LOAD PROFILES SIMULATION FOR EVALUATION ENERGGY LOSSES IN DISTRIBUTION NETWORKS

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Introduction. When calculating the energy losses in distribution networks using performance load profiles. Known methods of calculating energy losses in electric networks [1] are based on normal operating conditions and functioning of the electrical network, uninterrupted electricity supply to consumers.

Methods of calculating the losses of electricity use charts on duration. Earlier load profiles have stable characteristics and allow you to calculate the energy loss to adapt to these conditions, the simplified formulas. Currently, load profiles feeders 6-10 kV are many different forms, there were changes in the structure of energy consumption. Transition economies characterized by: non-uniformity in the daily load profiles; disconnection associated with non-payment for electricity; limitations associated with the overload of network elements, etc.

Most informative are the load profiles of individual groups of consumers for whom the known types of graphics. Load profiles of feeder formed of different consumer groups. The combination of load profiles generated total schedule feeder. Information about the probabilistic characteristics of load profiles is generally little known.

Calculation of energy losses by the method of medium loads is the use of expressions with the form factor. A calculation of the form factor reduces to obtaining the expressions having a clear and simple for hand calculation of the form. This is largely possible in a simple way to explain the patterns of influence on the profile, load losses of electricity. However, the pace of development of computer technology with great potential and their application in all spheres of government allow the use of complex computational algorithms, more flexible and accurate simulation. At the same time with this to some extent this may lose the simplicity and clarity of representation formulas for calculating the load losses.

Deterministic methods of calculation do not take into account the inaccuracy of initial data for plotting load. To overcome these deficiencies have developed methods for calculating the energy loss, based on the probabilistic representation of the graphs of electrical loads. These methods can be divided into: methods of submission of the load as a random variable and regression methods for calculating the losses.

Staging. Energy loss in the elements of an electric network is a function of the characteristics of load profiles. For the calculation of load losses in distribution networks using the method of average loads

$$\Delta W_L = \Delta P_{av} k_f^2 T \ ,$$

and the method of the number of hours the greatest losses

$$\Delta W_L = \Delta P_{max} \tau \ ,$$

where ΔP_{av} - loss of power in the network at an average load of nodes (or networks in general) for the time T; $k^2{}_f$ - a square form factor graphics power or current; ΔP_{max} - loss of power in the network at maximum loads of nodes; τ - the number of hours the maximum losses.

Key indicators of load profiles in the calculation of loss are: the number of hours of peak load T_{max}, the fill factor loading schedule. Another important characteristic of load is the ratio of minimum load to maximum $k_{min}=P_{min}/P_{max}$. In the calculations of energy losses characterize the shape of load profiles parameters: the number of hours of the greatest losses τ and form factor graphics power $k^2{}_f$. The most accurate values of τ and $k^2{}_f$ can be identified by well-known load profiles. Research aimed at obtaining a more accurate dependency on the parameters characterizing k^2_f load profiles led to a set of design formulas. With unknown load schedule k^2_f value can be determined using various empirical formulas [1].

The most commonly used in technical literature are the following calculation formula k^2_f depending on two parameters, k_Z and k_{min} [3]:

$$k_f^2 = 1 + \frac{(1-k_з)^2(k_з - k_{min})}{(2-k_{fill}-k_{min})k_{fill}^2} \quad \text{when } \lambda < 1;$$

$$k_f^2 = 1 + \frac{(1-k_{fill})(k_{fill} - k_{min})^2}{(1+k_{fill}-2k_{min})k_{fill}^2} \quad \text{when } \lambda \ge 1 , \tag{1}$$

where $\lambda = \frac{k_з - k_{min}}{1-k_{fill}}$.

In [1] based on approximations performed alternative calculations for all possible configurations of the load duration profile in increments of 0.1 in both axes (t and k_{fill}), a formula for the average expected value

$$k_f^2 = \frac{1+2k_{fill}}{3k_{fill}} \tag{2}$$

The error in the formula (1) using two parameters (k_{fill} and k_{min}) is estimated [1] is about 10.8%, and the error formula (2) uses only one parameter, k_{fill} is about 13%.

Assuming that the specification obtained by the two small parameters, in [1] proposed to use the formula (2). In this case, also noted that k_{min} has less credibility.

In [4] the error of the known empirical expression of certain k^2_f, as well as the formula (1). Accuracy in determining k^2f can increase the input except used two parameters k_{fill} and k_{min}, additional parameters characterizing the load profiles. As an additional parameter that can be taken during the duration of the maximum and minimum load graphics, etc. For example, the duration of the off-peak schedule is one of the parameters characterizing the performance load profiles. Normally, advance information on the duration of the minimum load can be obtained. Since the total load profile is formed from the sum of standard load profiles, we can evaluate the length of the minimum load. As an additional parameter taken during the duration of treatment with minimal impact - T_{min} or in relative units k_{tmin}.

It is known that more significantly affect the parameters are taken into account in determining k^2_f, the greater accuracy of simulation can be achieved. Thus, the load profile is proposed to characterize the three parameters k_{fill}, k_{min} and k_{tmin}.

In connection with the foregoing, the article examines the issues of error estimation k2f taking into account the dependence on two parameters, k_{fill} and k_{min} and three k_{fill}, k_{min} and k_{tmin}

To assess the calculation errors k^2_f in this article are considered: the use of simulation modeling of discrete possible configurations load duration profile and simulation load profiles analytical dependences in time.

Load profiles on duration are smoothly varying. In this regard, following the technique of estimating the loss of electricity distribution networks performance load duration profile as a continuously decreasing function of time. Calculations of energy losses are usually made on the PC. Therefore, excessive efforts to simplify the formulas for calculating k2f in modern conditions of development of computer technology due to the loss of accuracy unreasonable.

Simulation discrete simulation of the possible configurations of the load duration profile. Modeling of possible configurations of the load duration profile is reduced to the equivalent problem of simulation, a combination of levels of the columns of n * n and solving the following integral equations with inequalities.

Formed equation for specified values k_{fill} and k_{min} in the form of equation

$$I_1 + I_2 + I_3 \cdots I_n = n \cdot k_3. \quad (3)$$

where I_n- the current value or the power corresponding n-th stage of load profile.
Sets values of the first and the n-th column

$$I_1 = n, \qquad I_n = n \cdot k_{min}. \quad (4)$$

Formed by inequalities of the form

$$I_2 \le I_1, \; I_3 \le I_2, \cdots I_n \le I_{n-1}. \quad (5)$$

Solution of equations (3), (4) and (5) are integer variables $I_2 \div I_{n-1}$. Search all the options for given values of k_{fill} and k_{min} is produced by changing the values in columns (a decrease by one unit) from the load profile corresponding to the maximum k^2f toward its reduction. With respect to the discrete change of stress level $\Delta_{\Delta I}$=1/n and the time duration of the $\Delta_{\Delta T}$=1/n discrete step changes in the level k_{fill} has a value of $\Delta_{\Delta Kfill}=1/n^2$.
In accordance with the algorithm (3), (4) and (5) developed a mathematical model and simulation program for the possible configurations of the load duration profile. For example, Fig. 1 shows a histogram k^2_f when n=10, Δ=0.01 and 340 possible choice of load profiles when k_{fill}=0.4, k_{min}=0.1 and its comparison with the normal distribution profile.

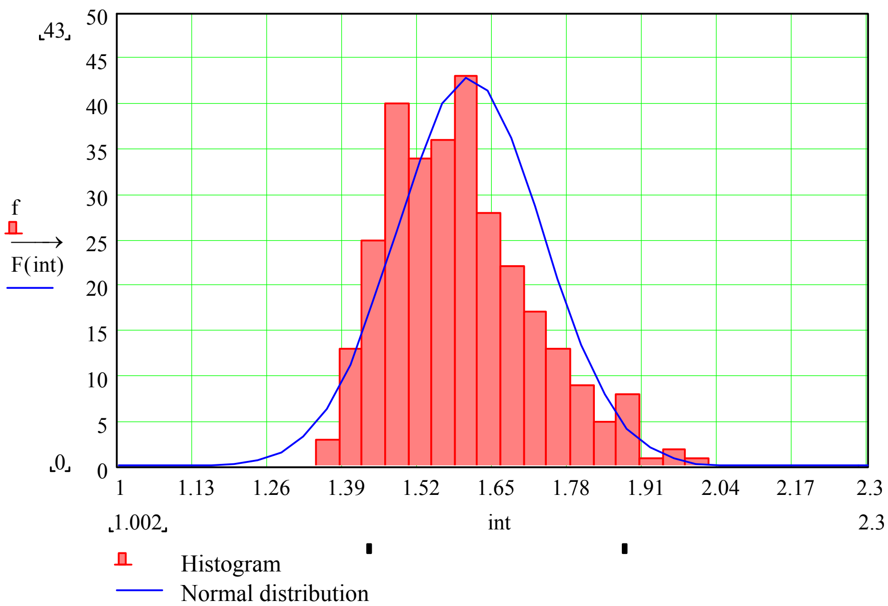

Fig. 1. Histogram k^2_f for load profiles k_{fill}=0.4, k_{min}=0.1.

The results of processing histograms k^2_f at different steps of discreteness show that the choice of the step discontinuity, having a sufficient number of possible load profiles, which allows to reliably determine characteristics of the distribution k^2_f have parameters close to the normal law. As shown in Fig.1 case, a normal law with mean 1,609 and standard deviation of 0.127.

Table 1 shows the average k^2_f for possible configurations of load profiles for the duration in increments of 0.1 according to the k_{fill} and k_{min}.

Analysis of the results shows that the use of formula (1) and (2) is associated with large systematic errors. Analysis of the results of the discrete simulation of characteristics of load profiles for various k_{fill}, depending on k_{min} shows the possibility of increasing the accuracy by obtaining appropriate and adequate dependency formulas.

Equation (2), obtained by averaging the form factor k^2_f all possible load profiles, can not completely eliminate the error. For example, for values of k_{min} = 0.1 (1) and (2) have a negative error k^2_f. For values of k_{min} = 0.2 and k_{min} = 0.3, (1) is negative, and (2) positive systematic errors. For k_{fill} = 0.4, k_{min} = 0.1, (1) has a systematic error reaches up to -35.2%, and (2) to - 19.82%.

Using discrete simulation with $k_{min} \geq 0.1$ with a limited step $\Delta_{\Delta I}=0.1$ leads to a systematic error modeling. For a preliminary comparative evaluation of the error histograms of the distribution k^2_f. For example, if $k_3=0.19$ and $k_{min}=0.1$ with a step of discreteness $\Delta_{\Delta I}=0.1$ and the time duration of the $\Delta_{\Delta T}=0.1$ there is a possibility $k^2_f=3.02$, then $k_{min}=0.1$ and a discrete step c $\Delta_{\Delta I}=0.05$, $\Delta_{\Delta T}=0.05$, n=400, a step change in the level of discreteness k_3 $\Delta_{\Delta Kfill}=0.0025$, we have over 300 options with an average $k^2_f=2.22$. Thus, the average value, as determined in step discrete 0.1 in this case has an error of 36%.

Table 1. Results comparing the values k^2_f by (1) and (2), depending on the k_{fill} at $k_{min} = 0.1$.

№	Results of the load profiles simulation			Results of the calculation according to the formulas			
	The fill factor, k_{fill}	Number of variants	Form factor, k^2_f	By formule (1)	By formule (2)	Error of formula %	
						(1)	(2)
1	0.4	340	1.58	1.45	1.50		
2	0.39	298	1.60	1.47	1.52	-8.36	-5.14
3	0.38	253	1.63	1.49	1.54	-8.59	-5.31
4	0.37	218	1.66	1.51	1.57	-8.81	-5.44
5	0.36	186	1.68	1.53	1.59	-8.8	-5.29
6	0.35	155	1.71	1.56	1.62	-8.94	-5.27
7	0.34	127	1.75	1.58	1.65	-9.53	-5.68
8	0.33	104	1.78	1.60	1.68	-9.9	-5.80
9	0.32	82	1.82	1.63	1.71	-10.47	-6.1
10	0.31	66	1.86	1.65	1.74	-11.02	-6.31
11	0.3	50	1.91	1.68	1.78	-11.8	-6.69
12	0.29	39	1.95	1.71	1.82	-12.54	-6.97
13	0.28	29	2.02	1.74	1.86	-13.96	-7.89

To ensure the adequacy of the discrete simulation problem arises of selecting a rational step, discrete, depending on the values of k_{fill} and k_{min}. For example to load profiles with k_Z <0.3 0.1 acceptance of discreteness step is coarse, in terms of number of charting options in terms of compliance with the normal distribution law.

Reduction of discrete steps increases the accuracy of the simulation. However, the sharply rising number of possible loads profiles. In this regard, along with a complete discrete simulation of characteristics of production load profiles according to the algorithm (3), (4) and (5) with a selectable discrete steps suggested below, the proposed use of a simplified simulation algorithm, which is based on the assumption that the distribution of k^2_f possible load profiles for the normal law.

Discrete simulation graphs of electrical loads for the duration of the choice of discrete steps, depending on the k_{fill} and k_{min} and receive library approximated by improving the accuracy of modeling technical energy losses in distribution networks.

Load profiles on duration are smoothly varying. Using the full discrete model leads to a systematic error and the relatively time-consuming to model. Therefore, further consider the use of simulation load profiles analytic functions, which has certain advantages dimension of the task, speed and visibility, and can explain the causes of systematic error in formula (1) and their elimination.

In this regard, following the technique of estimating the loss of electricity distribution networks performance load profiles on duration as a continuously decreasing function and obtaining the necessary characteristics of the graph by direct integration.

Method of determining k^2_f simulation load profiles analytical dependences in time. **Energy losses in the elements of an electric network are a function of the characteristics of load**

profiles. Load profiles **on duration can be expressed in different functions: parabolic when k_{fill}≥0.7; linear at k_{fill}=0.5÷0.7; exponential with k_{fill} =0.25÷0.5**; hyperbolic linear at **k_{fill} ≤ 0.25 etc. [2].**

Equation (1) obtained an approximation of load profiles for the duration of the following analytical dependences in time:

$$I = I_{max} - (I_{max} - I_{min})\left(\frac{t}{T}\right)^{\lambda} \quad \text{при } \lambda > 1 \tag{6}$$

$$I = I_{min} + (I_{max} - I_{min})\left(1 - \frac{t}{T}\right)^{\frac{1}{\lambda}} \quad \text{при } \lambda \le 1 \tag{7}$$

where - I_{max}, I_{min} values of maximum and minimum currents for the settlement period of time T.

Auxiliary factor λ determined as follows:

$$\lambda = \frac{I_{av} - I_{min}}{I_{max} - I_{av}}$$

In deriving (1) the following assumptions [3]: load profiles the load as a random variable has a beta - distribution; load profiles on duration represented by analytical dependences in time form (6) and (7). Given the fact that the analytical dependence (6) and (7) are inferable, the parameters for the beta - the distribution and, accordingly, (1).

Approximation load profiles analytical dependences of the form (6) and (7), although much more accurate simulation of energy loss, but does not completely eliminate the systematic errors [1]. In this regard, in [4, 5], attempts were made to obtain empirical relationships that eliminate these shortcomings. In [5], the choice of approximating functions load profiles different analytical dependences.

Next, we consider obtaining empirical approximation for k^2_fload profiles exponential dependence of the form

$$I = I_{min} + (I_{max} - I_{min}) \cdot e^{-(\alpha_2 t)^{\rho}} \tag{8}$$

Here, α and ρ - zoom options, determined by approximation.

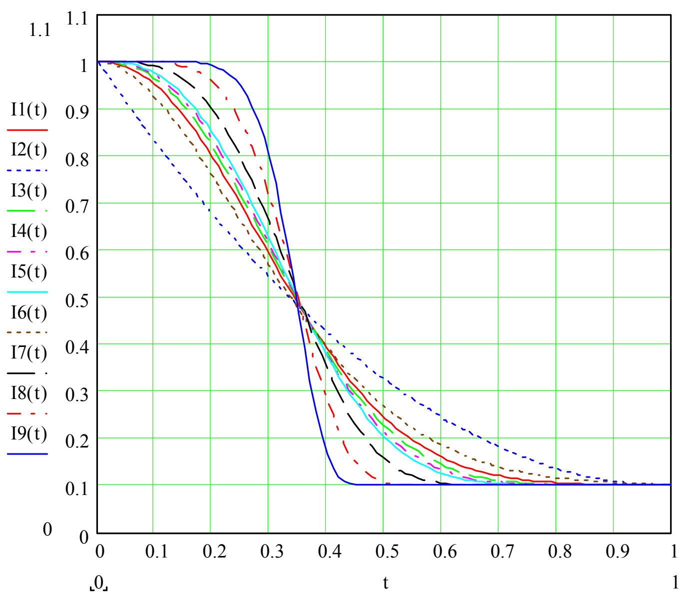

Fig. 2. Family load profiles with k_{fill} =0.4 , I_{min}=0.1 and λ=0.5 represented by a power function of the form (8) and the exponential form (7) for different ρ and α.

Improving the accuracy of modeling the energy loss and reduction of systematic errors can be achieved by selecting the type of approximating dependence (ρ and α) production load profiles. Modeling load profiles exponential form (8) by choosing ρ and α gives a family of graphs and kf are close to the real (Fig. 2).

Formulation of the problem of modeling the characteristics of production load profiles for the duration. Define the parameters α and ρ approximation load profiles dependence (8), which are also an implicit function of the parameters load profiles $\mathbf{k_{fill}}$, k_{min} and k_{tmin} .

$$k_{fill} = \int_0^1 (I_{min} + (I_{max} - I_{min}) \cdot e^{-(\alpha t)^{\rho}})dt \tag{9}$$

Dispersion for the given load profiles is determinates by expression

$$D_i = \int_0^1 \left(I_{min} + (I_{max} - I_{min}) \cdot e^{-(\alpha t)^{\rho}}\right)^2 dt - k_{fill}^2 \tag{10}$$

To calculate the definite integral (9) and (10) used numerical integration methods, in particular, Simpson method by selecting the corresponding α and ρ. In general, the load profiles $\mathbf{k_{fill}}$ = const have many solutions α_i and ρ_i and different dispersions.

Selection coefficients α_i and ρ_i, providing multiple solutions is a solution of the problem of minimizing the function

$$\left[\int_0^1 I_{min} + (I_{max} - I_{min}) \cdot e^{-(\alpha t)^{\rho}} dt - k_{fill}\right]^2 = 0 \tag{11}$$

subject to the restrictions on k_{min} and k_{tmin} as

$$0 \le k_{min} < 1,$$
$$0 \le k_{tmin} < 1.$$

Direct integration of expression (9, 10) is not possible and therefore requires the use of numerical methods.

When setting ρ is the minimization of (11) by selecting the value α, which provides a given value of k_{fill} (9)? In the case where for a given ρ can not provide appropriate value of k_{fill}, the change in ρ (increase) seek the solution set ρi and αi.

Ranges of α and ρ depend on the shape of load profiles k_{fill} and k_{min}. Modeling the load profile corresponding to given values of parameters k_{fill} and k_{min} is not always possible to provide. For example, setting the parameter α <2 often does not provide specified k_Z, k_{min} and k_{tmin} by choosing α.

As a preliminary criterion for complete selection of options appropriate approximation of (9) proposed to use the condition

$$(I_{max} - I_{min}) \cdot e^{-(\alpha t)^{\rho_i}} \le \varepsilon_{кз} \tag{12}$$

Here is invited $\varepsilon_{кз}$ =0.0005.

If condition (12) holds, then we can assume that (8) provides an approximation having an acceptable error.

The start time of minimum load graphics in the program is determined by the condition

$$(I_{max} - I_{min}) \cdot e^{-(\alpha t)^{\rho_i}} - k_{tmin} \le \varepsilon_{kt\,min} \tag{13}$$

The condition of precision search k_{tmin} invited to take within $\varepsilon_{кtmin}$ =0.001 ÷ 0.01

Simulation modeling of load profiles family to determine the ranges of shape factor.

Simulation marginal production schedules by the condition of obtaining the lowest and highest values for k^2_f. Technique for modeling load schedule (8) with k_{fill} (9) reduces to the problem of finding the parameters α and ρ from $(k_p - k_{fill})^2 \to$ min. For this purpose, using quadratic interpolation functions (11) for values of α for a given ρ in three different locations

$$f(\alpha) = a + b\alpha + \alpha^2 \qquad (14)$$

Algorithm for simulation of load profiles based on an iterative coordinate descent method and the method of quadratic interpolation. To find the minimum of the method of quadratic interpolation.

Programming. A program for simulation of load profiles (Fig. 3). The initial data inputs are: the filling factor of load profile k_{fill}, the ratio of minimum load to maximum kmin, the relative duration of the off-peak schedule - k_{tmin}, defined as the ratio of the length of the minimum load for the duration of the billing period. Simulation modeling of a family of load profiles by specifying parameters $\mathbf{k_{fill}}$, k_{min}, k_{tmin}. In this case, determined by α and k_{tmin}. Provides lower and upper limits of change ρ and pitch changes Δρ. Usually for 10-40 iterations can be obtained practically acceptable approximation for a load profile using a quadratic interpolation.

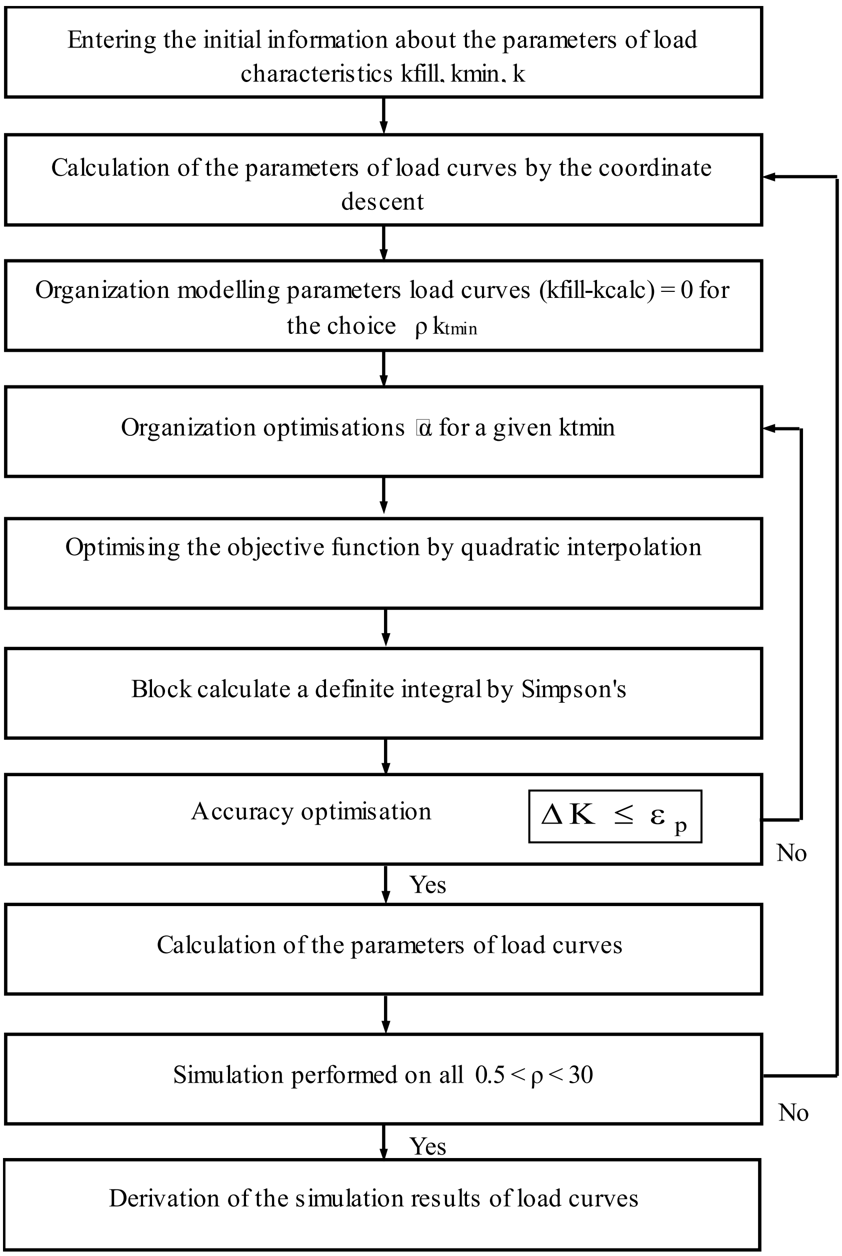

Fig. 3. Flow chart of load profiles simulation.

Recommended values of α and ρ depending on the load shape. Below are the recommended values of α and ρ to approximateload profiles function of the form (8) in duration, depending on the k_Z. For a given k_{fill} and k_{min} and relative growth ρ increases the dispersion and the value of α. When α = const and increasing ρ, k_{fill} decreases. An increase in α and ρ variance increases. To obtain relatively large k_Z must specify a relatively large value of ρ. To obtain profiles with longer duration load minimum k_{tmin} necessary to increase the value of α. To obtain profiles with longer duration of maximum load is also necessary to increase the value of α. Ranges of the dispersion of production schedules with the specified k_{fill} defined by setting ρ of $0.5 \le \rho \le 30$ and a step change in Δρ $0.1 \le \Delta\rho \le 1$, the choice of α corresponding to the set parameters and k_{fill} and k_{min}.

Numerical experiment. Simulation results for the load profile with k_{fill} = 0.4, k_{min} = 0.1 are shown in Table 2.

Table 2. Parameters of the simulation load profile.

Number	Coefficient of formula (8)		Results of simulation (9-13)		
	α_i	ρ_i	k^2_f	k_{tmin}	k_{tmax}
1	2.666	1.8	1.587		
2	2.661	1.9	1.61	0.17	0.08
3	2.658	2	1.631	0.2	0.08
4	2.679	3	1.777	0.38	0.14
5	2.719	4	1.857	0.46	0.17
6	2.755	5	1.907	0.5	0.2
7	2.783	6	1.941	0.53	0.22
8	2.806	7	1.966	0.55	0.23
9	2.825	8	1.985	0.57	0.24
10	2.841	9	2.0	0.58	0.25
11	2.854	10	2.012	0.59	0.26
12	2.865	11	2.022	0.59	0.26
13	2.875	12	2.03	0.6	0.27
14	2.883	13	2.037	0.61	0.27
15	2.891	14	2.043	0.61	0.28
16	2.897	15	2.049	0.61	0.28
17	2.903	16	2.053	0.62	0.28
18	2.908	17	2.058	0.62	0.29
19	2.906	18	2.059	0.62	0.29

Dependence of the squared form factor, the resulting simulation of load profiles for the values of k_{fill} = 0.4, k_{min} = 0.1 shows that for the same values of the k_{fill} value k^2_f varies within 1.587 ÷ 2.059. The average value is set to k^2_{fsr} =1.823. Limits k^2_f deviations from the average amount ±13%. The relative duration of minimum load varies in k_{tmin} = 0.13 ÷ 0.62.

Simulation modeling of load profiles as we obtain the limit profiles for k^2_f appropriate minimum, taking $k_{min} = 0.25 * k_{fill}$, and maximize, taking $k_{min} = 0.6 * k_{fill}$ algorithm (6-14), whose results are shown in Figure 4.

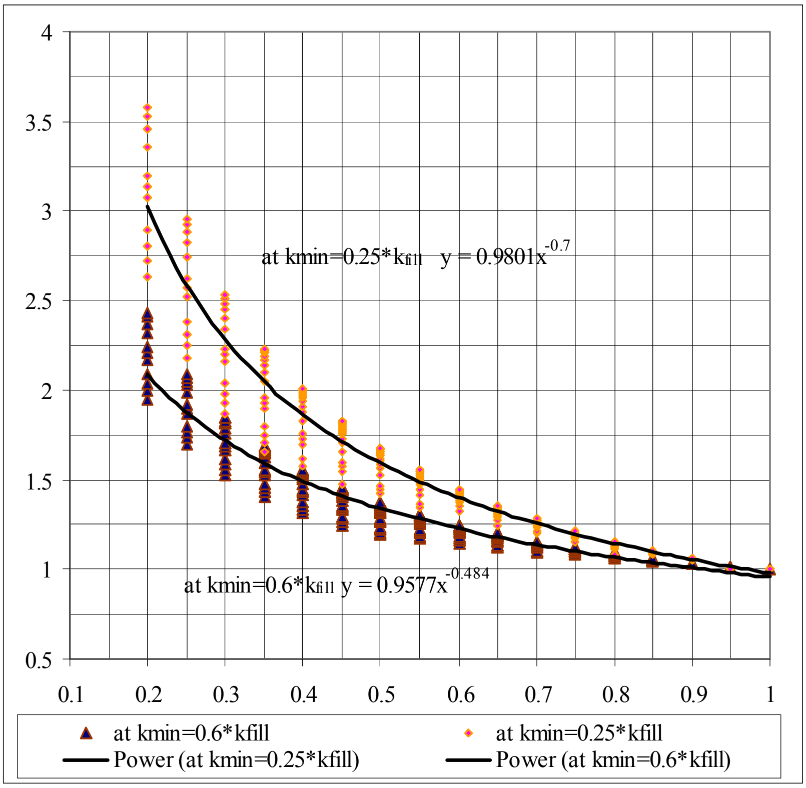

Fig. 4. Profiles of variation squared form factor of the k_Z to the possible load profiles.

Dependence of the squared form factor, the resulting simulation schedules (Table 2) and (Fig. 4) shows that for the same values of the k_Z and k_{min} time duration of treatment with minimal impact k_{tmin} and the corresponding values k^2_f vary widely. In the presence of advance information about ktmin available to assess k2f depending on three parameters: k_{fill}, k_{min} and k_{tmin}, allowing more accurate simulation.

Comparison of calculation results of simulation program schedules with the most commonly used empirical formulas.

Produced by comparing the results of the calculation k^2_f based on simulation graphs of electrical loads for the duration of the algorithms (3) - (5) and (6-14) (Table 3).

Table 3. The results of comparison k^2_f for k_{min} = 0.1 and ρ = 2 by simulation load profiles by function of the form (11) and (3) - (5)

Filling coefficient, $k_з$	Results of simulation (10)		Results of discrete simulation	Error of simulation (5)-(7), %
	α	$k^2_{fП}$	k^2_{fd}	$(k^2_{fД}- k^2_{fП})*100\backslash k^2_{fП}$
0.250	5.317	2.167	2.198	1.43
0.300	3.988	1.970	1.905	-3.30
0.350	3.190	1.789	1.709	-4.47
0.400	2.658	1.631	1.582	-3.00

Produced by comparing the results of the calculation for the average k^2f formula (1) and simulation plots of electrical loads for the duration of the algorithm (6-14) for load profiles, depending on the k_Z and k_{min}, taking k_{min} = ν * $\mathbf{k_{fill}}$. ν = 0.666, 0.5, 0.25, 0.125. The calculation results k^2_f shown in Table 4.

Table 4. Calculation errors k^2_f formula (1) for small values of k_{fill}

№	Filling coefficient , k_{fill}	Minimum of graph, k_{min}	Model estimated value k^2_f by		Error of k^2_f by formula (1)
			formula (1)	algorithm (8-13)	
1	0.5	0.3333	1.143	1.236	-7.52
2		0.25	1.2	1.366	-12.15
3		0.125	1.273	1.592	-20.04
4		0.0625	1.304	1.684	-22.57
5	0.4	0.2666	1.225	1.355	-9.59
6		0.2	1.321	1.585	-16.66
7		0.1	1.45	1.823	-20.46
8		0.05	1.508	1.971	-23.49
9	0.3	0.2	1.363	1.522	-10.45
10		0.15	1.527	1.792	-14.79
11		0.075	1.754	2.213	-20.74
12		0.0375	1.86	2.457	-24.30
13	0.2	0.1333	1.64	1.909	-14.09
14		0.1	1.941	2.344	-17.19
15		0.05	2.371	2.991	-20.73
16		0.025	2.577	3.371	-23.55

Empirical formula (1) has negative systematic inaccuracy, and (3) has a positive systematic inaccuracy in k^2_f compared with the average values obtained by the technique (6-14). The values of the systematic inaccuracy k^2_f vary in the range (7 ÷ 45%) depending on the k_{fill}.

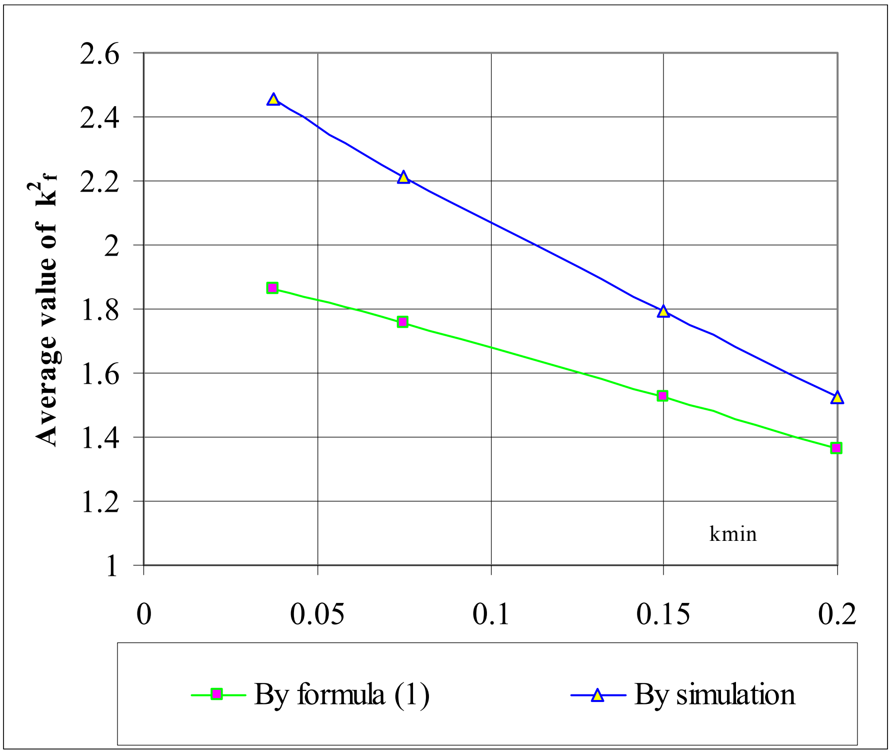

Fig. 5. Depending on the results k^2_f simulation load profiles (6-14) and by (1) k_{fill} = 0.3 from k_{min}.

The errors increase with decreasing k_{fill} from 0.5 in the direction of small values.

$k_{fill} = 0.5$ for the values of the errors in k^2_f vary in the range (7 ÷ 15%), for $k_{fill} = 0.4$ in the range (10 ÷ 17%), for $k_{fill} = 0.3$ in the range (16 ÷ 24%) and $k_{fill} = 0.2$, range (22 ÷ 45%).

Depending on the results k^2_f simulation load profiles (6-14) and by (1) $k_{fill} = 0.3$ from k_{min} shown in Fig. 5.

Dependence of the error in k^2_f by (1) $k_{fill} = 0.3$ from k_{min} is shown in Fig. 6.

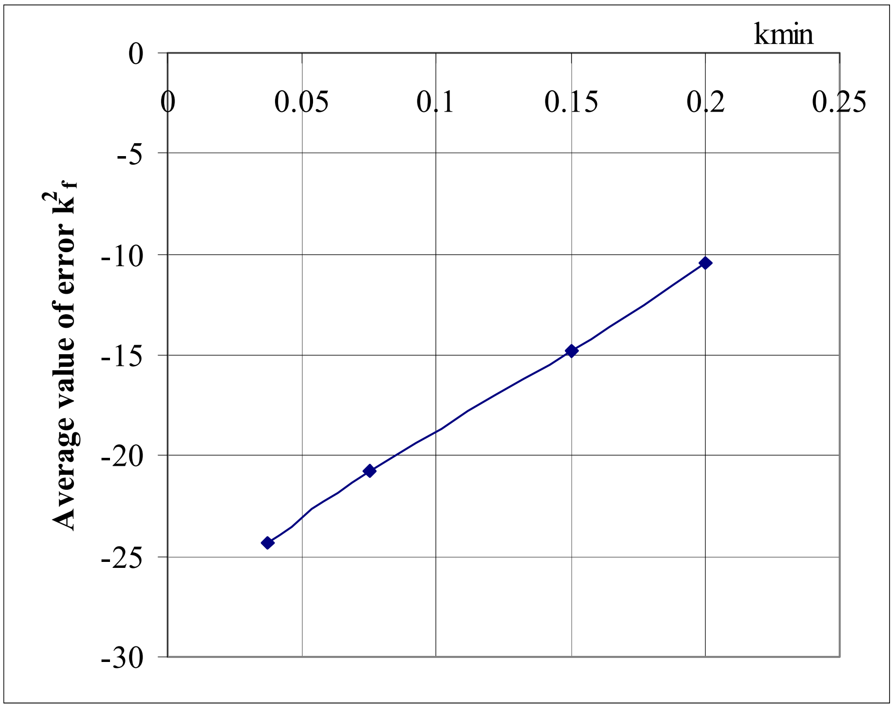

Fig. 6. Dependence of the error in k^2_f by (1) $k_Z = 0.3$ from k_{min} .

A comparison of shape factor family of load profiles on duration as a power function (7) and expression (8) show that, depending on the value of t_{max} approximation coefficients α and ρload profiles take different values. k^2_f value varies in the range 1.631 ÷ 1.856.

Approximation load profiles dependence (7) compared with (8) and algorithm (9) - (13) has a negative error of the estimated 7-30% depending on the k_{fill} and k_{min}.

The reasons for the growth of systematic errors (1) for small values of the fill factor due to the use for the approximation of production schedules depending on the form (7), which in this case, the forms chart from almost zero to a maximum load.

Using simulation diagrams of electrical loads according to the algorithm (6) - (14) allows more flexible modelling k^2_f and meets the additional desired parameters: the duration of the minimum and maximum loads.

Thus, the use of simulation load profiles exponential dependence of the form (8) differs from the known fact that is based on close to real load profiles and, accordingly, improves the accuracy of simulation k^2_f.

Conclusions

1. The technique of simulation load profiles of possible schedules for the duration of the electrical loads in the form of a continuous function approximation schedules exponentially.

2. Produced by comparison of the calculated form factor k^2_f with the results used in practice, empirical formulas, and establishes the presence of significant systematic errors at small values of the fill factor to 30%.

3. The proposed technique for modelling the characteristics of load profiles duration as a continuous function of improving the accuracy and flexibility of modelling k^2_f and losses in distribution networks.

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