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The algorithm of economically beneficial overhead wires cross section selection using corrected transmission lines mathematical models

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Abstract

The paper presents an unparalleled electric power system operating mode optimization algorithm aimed to economically beneficial overhead wires cross section selection with respect to electricity rate, electric power system elements price, reliability problem. The algorithm in question allows eliminating the limitation on the maximum allowable wires cross section with the help of corrected transmission lines mathematical models.

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Keywords: electric power system engineering; optimization; wires cross section; method of coordinatewise optimization; equivalent circuit; mutual inductance.

1. Introduction

To date due to the load rise a lot of existing electric power systems (EPS) need to be reconstruct-ed. Also new electric power supply systems are being constructed for a new objects. So the problem of sustainable EPS scheme selection is raised. The conditions of economically advantageous EPS variant choice are system scheme, wires cross section, voltage level, measure of reliability, number of back-up power sources, the number and points of installation of compensating devices. The above mentioned factors in turn determine power, electricity and voltage losses, investments into the EPS under reconstruction or engineering.

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The first step of power system engineering is a loads computation resulting in transformers and wires selection. At the moment according to the Electrical Installations Code the choice of wires cross section is executed on the basis of economic current density. But such a way does not allow to take into account the above mentioned factors in terms of modern EPS. Thus in the [1] reliability of overhead electric transmission lines (OHL) accountance and in [2] the question of reactive power compensation are considered. Moreover the choice of economically advantageous EPS scheme variant, wires cross section in particular, is executed using direct search method that lengthen dramatically the process of EPS engineering on its first steps.

Consequently the algorithm of optimal OHL wires cross section selection should be elaborated. The algorithm in question is supposed to be materialized using coordinatewise optimization method in combination with penalty function approach.

2. Optimization algorithm

Basing on the preplanned EPS scheme and calculated parameters of its operation mode using the methods of matrix math providing certain wires cross section variants the optimal ones are chosen.

To understand the approach of optimal power flow in power systems there are a lot of views. At the [3] authors using the gradient-type interaction prediction approach to define the optimal control problems. The article [4] presents a gravitation search method to find an optimal power flow in a distribution network. The other way in response to this problem is the use of differential evolution method [5]. Power supply systems are described with multi-objective function. In order to address the multi-objective optimal power flow at the [6, 7] algorithms of evolutionary programming, genetic algorithm, and particle swarm optimization are considered. The other way is described at [8].

Authors of this paper offer to solve the problem of multi-objective optimization using coordinatewise optimization method [9, 10].

The optimally criterion is the minimum of EPS construction and operation costs (C) with respect to the electric power supply interruption costs. So target function is computed according to (1)

$$\min C(I + OC_{\Delta P} + IC), \tag{1}$$

where C – aggregate costs, RUR; I - investments into the EPS, RUR; $OC_{\Delta P}$ - cost of power transmission, RUR; IC - electric power supply interruption costs, RUR.

When calculating investments according to (2) it is necessary to take into account wires cost, OHL construction costs, climate region and investments into the switching equipment.

$$I = I_{OHL} + I_{SE}, \tag{2}$$

where I_{OHL} – investments into the OHL construction costs, RUR; I_{SE} - investments into the switching equipment, RUR.

The cost of power transmission is calculated according to (3)

$$OC_{\Delta P} = \sum_{i=1}^{n} \Delta P_i \cdot \tau_i \cdot \beta_i , \tag{3}$$

where n – number of EPS regions; ΔP_i – power losses, kW; τ_i – the using time of power losses, h; β_i – electricity rate, RUR/kWh.

Power losses are calculated with respect to EPS operation mode parameters. Electricity cost is offended by the power supply organization. The using time of power losses according to [2] is to be computed using the following empirical equation (4).