ANALYSIS OF THE CONDITION AND MONITORING OF EMERGENCY POWER OUTAGES IN 10 kV OVERHEAD LINES OF THE ORYOL REGION

Igor Nikolaevich Fomin[1*], *Alexander Vladimirovich* Vinogradov[2], *Roman Pavlovich* Belikov[3], *Tatyana Anatolyevna* Kudinova[4], and *Marat Firdenatovich* Nizamiev[5]

[1]Orel State Agrarian University named after N.V. Parakhin, Orel, Russia
[2]Leading Researcher,Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM", Moscow, Russia
[3]Orel State Agrarian University named after N.V. Parakhin, Orel, Russia
[4]Orel State Agrarian University named after N.V. Parakhin, Orel, Russia
[5]Kazan State Power Engineering University, Kazan, Russia

Abstract. Efficiency improvement of modern production is associated with uninterrupted power supply to consumers. Power supply reliability to consumers is ensured by reliable operation of power lines. The number of outages depends on their condition and operation quality. An increase in the number of outages affects the further degradation of power line state, significantly reducing the resource of lines and equipment; and it takes a lot of time to find faults and eliminate them. Monitoring of power outages in overhead power lines will reduce the time of emergency elimination.1

1 Introduction

The need to implement power outage monitoring was predetermined by the analysis of the condition and fault rate of 10 kV radial overhead lines in the Oryol region. Analysis of the condition and fault rate of overhead lines in the Oryol region includes: analysis of the length of lines, technical condition of 10 kV overhead lines, indicators and main causes of line breakdowns. These indicators characterize the dynamics of the state of overhead lines and make it possible to forecast their faults [1, 2]. Frequent outages of overhead power lines, including emergency ones, are associated with large time expenditures, financial resources and power undersupply to consumers. Implementation of power outage monitoring in 10 kV overhead lines will allow attending personnel to eliminate faults as soon as possible and also to prevent them [3-6].

2 Theoretical research

The overhead lines of 10 kV in the electric networks of the Oryol region today are made mainly of wire grade AS - 35. The cross-section of this wire is two steps lower than currently recommended for trunk sections under the condition of providing mechanical strength. This fact alone is one of the reasons for the increased number of line faults.

Another reason is related to the fact that the main part of the 10 kV overhead lines (60%) was built before 1990 and therefore their service life has already exceeded the standards. Lines in unsatisfactory condition are dismantled (not in full, many of them continue to operate), while new lines are not fully put into service, which leads to the total length reduction of electric networks. Over the past 5 years, it decreased by 570.1 km (by 4.13% of the length of 2015), that is, by an average of 142.5 km per year (0.8%). At the same time, the length of some overhead lines is much higher than the recommended one and in many cases is more than 25 km, and sometimes more than 50 km. It also affects the number of line outages, as it reduces their reliability and operation quality. It is practically impossible to provide the required voltage level for the consumer with such a line length and wire cross-section [7-9].

In percentage terms, the length of lines less than 25 km is about 75%, from 25 km to 50 km is 21-22%, more than 50 km is 2.4%.

Analysis of the number of power outages shows that this indicator is growing every year due to an increase in the number of planned and emergency outages (Fig. 1.).

Over the 5 years, the number of planned outages increased by 284 outages, and the number of emergency outages increased by 492 ones. And if in 2014 emergency outages amounted 67.4% of the number of planned outages, then in 2017 they made up 81.1%.

* Corresponding author: igor.fom-in@yandex.ru

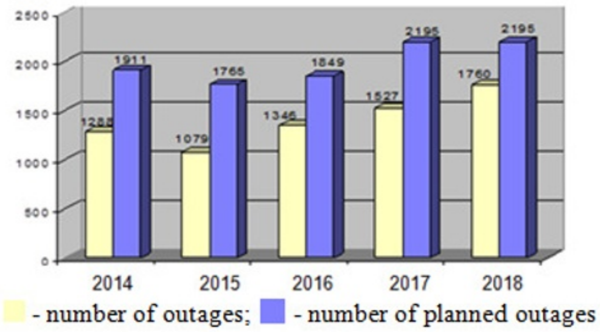

Fig. 1. Number of power outages in 10 kV overhead lines in the Oryol region.

Planned outages are determined by the repair work (the number of repairs has increased, therefore, there is a need in them). At the same time, the number of emergency (unplanned) outages is growing; it means that it will take some time to find out the cause, to locate and to eliminate the fault (in case if the power outage was not cleared by the automatic reclosing (AR) or manually), so the duration of power supply interruptions and the power undersupply to consumers is growing [10, 11].

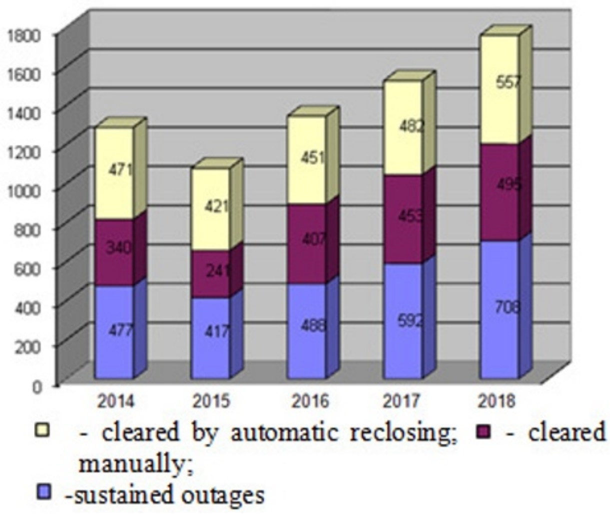

Fig. 2. Number of emergency outages in 10 kV overhead lines in the Oryol region.

The ranking of emergency outages, in turn, shows that sustained outages make up the majority. The same component is growing most rapidly. The efficiency of automatic reclosing, instead of theoretical 70%, in practice is 56.5% in 10 kV networks. This is due to the fact that most drives of automatic reclosing are obsolete models [12, 13].

Due to the increased rate of faults in 10 kV overhead lines, over the specified period of time, the power undersupply to consumers has significantly increased. The increase in the number of outages affects the further degradation of power line state, significantly reducing the resource of lines and equipment. The large length of the lines, in turn, increases the power undersupply due to the fact that it takes a lot of time to locate and to eliminate the faults.

In order to minimize these negative developments, an algorithm for remote monitoring of emergency outages in overhead lines was proposed; it is based on the analysis of various operation options of line switches.

The algorithm is a program of work that the means of remote monitoring of emergency outages must fulfill, regardless of how these means are implemented: on relay elements, microcircuits, or using a programmable logic matrix (PLM). Correctly composed work algorithm and its implementation determine the correct operation of the system as a whole. In this case, the algorithm (Fig. 3) implements the developed methods for monitoring emergency outages of circuit breakers in 10 kV overhead lines [4, 14, 19, 25].

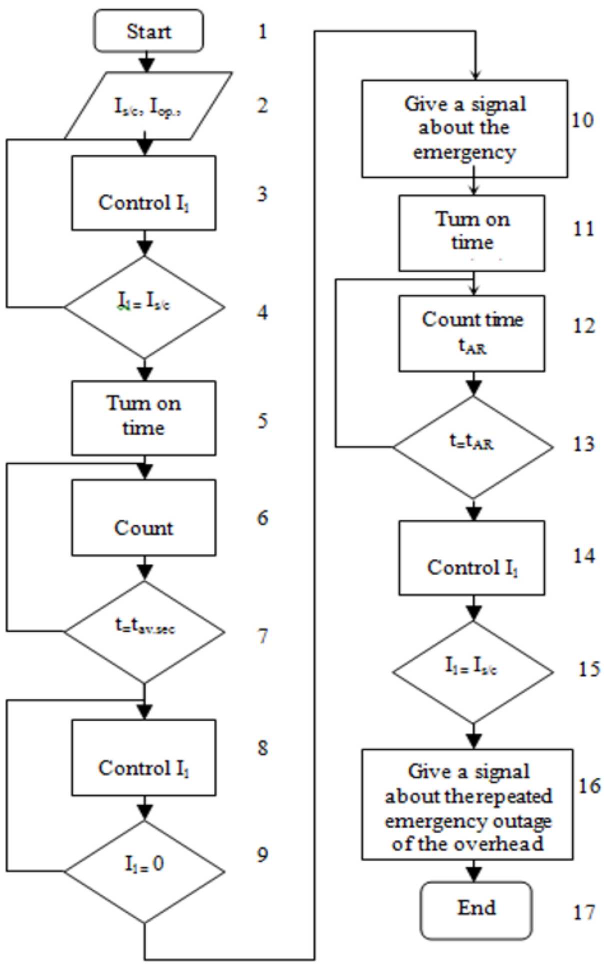

Fig. 3. Algorithm for monitoring emergency outages of circuit breakers in 10 kV overhead lines.

The beginning of the algorithm provides for the presence of embedded data on the values of the operating current and the minimum short circuit current, the rise rate of the short circuit current, the holding time of the automatic reclosing of the switch. The beginning of the algorithm (Fig. 3) provides monitoring of the appearance of the short-circuit current in 10 kV overhead lines, not only in its magnitude, but also in the rise rate. When the conditions laid down in block 4 of the algorithm are fulfilled, it is concluded that a short circuit has occurred and the time counter is started, counting down the time equal to the protection response time of the controlled circuit breaker in overhead lines. This is ensured by the operation of blocks 6 and 7. At the end of the countdown using blocks 8 and 9, the current is controlled [15, 16].

When the condition laid down in block 9 is fulfilled, block 10 gives a signal about the emergency outage of the overhead line switch. And then, the time counter of block 11and the exposure time of the automatic reclosing of this switch will turn on. This is ensured by the operation of blocks 12 and 13. At the time the countdown ends, the current is controlled by blocks 14 and 15. When the condition laid down in block 15 is fulfilled, block 16 gives a signal about the repeated emergency outage of the overhead line switch [17, 18, 20, 21].

3 Technical implementation

The proposed algorithm is implemented in an information processing device, made on the basis of a personal computer, with subsequent software-based processing of the received data. [21-24].

The device consists of a block for connecting current sensors and a block for converting and analyzing the input signal. This device has passed laboratory tests on the basis of FSBEI HE "Oryol State Agrarian University named after N.V. Parakhin" and proved its effectiveness [22, 24]. Currently, an agreement has been reached on the installation of an experimental emergency outage monitoring device in the Oryol Power Distribution Zone.

4 Conclusions

1. Analysis of the state of 10 kV overhead lines in the Oryol region made it possible to rank the outages. Ranking of emergency outages, in turn, showed that the majority of these outages were sustained ones.
2. In order to reduce the time for eliminating faults in overhead lines, an algorithm for remote monitoring of emergency outages was proposed.
3. Implementation of monitoring of emergency outages will reduce the time to eliminate the fault. It will lead to increased reliability of power supply to consumers through the adoption of the necessary decisions by attending personnel.

References

[1] I.N. Fomin, R.P. Belikov, Algorithm for Remote Monitoring of the Head Switch Line, Bulletin of Orel State Agrarian University **61**, 4, 72–77 (2016)

[2] L.D. Surov, I.N. Fomin, Monitoring of Successful Automatic Reclosing Of Sectionalizing Circuit-Breaker Line Ring Network, Bulletin of Orel State Agrarian University **22**, 1, 23–25 (2010)

[3] L.D. Surov, I.N. Fomin ,Monitoring Failure of Automatic Reclosing of the Sectionalizing Circuit-breaker, ELEKTRO, Electrical engineering, electricity, electrical engineering, 6, 46–48 (2009)

[4] L.D. Surov, I.N. Fomin, The Statefulness of the Head Switch Line Ring Network, Bulletin of Orel State Agrarian University **29**, 2, 112-117 (2011)

[5] M.V. Borodin, *Increase of Efficiency of Functioning of Power Supply Systems by Monitoring Power Quality* (Dissertation ... of candidate of technical Sciences: 05.09.03 / Lipetsk State Technical University, Lipetsk, 177, 2013)

[6] M.V. Borodin, A.V. Vinogradov, *Increase of Efficiency of Functioning of Power Supply Systems by Monitoring Power Quality, Monograph* (Orel: Publishing house of Orel SAU, 185, 2014)

[7] S.M. Astakhov, N.S. Sorokin, E.A. Semenov, Investigation of the Reliability of Information on the Occurrence of Short Circuits, Bulletin of Orel State Agrarian University **22**, 1, 25–28 (2010)

[8] A.V. Vinogradov, A.N. Vasilyev, A.E. Semenov, A.N. Sinyakov, V.E. Bolshev, The Analysis of Time of Interruptions in Power Supply of Rural Consumers and Methods of its Reduction Due to Monitoring of a Technical Condition of Power Lines, Bulletin of All-Russian Institute of Farm Electrification **2**, 27, 3–11 (2017)

[9] N.S. Sorokin, N.N. Chaadaeva, *The method of Estimating the Reliability of Power Supply Systems* (Bulletin of Construction and Architecture, the Collection of Scientific Papers, Orel, 127–130, 2016)

[10] A.V. Vinogradov, A.E. Semenov, A.N. Sinyakov, Analysis of Recovery Time of Power Supply of Rural Consumers in Case of Failure in Power Lines, Innovation in Agriculture: Problems and Prospects **1**, 13, 12–22 (2017)

[11] A.V. Vinogradov, A.V. Vinogradova, A.E. Semenov, A.N. Sinyakov, The analysis of Idle Time of the Electric Equipment Involved in Agricultural Technological Processes After Restoration Of Electric Power Supply, Agrotechnics and Power Supply **2**, 15, 26–31 (2017)

[12] A.V. Vinogradova, A.V. Vinogradov, V.A. Konstantinov, Application of Partitioning of Transmission Lines 0,38 kV to Improve the Reliability of Electric Power Supply of Rural Consumers, Innovation in Agriculture: Problems and Prospects **2**, 10, 12–26 (2016)

[13] A.V. Vinogradova, S.V. Blinov, The Improving of the Reliability of Transmission Lines of 0.38 kV With Their Partitioning, News of Higher Educational Institutions of Chernozem Region, 3, 8–12 (2014).

[14] L.D. Surov, I.N. Fomin, A way of Monitoring Successful and Unsuccessful Automatic Reclosing of the Switches in the Partitioned Line Ring Network, Patent of Russia No. 2305356, Bull., 24 (2007)

[15] A.V. Chernyshov, *Identification of Defects of Insulation of Overhead Transmission Lines With Voltage of 10 kV With the Formation of Artificial Ground Fault* (Physics and Modern Technology in Agriculture, Proceedings of the IX International Youth Scientific-Practical Conference, Orel: Publishing house of Orel State Agrarian University, 270–273, 2017)

[16] B.N. Meshkov, V.A. Chernyshov, Diagnostics of Damage of Overhead Power Lines in the Distribution Network Complex 10 kV, Innovations in Agriculture **2**, 12, 87–91 (2015)

[17] L.D. Surov, V.V. Filippov, The Monitoring of Disconnection and Failure of Automatic Reclosing of the Main Switch of Line, The News of Volgograd State Technical University **11**, 8 (135), 88–91 (2014)

[18] L.D. Surov, I.N. Fomin, N.V. Makhianova, Method of Monitoring of Disconnection and Failure of Automatic Reclosing Sectionalizing Circuit-Breaker Line Ring Network, Patent of Russia No. 2304338, Bull. 22 (2007)

[19] L.D.Surov, I.N. Fomin, N.V. Makhianova, R.V. Lebedev, Method of Monitoring State Changes of the Head Switch Line Ring Network, Patent of Russia No. 2410817, Bull. **3** (2011)

[20] L.D. Surov, V.V. Filippov, Determination of the Damaged Section of the Ring Network Line, Bulletin of the Volgograd State Technical University **8**, 187, 105–110 (2016)

[21] N.S. Sorokin, Using of the Integrated Circuit FT232R Chip AD7495AR and in a Block of Digital Processing in the System to Monitoring the Operation of Electrical Networks 6-35 kV, Bulletin of Orel State Agrarian University **60**, 3, 3, 87–93 (2016)

[22] Y.A. Kuznetsov, L.D. Surov, I.N. Fomin, Remote Monitoring of Automatic Reclosing Sectionalizing Circuit-breakers, Machinery and Equipment for the Village, 7, 29–33 (2015)

[23] N.S. Sorokin, Improving the Operation Efficiency of Electrical Networks with Voltage of 6-35 kV by Monitoring the Parameters of the Electrical Network, National University of Life and Environmental Sciences of Ukraine. Series: Technics and Energy of the Agro-industrial Complex, 209-2, 92–95 (2015)

[24] N.S. Sorokin, Connection Unit for Alarm Detection Sensor in Distribution Networks 6-35 kV, Bulletin of Orel State Agrarian University **29**, 2, 118–119, (2011)

[25] V.A. Chernyshov, E.A. Pechagin, *The Remote Monitoring of Overhead Transmission Lines with Insulated Neutral* (In the book: Energy Conservation and Efficiency in Technical Systems, Proceedings of the IV International Scientific-Technical Conference of Students, Young Scientists and Specialists, Tambov State Technical University, 355–356, (2011)