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ECONOMIC LOAD INTERVALS FOR SELECTION OF CABLE SECTIONS FOR AGRICULTURAL PURPOSE

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Abstract. The article is devoted to the issues of choosing the optimal cross-section of cables and their scales for the lines of rural electrical networks by the method of economic intervals for various laws of load growth, taking into account the restrictions on long-term permissible current loads and permissible voltage loss, and a comparison of the load boundary obtained on the optimization model with economic intervals is carried out load.

Introduction

Electrical distribution networks for agricultural purposes are characterized by a constant increase in loads. In these conditions, the correct choice of the parameters of power lines and, first of all, the cross-sections of wires of overhead lines and cables of cable lines is of great importance. To select the cross-sections of cable power lines, until now, the economic current density is widely used, which does not meet the condition of the minimum total costs [1-8]. In this regard, it became necessary to determine the economic load intervals for the selection of cable cross-sections and the solution of related problems, taking into account the dynamics of load growth.

In this case, the boundaries of economic intervals for adjacent sections for the case that does not take into account the dynamics of load growth are determined [9-10]:

$$S_{\text{гр}} = \sqrt{\frac{(E_{\text{н}} + p_a)(K_{i+1} - K_i)U_{\text{н}}^2\gamma F_{i+1}F_i 10^5}{U_{\Pi}(F_{i+1} - F_i)}} \quad (1)$$

where F_i and F_{i+1} are standard sections; $E_{\text{м}}$ - standard efficiency ratio, p_a- standard depreciation deduction ratio; $U_{\text{н}}$ - Rated voltage; K_i and K_{i+1} - values of capital costs; $U_{И}$ - the cost of compensating for electricity losses.

The boundary values of the economic load intervals, taking into account the dynamics of load changes, are determined:

$$S_{\text{гр}} = \sqrt{\frac{(E_{\text{н}}+p_a)(K_{i+1}-K_i)U_{\text{н}}^2\gamma F_i F_{i+1}10^5}{U_{\Pi}(F_{i+1}-F_i)A}} \quad (2)$$

where is the coefficient determined by the law of load growth.

To take into account the laws of load growth, the shear coefficient is convenient. In this case, the shift coefficient is determined:

$$k_{\text{c}} = A^{-\frac{1}{2}} \quad (3)$$

The shear factor does not depend on the cross-section of the cables and is determined by the factor relative to the load growth (multiplicity of load growth) and the design period.

To study the effect of various laws of load growth on the shear coefficients, appropriate calculations were made. The calculation results are shown in Fig. 1 and 2.

In all possible cases, the shift factor is always greater than one. At the same time, the boundaries of economic load intervals will always be large when choosing cable cross-sections for lines on which the load changes over time. Thus, having determined the boundaries of the economic intervals of the load without taking into account the change in the load over time and using the coefficients of the shift of the boundaries of the economic intervals, it is possible to determine the boundaries of the economic intervals for any laws of growth of the load.

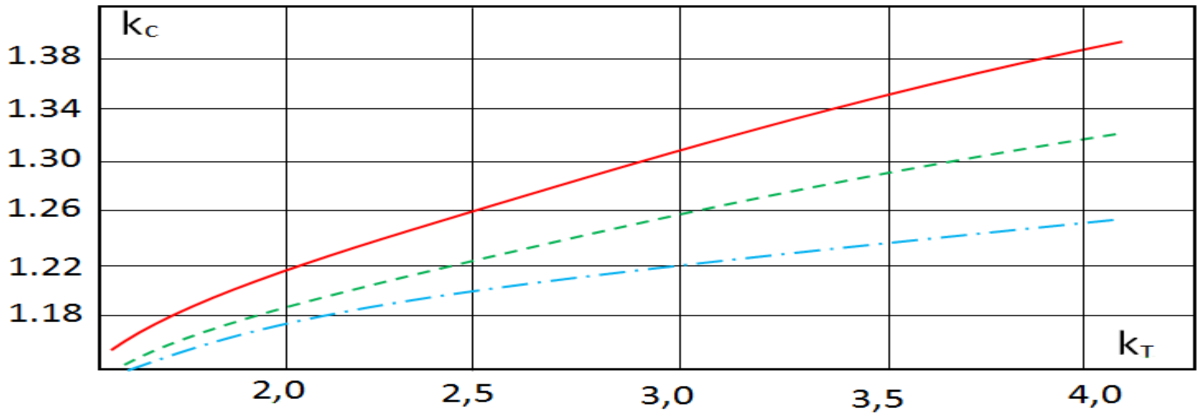

Fig. 1 Dependence of shear coefficients on change

k_T for a) $T = 15$ years; —— $k_c^э$; – – –$k_c^ч$; –·–$k_c^{мэ}$;

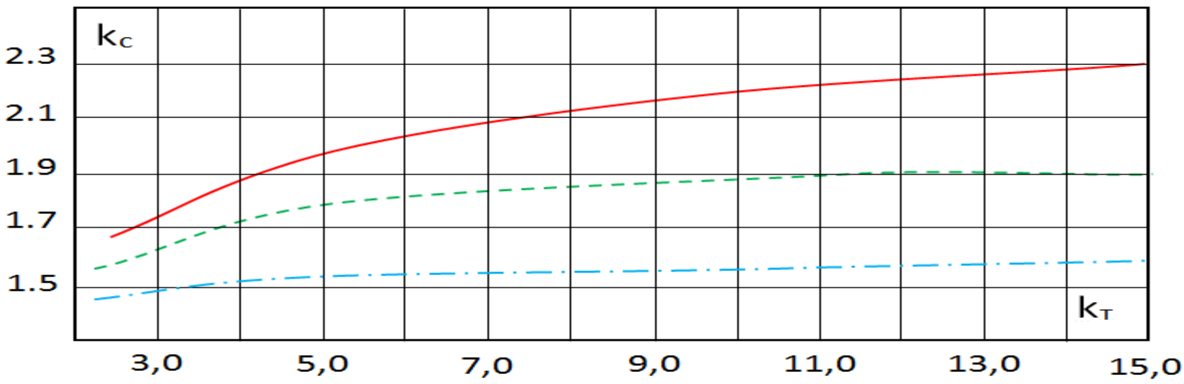

Fig. 2. Dependence of shear coefficients on change

k_T for a) $T = 30$ years ; —— $k_c^э$; – – –$k_c^ч$; –·–$k_c^{мэ}$;

In all possible cases, the shift factor is always greater than one. At the same time, the boundaries of economic load intervals will always be large when choosing cable cross-sections for lines on which the load changes over time. Thus, having determined the boundaries of the economic intervals of the load without taking into account the change in the load over time and using the coefficients of the shift of the boundaries of the economic intervals, it is possible to determine the boundaries of the economic intervals for any laws of growth of the load [11-13].

Comparison of the load boundaries obtained on the optimization model with the economic load intervals showed the following. When the restrictions on long-term permissible current loads and permissible voltage loss are removed, the load boundaries determined according to the proposed program practically coincide with the economic load intervals, the optimization model, determined taking into account the shear coefficient for any duration of the design period (Tables 1-3). Thus, for any settlement period, the boundaries of economic intervals coincide. Based on such a comparison, it can be concluded that the proposed optimization model is correct [14-16].

For calculated periods of 10 and 15 years, the boundaries of economic load intervals determined by the method of economic intervals and by the optimization model, taking into account the limiting conditions, practically coincide (the relative error does not exceed 1%, i.e. the discrepancy is explained by the accuracy of the calculations) [17-22]. With the duration of the calculation period of 20 years, the upper boundaries of the economic load intervals for the cross-section of cable conductors of 50, 120, 150 and 185 mm^2 do not coincide. However, for the rest of the sections, the boundaries of the economic load intervals practically coincide [23-28].

Table 1

The upper limits of economic load intervals, taking into account

Section, mm2	Calculated period, years			
	10	15	20	30
16	269	310	363	513
25	441	507	594	839
35	569	655	767	1086
50	944	1087	1272	1798
70	1169	1346	1575	2227
95	1456	1675	1954	2772
120	2009	2312	2707	3826
150	2417	2782	3257	4604
185	2856	3291	3853	5445

Table 2

Upper boundaries of economic load intervals according to the model

Section, mm2	Calculated period, years			
	10	15	20	30
16	268	311	361	525
25	443	503	594	831
35	567	658	765	1051
50	948	1095	1274	1795
70	1170	1346	1572	2232
95	1453	1672	1954	2801
120	2009	2315	2718	3852
150	-	2781	3250	4596
185	-	-	3865	5472

Table 3

Economic load intervals according to the optimization model taking into account the limiting conditions

Section, mm2	Calculated period, years			
	10	15	20	30
16	268	311	361	394
25	443	503	595	613
35	567	651	765	832
50	948	1095	1189	1269
70	1175	1346	1572	1751
95	1453	1672	1954	2145
120	-	2308	2570	5122
150	-	2781	3101	6347
185	-	-	3674	7310

Thus, the boundaries of the loads determined by the proposed optimization model without taking into account the influence of the limiting conditions fully correspond to the boundaries of the economic intervals of the load, determined taking into account the shear coefficient, subject to the conditions of comparability. To select the cable sections of the lines, the relationships were established between the boundaries of the economic load intervals, the values of the load intervals themselves and the value of the total costs at the boundaries of the economic load intervals. The influence of the nature and dynamics of changes in the load on the boundaries of economic intervals is investigated and the shift coefficient is proposed.

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