OPTIMAL QUALITY MANAGEMENT ALGORITHM FOR ASSESSING THE USAGE CAPACITY LEVEL OF MINING TRANSFORMERS

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Abstract: In order to establish if a transformer corresponds to the requirements of the power network, it is mandatory to know the consumption characteristics. Heretofore, the determination of load level of transformers was performed based on technical-economic criteria. However, for the situation in which the real load would be equal to the one resulting from calculations, this fact would be valid only for a short time period, maximum two years, but the calculation based on the total updated expenditure is performed for a twenty years period, in which it is more than certain that the load will undergo variations within certain limits compared to the initial one. The central theme of this paper is represented by the development of an optimal quality management algorithm for assessing the load of transformers, which provides more information related to the economic usage capacity level, the value of power losses, economic transient power, possible over-voltages, the pricing of energy and charging of energy losses. In the end, results have been simulated for three series of mining transformers with different transformation ratios.

Key words: economic usage capacity, optimal usage capacity, quality management, usage capacity level

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Introduction

European and US specialized literature, prescriptions and instructions for calculating systems in order to characterize the operation of distribution networks use the load curve filling coefficient (k_u) known also as load factor. In electrical networks from the mining industry, the load factor for a distribution station varies within a tight range from one year to the other. When connecting significant

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consumers, case in which k_u is modified, there is required to re-determine this factor. There is also noted that for a certain type of consumption, it varies from one consumption centre to the other (Liang and Parlikad, 2015; Pasculescu et al., 2015; Kalenova et al., 2017; Oláh et al., 2018). Therefore, after a careful investigation and after the load factor determination, it is noted that by the measurement of active and reactive energy there may be determined all elements required for operation analysis (Mokhova et al., 2018). For the determination of power and energy losses and for assessing the economic usage level occurs an approximation degree which is sometimes quite high, therefore is proposed to waive the economic usage level (GUT) in case of load approximation and to insert the terms of usage capacity level (GUC), economic capacity usage level (GUC_{ec}) and optimal capacity usage level (GUC_{opt}). In the situation in which within a transformer and distribution station are mounted several transformers, for calculating power losses has to be known the load regime of each transformer, as well as its' characteristics. Also, the power loss value is influenced by the value of the consumption's power factor. In this regard is proposed an optimal quality management algorithm for analysing the load of transformers from the mining industry (Oommen and Kohler, 1999; Mikita et al., 2017; Wang et al., 2018).

Optimal Quality Management Algorithm Presentation

The current methodology based on which is performed the analysis of power transformers load is based on momentum measurements of maximum load (currents or powers), and the establishment of load degree is performed either by simple comparison of maximum current measured in peak hours with the nominal current (Niculescu et al., 2014; Pasculescu et al., 2017), or by calculating the economic usage level. Using this method in practice brings along quite large errors in assessing the efficient (economic) usage of mining transformers (Jahromi et al., 2017; Lenka, 2017). Taking into account the aspects, in the following there is proposed a new method for analysing the load of power transformers, method which is based on well-established elements (Abrham, 2017; Janekova et al., 2017). Economic power of the transformer is in fact the maximum value of a power which is constant over the entire operation duration, which by circulation through the transformer generates minimum power losses. The economic apparent power of the transformer is determined using the following equation:

$$S_{ec.T} = S_{nT} \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k}} \qquad (1)$$

In this case, there exists a maximum economic power $S_{max.ec.T}$ of the load curve given for which the energy transfer through a given transformer is performed with minimum power losses (Misak and Fulnecek, 2017).

$$S_{max.ec.T} = S_{nT} \cdot \sqrt{\frac{\Delta P_0 \cdot T_f}{\Delta P_k \cdot \tau}} = S_{nT} \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k} \cdot \frac{1}{\tau^*}} = S_{nT} \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k}} \cdot k_d \qquad (2)$$

in which:
τ^* is the technological loss factor or the relative value of the loss duration, and is given by the relationship:

$$\tau^* = 0.2 \cdot k_u + 0.8 \cdot k_u^2 \qquad (3)$$

k_d is the coefficient of displacement of the maximum economic operation power and is given by the following equation:

$$k_d = \sqrt{\frac{T_f}{\tau}} = \sqrt{\frac{1}{\tau^*}} \qquad (4)$$

On the basis of the above equations, the calculation of the maximum economic load, expressed in kVA, is deduced as follows:

$$S_{max.ec.T} = S_{ec.T} \cdot k_d \qquad (5)$$

Using the maximum economic power, the economic usage (charge) of transformer's capacity GUC_{ec} is calculated for which the losses are minimal, with the following equation:

$$GUC_{ec} = \frac{W_{ec}}{C_t} = \frac{S_{max.ec.T} \cdot T_M}{S_{nT} \cdot T_f} = \frac{S_{max.ec.T} \cdot k_u}{S_{nT}} = \frac{S_{ec.T} \cdot k_d \cdot k_u}{S_{nT}} \qquad (6)$$

The economically transient (with minimum loss) energy, in kVAh, is given by:

$$W_{ec} = GUC_{ec} \cdot C_t = S_{ec.T} \cdot k_d \cdot k_u \cdot T_f \qquad (7)$$

The transit (passage) capacity of the transformer, in kVAh, which is defined by the transition of a power equal to the nominal power S_{nT} throughout the duration of its operation, is calculated using the formula:

$$C_t = S_{nT} \cdot T_f \qquad (8)$$

The parameter that best defines the shape of the load curves is the fill factor of the load curve k_u (which is also known as the installed power factor or the flattening factor) and is given by the following equation:

$$k_u = \frac{S_{med}}{S_{max}} = \frac{W_r}{T_f \cdot S_{max}} = \frac{T_M}{T_f} \qquad (9)$$

in which:
$S_{med} = \frac{W_r}{T_f}$ is the mean apparent power expressed in kVA, defined as the ratio between the real apparent power transited over the operation time (W_r) and the operation time
S_{max} the maximum duration apparent power, expressed in kVA
T_M the usage time of yearly maximal power, in h/year.

From the above relationship it follows that:

$$GUC = \frac{W_r}{C_t} = \frac{W_r}{S_{nT} \cdot T_f} \quad (10)$$

Finally, there is determined the calculation relationship for the maximum duration load, in kVA:

$$S_{max} = \frac{GUC}{k_u} \cdot S_{nT} \quad (11)$$

The analytical expression of the economic usage of the transformer capacity GUC_{ec} can be written as follows:

$$GUC_{ec} = \frac{S_{max.ec.T} \cdot k_u}{S_{nT}} = k_u \cdot k_d \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k}} \quad (12)$$

The analytical calculation expression, which is most often used to determine load-dependent energy losses during transformer operation, is:

$$\Delta W_k = \Delta P_{kn} \cdot \left(\frac{S_{max}}{S_{nT}} \right)^2 \cdot \tau = \Delta P_{kn} \cdot \left(\frac{S_{max}}{S_{nT}} \right)^2 \cdot \tau^* \cdot T_f \quad (13)$$

The problem of accurately calculating the losses in transformer windings consists, in fact, in determining as precisely as possible the sizes of τ and S_{max}.

In practice, by determining the load degree of each transformer using the new method, there can quickly be detected the level of energy loss and taken the necessary measures for obtaining the operation within the optimum load range (Goh et al., 2012; Shaefiee and Animah, 2017).

Simulation and Results Interpretation

Using the new load degree concept, there are presented in the following several case studies for the current transformer series from the mining industry. With the help of the previously determined relationships, the results obtained from the calculations for the currently used series of mining transformers, of type TT-AN, 6/0.4 kV, 6/0.69 kV and 6/1.05 kV, are presented in Tables 1, 2 and 3.

Table 1. GUC assessment for the actual series of mining transformers type TT-AN, of 6/0.4 kV

S_{nT} [kVA]	ΔP_0 [kW]	ΔP_k [kW]	$S_{ec.T}$ [kVA] [%S_{nT}]	k_u	k_d	$S_{max.ec.T}$ [kVA] [%S_{nT}]	GUC_{ec} [%S_{nT}]	W_{ec} [kVAh/day]	ΔW_a [kWh/day]
250	1.3	2.3	187.95 75.18	0.35	2.43	456.71 182.68	0.63 63.94	3780	61.24
				0.5	1.82	343.14 102.37	0.68 68.41	4080	61.82
400	1.5	3.1	278.24 69.56	0.35	2.43	676.12 169.03	0.59 59.16	5664	71.69
				0.5	1.82	506.39 126.59	0.63 63.29	6048	71.43
500	1.63	3.6	336.44 67.28	0.35	2.43	817.45 163.49	0.57 57.22	6840	77.21
				0.6	1.56	524.78 104.95	0.63 62.97	7556.4	77.24

Table 2. GUC assessment for the actual series of mining transformers type TT-AN, of 6/0.69 kV

S_{nT} [kVA]	ΔP_0 [kW]	ΔP_k [kW]	$S_{ec.T}$ [kVA] [%S_{nT}]	k_u	k_d	$S_{max.ec.T}$ [kVA] [%S_{nT}]	GUC_{ec} [%S_{nT}]	W_{ec} [kVAh/day]	ΔW_a [kWh/day]
400	1.5	3.2	273.86 68.46	0.35	2.43	665.43 166.35	0.58 58.22	5568	71.11
				0.5	1.82	498.38 124.59	0.62 62.29	5952	71.42
500	2.75	2.6	514.22 102.84	0.35	2.43	1249.55 249.9	0.87 87.46	10440	90.79
				0.6	1.56	802.15 160.43	0.96 96.25	11871.6	131.17

Table 3. GUC assessment for the actual series of mining transformers type TT-AN, of 6/1.05 kV

S_{nT} [kVA]	ΔP_0 [kW]	ΔP_k [kW]	$S_{ec.T}$ [kVA] [%S_{nT}]	k_u	k_d	$S_{max.ec.T}$ [kVA] [%S_{nT}]	GUC_{ec} [%S_{nT}]	W_{ec} [kVAh/day]	ΔW_a [kWh/fay]
250	1.3	2.5	180.27 72.11	0.35	2.43	438.05 175.22	0.61 61.32	3660	61.71
				0.5	1.82	328.10 131.24	0.65 65.62	3900	61.62
400	1.6	3.5	270.45 67.61	0.35	2.43	657.19 164.29	0.57 57.5	5520	76.35
				0.5	1.82	492.21 123.05	0.61 61.52	5905.92	76.52
630	2.1	4.2	445.47 70.71	0.35	2.43	1082.49 171.82	0.60 60.13	9091.16	99.91
				0.6	1.56	694.93 110.3	0.66 66.18	10006.41	100.16

In the case studies analysed using the numerical relations presented in this article there can be determined the value of the transited economic energy, the load percentage of the transformers and the peak load that may occur at various loads. It can be noticed that in case of mining transformers GUC_{ec} is in the [47, 66]% range, depending on the values of the load curve fill coefficient. Therefore GUC_{ec} is defined by the following equation:

$$GUC_{ec} = k_u \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k} \cdot \frac{1}{\tau^*}} = k_u \cdot k_d \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k}} \quad (14)$$

powerfully influenced by the ratio $\frac{\Delta P_0}{\Delta P_k} = [0.42, 1.05]$ ranging between very tight limits (Table 1, Table 2 and Table 3).

At the same time, because of the k_u filling coefficient which establishes the load for which the overloads occur, it results that it is required a displacement of the optimal loads range (GUC_{opt}) and therefore of the economic load point (GUC_{ec}) to the left in the case of low power transformers, to the right in the case of high power transformers. In this regard, it can be said that in order to achieve the optimal usage of transformers, it is necessary that the points GUC_{ec} to be spread over a range as large as possible, preferably [25(30), 45(50)]%, thus reducing the correlation with the power of the transformers, as shown in Figure 1.

In Figure 1, respectively in Figure 2, the coordinates of the point defining the transformer load degree (GUC_{ec}) are determined further.

Finally, result the relations for the abscissa and ordinate of the point defining the optimum load degree of the transformer:

$$x = GUC_{ec} = \frac{S_{max.ec.T} \cdot k_u}{S_{nT}} = \frac{S_{ec.T} \cdot k_u \cdot k_d}{S_{nT}} = k_u \cdot \sqrt{\frac{\Delta P_0}{\Delta P_k} \cdot \frac{1}{\tau^*}}$$

(15)

$$y = \Delta W = \frac{2 \cdot \Delta W_0}{W_{ec}} = \frac{2 \cdot \Delta W_0}{C_t \cdot GUC_{ec}} = \frac{2 \cdot \Delta P_0}{S_{ec.T} \cdot k_u \cdot k_d}$$

It follows that in the case of curves with pronounced load peaks (with low filling coefficients) a natural shift of the economic load point to the left occurs. In this way, the range of optimal load (GUC_{opt}) is moved to the left, for reducing the possibilities of using the transformer capacity. In the case of curves with such peaks, the possibility of using the capacity of the transformer is also reduced due to possible overloads. Practically, one can try to set the GUC_{ec} point at coordinates (x, y) as small as possible. This can be done by knowing that the active copper and iron mass required to execute a transformer of a certain power is kept approximately constant, ie:

$$C_1 \cdot M_{Cu} + C_2 \cdot M_{Fe} = C_3 \cdot S_{nT} \quad (16)$$

in which:
M_{Cu}, M_{Fe} total active mass in copper, respectively in iron of the transformer, in kg
C_1, C_2, C_3 numerical constants

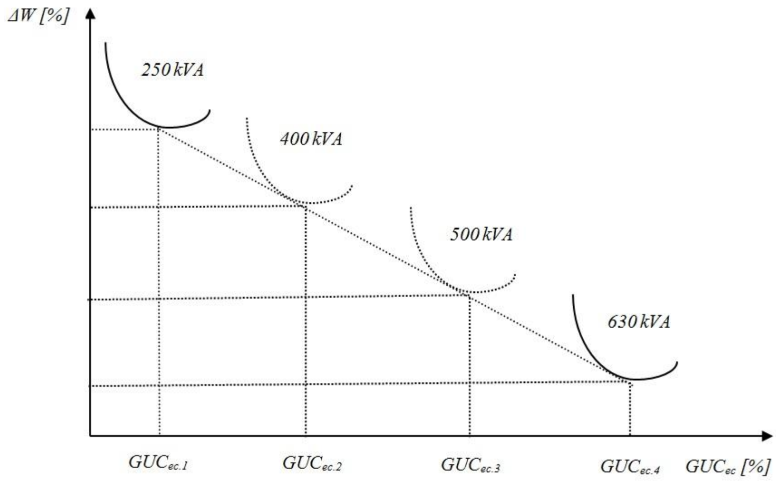

Figure 1. Linking nominal power of type TT-AN transformers depending on GUC_{ec}

From the case studies previously analysed, it can be said that the optimal use of TT-AN transformers can be achieved if the following conditions are met:

– To reduce specific iron losses, because the operation is at low loads anyway, and during this load interval, iron losses hold the largest share of total power losses in transformers.

- Because the iron losses cannot decrease in any way and in any amount, the copper losses should be increased (according to the principle that the active mass of a transformer must be approximately constant for a given nominal apparent power). This is beneficial because there is an increase in the loss ratio $\frac{\Delta P_k}{\Delta P_0}$, which causes a shift to the left of the GUC_{ec} and, implicitly, of the optimal load interval (GUC_{opt}).
- To increase the overload capacity of the transformer in order to be able to operate at the right limit of the optimal load range (GUC_{opt}), where S_{max} far exceeds the nominal power of the transformer.

As mentioned before, the above-mentioned conditions refer to low-power MV/LV transformers (up to 100-250 kVA), as generally there may only be very high peak load curves for their case.

If for the load curves with low filling coefficients (with high load peaks), the above mentioned conditions are required, and in the case of high load factor (k = 0.5) load curves, such conditions are not required, on the contrary, for optimal use of transformer capacity (of the investment made) it is even advisable to move the field of optimal load to the right by reducing the ratio $\frac{\Delta P_k}{\Delta P_0}$.

Figure 2 shows the optimal degree of operation of a transformer in the case of a curve of energy losses in relative values.

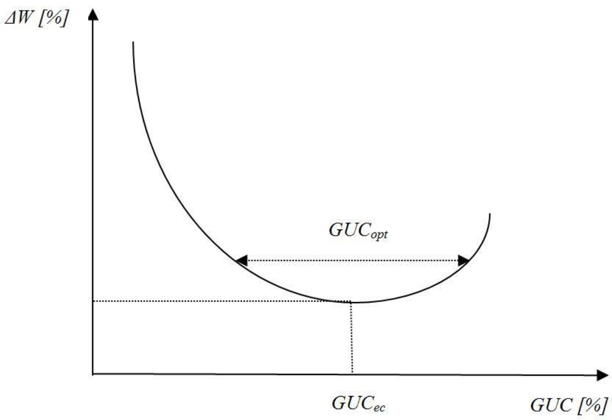

Figure 2. Optimal operation range (GUC_{opt}) for a percentage loss curve of mining transformers

In order to obtain the displacements of the GUC_{ec} points it is necessary to modify the ratio $\frac{\Delta P_0}{\Delta P_k}$, which must vary within wider limits and correlated with the rated power of the transformer.

In this way, a real optimum load range is shifted until this domain is at the same time the range of possible optimal loads.

The modification of the ratio $\frac{\Delta P_0}{\Delta P_k}$ at the same time means the change of values of specific iron and copper losses that cannot be changed in any manner. Their modification must be made in such a way that the energy losses obtained by moving the GUC_{opt} domain to be smaller throughout the range of the optimal load range compared to the energy losses of the currently used transformers.

Finally, it can be mentioned that within a modern design of power transformers activity, it is absolutely necessary to use the concepts presented within this paper. It can also be said that when designing the new transformer series, the new overload capacity concept has to be taken into consideration.

Conclusions

By defining the optimal usage capacity, a wide range of load values of the transformer has been accepted, range for which the losses could increase, compared to the minimum losses, with a fairly small percentage [5, 10]%. In this way, the great advantage is that, both in design and in operation, the load of the transformer can be located in this range (range between about 20% to about 45%). The degree of economic usage GUC_{ec} of the transformer's capacity, which has only a theoretical significance, and the optimal usage capacity GUC_{opt}, which has an important practical utility, are defined (Pana, 2006).

For load curves with filling coefficients comprised within the range [0.35, 0.5], in case of mining transformers type TT-AN, of 6/0.4 kV and 6/1.05 kV, (Table 1 and Table 3) the optimal load cannot be extended over GUC_{ec} ([57, 68] %), because energy losses significantly increase. In this case, from the performed analyses, the upper limit of the optimal load range corresponds to GUC_{ec}., therefore, for obtaining an optimal regime in this situation, it shall be monitored in exploitation so that to operate at the lower limit of the GUC_{opt} range, meaning lower loads, of [30, 45]%.

In case of the transformer of 6/0.69 kV, 500 kVA (Table 2) resulted a ratio of $\frac{\Delta P_0}{\Delta P_k} = 1.02$, due to the fact that iron losses are higher than copper losses. For values of the filling coefficient of [0.35, 0.6], the value of GUC_{ec} is [87.46, 96.25]%. In this case, operation will not take place for such loads due to the fact that there occur very hazardous load peaks, which exceed the power of the transformer, with the value S_{max}=2.5 S_{nT}, for k_u=0.35. In order to obtain an optimal operation regime of the transformer, there is aimed to achieve a value of the filling coefficient which to be higher in exploitation [0.5, 0.6]. In operation, there will be aimed for the transformer to operate at a lower limit of GUC_{opt}, namely to the left of the point that defines GUC_{ec} (Figure 1 and 2). If the transformer operates for the

economic load established by calculation, (GUC_{ec}=[87.46, 96.25]%), active energy losses have high values (ΔW_a=[90.79, 131.17] kWh/day) (Table2).
A constant power $S_{ec.T}$ is not passed through the transformer, but one that is variable after a certain load curve, this ranging between two limits: one minimum and one maximum. Knowing the place of consumption (defined by the transition capacity of the transformer C_t and the value of the filling coefficient k_u), the maximum energy that can be transited can be determined for each transformer without reaching hazardous overloads. In conclusion, due to a more accurate determination of τ and S_{max}, result values of the winding losses, which are error-free compared to the actual losses, of ±10% at most, compared to the ±25% errors resulting from the use of the current methodology.
Energy management aspects may be extended in the future by determining the costs of energy losses using the results presented in Tables 1, 2 and 3 (Power Engineering Guide, 2009).

References

Abrham J., 2017, *Project management and funding in the Euroregions*, “Polish Journal of Management Studies”, 16(1).

Goh Y.M., Lover P.E.D., Brown H., Spickett J., 2012, *Organizational accidents: a systemic model of production versus protection*, “Journal of Management Studies”, 49(1).

Jahromi M.G., Mirzaeva G., Mitchell S.D., 2017, *Design and control of a high-power low-loss DC-DC converter for mining applications*, IEEE Transactions on Industry Applications, 53(5).

Janekova J., Fabianova J., Onofrejova D., Puskas E., Busa M., 2017, *Implementation of deviation analysis method in the utilisation phase of the investment project: a case study*, “Polish Journal of Management Studies”, 15(1).

Kalenova S., Onyusheva I., Yerubayeva G., 2017, *The contemporary state of eco-economy of Kazakhstan: Problems and solutions*, “International Journal of Ecological Economics and Statistics”, 38 (2)

Lenka S., 2017, *The relationship between company returns and leverage depending on the business sector: empirical evidence from the Czech Republic*, “Journal of Competitiveness”, 9(3).

Liang Z.L., Parlikad A.K., 2015, *A condition-based maintenance model for assets with accelerated deterioration due to fault propagation*, IEEE Transactions on Reliability, 64(3).

Mikita M., Kolcun M., Spes M., Voktek M., Ivancak M., 2017, *Impact of electrical power load time management at sizing and cost of hybrid renewable power sys*tem, “Polish Journal of Management Studies”, 15(1).

Misak S., Fulnecek J., 2017, *The influence of ferroresonance on a temperature of voltage transformers in undeground mines*, [In:] Proceedings of the 2017 18th International Scientific Conference on Electric Power Engineering (EPE), May 17-19, Kouty nad Desnou, Czech Republic.

Mokhova N., Zinecker M., Meluzin T., 2018, *Internal factors influencing the cost of equity capital*, Entrepreneurship and Sustainability Issues, 5(4).

Niculescu T., Pasculescu D., Pasculescu V.M., Stoica I.O., 2014, *Evaluation of electrical parameters of intrinsic safety barriers of the electrical equipment intended to be used in atmospheres with explosion hazard*, [In:] Geoconference on informatics, geoinformatics and remote sensing, vol. I, 14th International Multidisciplinary Scientific Geoconference (SGEM), June 17-26, Albena, Bulgaria.

Oláh, J., Nestler, S., Nobel, T., Popp, J., 2018, *International characteristics of the macro-logistics system of freight villages, "*Periodica Polytechnica Transportation Engineering", 46(4).

Oommen M.P., Kohler J.L., 1999, *Effect of three-winding transformer models on the analysis and protection of mine power systems*, IEEE Transactions on Industry Applications, 35(3).

Pana L., 2006, *Tehnici de optimizare în sistemele electroenergetice miniere*, Editura Focus, Petroşani, Romania.

Pasculescu V.M., Pricop D.G., Morar M.S., Florea V.A., 2015, *Research on the development of an expert system for selecting technical equipment intended to be used in potentially explosive atmospheres*, [In:] Informatics, Geoinformatics and Remote Sensing, Vol. I, 15th International Multidisciplinary Scientific Geoconference (SGEM), June 18-24, Albena, Bulgaria.

Pasculescu V.M., Vlasin N.I., Suvar M.C., Lupu C., 2017, *Decision support system for managing electrical equipment used in hazardous atmospheres*, "Environmental Engineering and Management Journal", 16.

Power Engineering Guide, 2009, Edition 7. Available at: https://www.siemens.com/content/dam/internet/siemens-com/global/products-services/energy/high-voltage/transformers/brochures-transformers-en/siemens-transformers-in-the-power-engineering-guide-transformers-product-brochure.pdf

Shaefiee M., Animah I., 2017, *Life extension decision making of safety critical systems: An overview*, "Journal of Loss Prevention in the Process Industries", 47.

Ulewicz R. 2016, *Quality Management System Operation in the Woodworking Industry*, International Conference on the Path Forward for Wood Products: A Global Perspective, "Proceedings of Scientific Papers"

Wang D.M., Tee S.J., Liu Q., Wang Z.D., 2018, *Factorial analysis for ageing assessment of in-service transformers*, IET Generation Transmission & Distribution, 12(13).

OPTYMALNY ALGORYTM ZARZĄDZANIA JAKOŚCIĄ DO OCENY WYDAJNOŚCI POZIOMU TRANSFORMATORÓW GÓRNICZYCH

Streszczenie: W celu ustalenia, czy transformator odpowiada wymaganiom sieci energetycznej, obowiązkowe jest poznanie charakterystyki zużycia. Dotychczas wyznaczanie poziomu obciążenia transformatorów odbywało się w oparciu o kryteria techniczno-ekonomiczne. Jednakże w sytuacji, w której rzeczywiste obciążenie byłoby równe wynikowi wynikającemu z obliczeń, fakt ten byłby ważny tylko przez krótki okres, maksymalnie dwa lata, ale obliczenia oparte na całkowitych zaktualizowanych wydatkach są dokonywane dla dwudziestu, w okresie, w którym jest więcej niż pewne, że obciążenie ulegnie zmianom w pewnych granicach w porównaniu z okresem początkowym. Głównym tematem tego artykułu jest opracowanie optymalnego algorytmu zarządzania jakością do oceny obciążenia transformatorów, który dostarcza więcej informacji dotyczących ekonomicznego poziomu wykorzystania mocy, wartości strat mocy, ekonomicznej przejściowej mocy, możliwych przepięć, wycena energii i pobieranie strat energii. W

efekcie symulowano wyniki dla trzech serii transformatorów górniczych o różnych współczynnikach transformacji.
Słowa kluczowe: wykorzystanie ekonomiczne, optymalne wykorzystanie, zarządzanie jakością, poziom wykorzystania mocy.

最优质量管理算法评估采矿变压器的使用能力水平

摘要: 为了确定变压器是否符合电网要求，必须了解消耗特性。迄今为止，基于技术经济标准进行变压器负载水平的确定。但是，对于实际负荷等于计算产生的负荷的情况，这个事实仅在短时间内有效，最长两年，但基于总更新支出的计算是针对二十年进行的。几年时间，与初始时间相比，负载在一定限度内会发生变化。本文的中心主题是开发用于评估变压器负载的最佳质量管理算法，该算法提供了与经济使用容量水平，功率损耗值，经济瞬态功率，可能的过电压相关的更多信息。
，能源的定价和能源损失的收费。最后，对具有不同变比的三个系列采矿变压器进行了模拟。
关键词: 经济使用能力，最佳使用能力，质量管理，使用能力水平。