysis of the work of the straight-through type drawing machine, a recalculation of the drawing sequence has been carried out, and the fractional deformation has been reduced without making changes to the operation of the electromechanical system (EMS) of the technological equipment (Fig.5).

**Passes along the drawing sequence for a circular section before sequence recalculation**




**Passes along the drawing sequence for the shaped section before sequence recalculation**

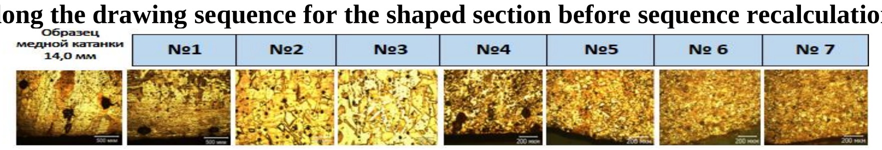



**Fig.5 Comparative result of changes in the microstructure of a conductive core**

| | |
|---|---|
| Образец медной катанки | Sample of copper wire rod |

The conducted scientific studies of the work of the straight-through type drawing machine yielded results: on drawbench (VPC-3-4-550 , VSK-13M, MSM-85) the result has been achieved by improving the quality indicators of copper wire samples by 5% (Fig. 6), aluminum wire and aluminum alloy wire by an average of 2-2,5% due to a reduction in the number of passes (filling of the straight-through type drawbench has been carried out along the drawing sequence calculated according to the proposed methodology). As a result of the conducted research, a decrease in the effect of fractional deformation and, accordingly, an improvement in the microstructure of copper has been obtained. Thus, for straight-through type drawbench with an individual electric drive (ED) for each pulling unit of straight-through type drawing machines, in addition to improving the quality of the resulting wire [9, 12], an energy-economic effect has also been obtained.

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## V. CONCLUSION

The calculated data obtained, supported by the results of an industrial experiment, confirmed the correctness and adequacy of the proposed method of recalculation and optimization of the drawing sequence [9, 12, 13, 14] with justification of shutdown solutions not involved in the proposed drawing sequence for the electric motors of the pulling units of the straight-through type drawing machine (Table-1).

**Comparative analysis of the parameters of the drawing process for the electromechanical system of the drawing machine** [9, 12].

Table-1

| Drawing process parameters | General electric drive for drawing machine | | Individual electric drive for each pulling unit | |
|---|---|---|---|---|
| | Current | Estimated | Current | Estimated |
| **1** | **2** | **3** | **4** | **5** |
| **Number of passes, pcs.** | 10 | 6 | 7 | 5 |
| **Number of electric motors** | 1 | | 7 | 5 |
| **Power consumption, kW** | 252 | | 45 | 33,2 |
| **Material** | Copper | | | |
| **Drawn product** | Round wire | | Round wire | |

Reducing the ohmic resistance of the current-carrying part of the cable will not only increase the capacity of the cable, but also reduce the design cross-section of the core, and reduce the price of the cable line as a whole.

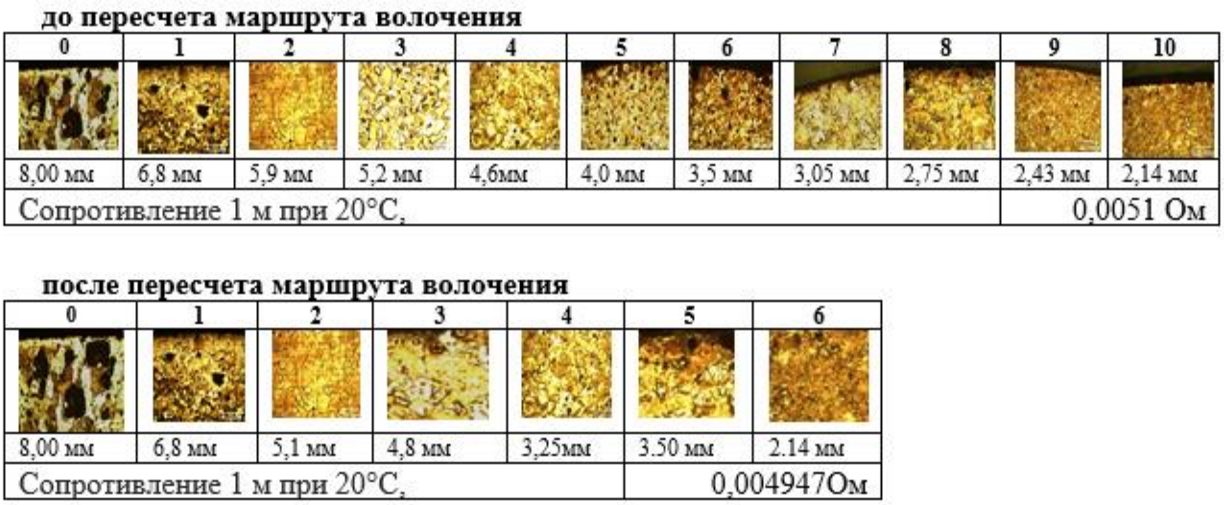


**Fig.6 Comparative result of measuring the ohmic resistance of a conductive core**

| | |
|---|---|
| До пересчета маршрута волочения | Before recalculation the drawing sequence |
| Сопротивление 1 м при 20°C | Resistance of 1 m at 20 °C |
| После пересчета маршрута волочения | After recalculation the drawing sequence |

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The proposed technical solution is focused on the technological operation – drawing and allows, by making changes to the standard drawing sequence, to reduce the ohmic resistance of the conductive core by 3-5% for copper and aluminum, respectively, which has a positive effect on reducing the operating temperature of the current-carrying part of the cable and will increase the reliability of the cable line as a whole (Fig.6).

## REFERENCES

[1]. Bushuyev V.V., Kucherov Yu.N. Innovative development of the Electric Power Industry as the most important priority of Russia's Strategic Development // Electro, No. 1, 2016.
[2]. Yu.N. Kucherov, A.V. Ivanov, D.A. Korev, N.A. Utkin, A.Z. Zhuk. Development of active consumer technologies and their integration into the public electric network // Digital energy http://www.energystrategy.ru/DP/Source/DE_03.pdf
[3]. Ways to increase the throughput of CL with cross-linked polyethylene insulation https://mobile.ruscable.ru/article/212/
[4]. Increasing the capacity and operation of the cable line http://www.energomet-e.ru/news/kabel-s-izolaziey-spe.
[5]. Sultanov G.A., Chaikin V.P., Demchenko V.T., Chaikin V.V. Visual and psophometric characteristics of failures of cable transmission lines / Materials of the All-Russian Scientific and Technical Conference "Problems of development of urban electric networks in modern conditions". – Krasnodar, "Sovetskaya Kuban", 2000. – p. 27–37.
[6]. Kucherenko D.E., Kochubey E.A./ Methods of cable line diagnostics. - Materials of the VI International Scientific and Practical Conference "Actual problems of energy in the agro-industrial complex". - Saratov, 2015 – p.130-131.
[7]. Kochubey E.A., Didenko E.R. / Assessment of the technical condition of cable lines. - Materials of the International Scientific and Practical Conference "The role and place of information technologies in modern science", - Saransk, February 2016 – p. 23-25.
[8]. Sazykin V.G., Kudryakov A.G. Problems of worn-out electrical equipment in modern power engineering // International Research Journal, 2015. – No. 7. – p. 89–91.
[9]. Ivanova V.P. Increase of energy and resource saving of straight-through type drawbench. Dissertation for the degree (PhD) of Doctor of Philosophy in Technical Sciences, Tashkent 2020.
[10]. Vega G., Haddi A., Imad A., Temperature effects on wire-drawing process: experimental investigation // Int J Mater Form, 2009 – V. 2, No.1. – p. 229 – 232.
[11]. Berin I.Sh., Dnestrovsky N.Z. Production of copper and aluminum wire, Publishing House "Metallurgy", Moscow, 1974, p. 16-17, 19-22, 22-26.
[12]. Tsypkina V.V., Ivanov A.A. Development of generalized requirements for the modernization of the electric drive of cable drawing machines //Universum: Technical Sciences: Electronic Scientific Journal, 2017. No. 4 (37). URL: https://7universum.com/ru/tech/archive/item/4629 (date of application: 23.03.2023).
[13]. Tsypkina V.V. Issues of the efficiency of the production process of conductive cores based on composite materials for cabling and wiring products // Universum: Technical Sciences: Electronic Scientific Journal, [et al.], 2021, 5(86). URL: https://7universum.com/ru/tech/archive/item/11826 (date of application: 22.03.2023).
[14]. Ivanova V.P., Tsypkina V.V., Akbarov F.A., Nosirova D.A., Muminov Kh.A. The effect of improving the technology of manufacturing a conductive core on the operational characteristics of cabling and wiring products // Universum: Technical Sciences, 2020, No. 11-5 (80). [et al.], 2020, 11(80). URL: https://7universum.com/ru/tech/archive/item/10971 (date of application: 23.03.2023).