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METHOD OF THE INPUT REACTIVE POWER CORRECTION FOR CONSUMERS

The method of input reactive power correction is proposed . It is shown that it is expedient to solve the problem taking into account economical stability that allows to realize the input reactive power correction only for some consumers. It allows to decrease expenses for input reactive power correction.

Keywords: *input reactive power, correction, economical stability, expenses.*

Introduction

Electric power losses decrease in electric networks of power supply systems is one of the most urgent problems of these networks. Losses reduction can be achieved at the expense of condenser installations (CI) mounting in consumers' networks. Solving of this problem requires the definition of economically expedient values of reactive power, transmitted to consumers from a power supply system (input reactive power of consumers) and, accordingly, power of CI . There are methods of input reactive power calculation nowadays [1,2]. The calculation results application provides the state of the network which corresponds to the least value of expenses for reactive power transmission. New consumers are being constantly connected to the network. This connection results in additional expenses and the input reactive power for all consumers needs to be corrected. But these corrections are rather complicated in practice.

The purpose

The purpose of this article is the additional decrease of expenses for reactive power transmission at minimum input reactive power correction for consumers.

Problem statement

Let a new consumer be connected to the network. The substitution circuit is shown in Fig.1.

In [3] it was proposed that the optimal input reactive power values for active consumers before and after connecting of a new consumer are calculated as:

$$Q_{ob} = \frac{E_{CI} \cdot U_n^2}{2 \cdot c_0 \cdot R_{Nb}}, \; Q_{oa} = \frac{E_{CI} \cdot U_n^2}{2 \cdot c_0 \cdot R_{Na}} \cdot \frac{\mathrm{r_b} // \mathrm{r_n}}{\mathrm{r_b}}, \tag{1}$$

where $\mathrm{R_{Nb}}$, $\mathrm{R_{Na}}$ – the equivalent resistances of the network before and after the connecting of a new consumer accordingly and are calculated as:

$$R_{Nb} = r_n + r_b, \; R_{Na} = r_a + \frac{r_b \cdot r_n}{r_b + r_n}. \tag{2}$$

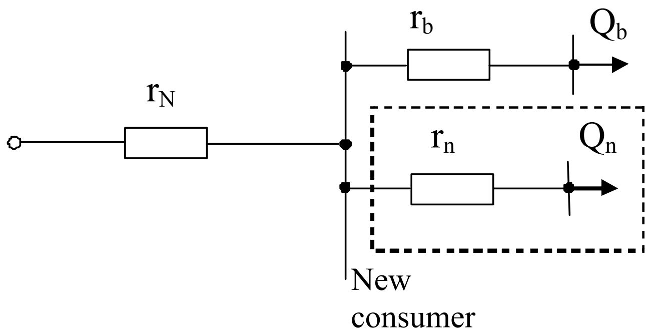

Fig. 1 – Equivalent circuit of electric power network when a new consumer was connected, r_b, r_n, r_N – the equivalent resistances of electric power system, of active consumer and a new consumer accordingly; Q_b, Q_n – the reactive loads of active and new consumers3

From (1) and (2) it follows that $Q_{ob} \neq Q_{oa}$.

As the condenser installation power which is reasonable to install in electric power network for an active consumer before and after a new consumer was connected are defined as:

$$Q_{CIb} = Q_b - Q_{ob}; \quad Q_{CIa} = Q_b - Q_{oa}, \tag{3}$$

than we get: $Q_{CIb} \neq Q_{CIa}$.

In other words we have to correct the input reactive power of CI for active consumers taking into account new consumers.

The realization of this correction is impossible in practice. It requires the correction of CI power in all the nodes of electric power systems and ,accordingly, considerable additional expenses. Therefore we should develop a necessary method of the input reactive power correction for consumers. This method should provide economically expedient results and give possibility for their practical application.

The main part

Let a new consumer be connected to a network. This network is characterized by a matrix of node resistance $\mathbf{R_b}$ and a matrix of mean reactive powers $\mathbf{Q_b}$. Node resistance matrices $\mathbf{R_a}$ and mean reactive power matrix $\mathbf{Q_a}$ **correspond to** new state of the network.

According to [3] matrix of optimum values of CI power matrix before the consumer was connected is:

$$\mathrm{Q}_{bCI} = \mathrm{Q}_b - \mathrm{R}_b^{-1} \cdot C \tag{4}$$

and after consumer connection as follows:

$$\mathrm{Q}_{aCI} = \mathrm{Q}_a - \mathrm{R}_a^{-1} \cdot C \tag{5}$$

where C is matrix column which elements are characterized by technical parameters of the network.

Obviously the optimum values of CI power in nodes of active and new consumers are different:

$$\mathrm{Q}_{CIi}^{before} \neq \mathrm{Q}_{CIi}^{after}, \tag{6}$$

therefore it is necessary to change their capacity by the value:

$$\Delta \mathrm{Q}_{CIi} = \left| \mathrm{Q}_{b\mathrm{CIi}} - \mathrm{Q}_{a\mathrm{CIi}} \right|. \tag{7}$$

The problem is expedient to solve taking into account sufficient economic stability in problems of reactive power compensation(4). It allows to correct the input reactive power only for a determined number of consumers.

The criterion of the acceptability of such an approach is the inequality realization:

$$\frac{E}{E_{opt}} - 1 < \xi_d \,, \qquad (8)$$

where E- expenses for reactive power transmission in electric network which corresponds to selected variant of the problem solution (partial correction of the input reactive power). E_{opt} – value of expenses which correspond to optimal solution of the problem (the input reactive power correction for all the consumers), ξ_d – a set value.

The first step in the proposed method of the input reactive power correction to determine the input reactive power for a consumer which is connected when CI power for all active consumers is constant. If it leads to non fulfilment of ξ_d, then it is necessary to correct the input reactive power for active consumers. The problem should be solved proceeding from minimum numbers of corrections. There arises a question in what sequence is it necessary to perform input reactive power correction in order to obtain economically expedient solution with minimum quantity of correction?

First, it is necessary to make a correction in that node the CI of which decreases losses of active power in the network to greater extent.

When we correct the reactive load for i-th node by CI power value, than the value of losses reduction can be written as:

$$\delta P(Q_{ci}) = \frac{1}{U_n^2} \cdot (Q_b^{t} \cdot R_b \cdot Q_b - Q_a^{t} \cdot R_a \cdot Q_a) \qquad (9)$$

The input reactive power correction algorithm is presented in Fig. 2.

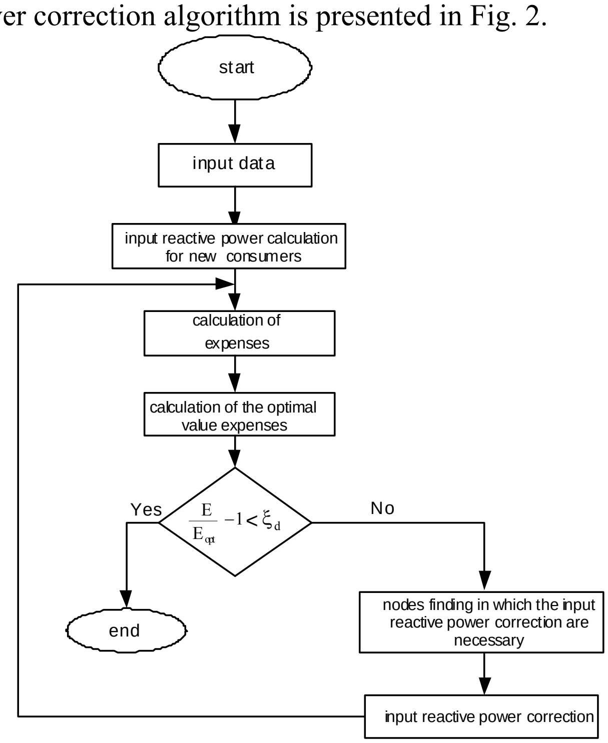

Fig. 2 – Block-diagram of input reactive power correction algorithm

Example

Define the expediency of the input reactive power correction for networks consumers. This substitution circuit is shown in Fig.3. The real flows of reactive power are shown on the diagram before a new consumer was connected, reactive loadings of consumers and active resistance values of the elements are reduced to 10 kV. The input reactive power values and reactive loadings are given in Mvar and active resistances – in Ohm. The permissible deviation of expenses from an optimal value $\xi_d = 0{,}05$. Specific cost of active power losses is 68,5 grn/kvar.

Solution

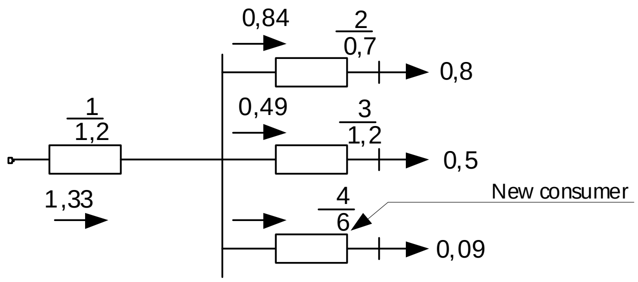

Fig. 3 – Equivalent circuit of electric power utilities

1. Find input reactive power value for a new consumer at constant values of CI power for all active consumers [3].

$$Q_c^{n.c.} = 0{,}027 \text{ Mvar.}$$

2. According to(1) we calculate value of expenses:

$$E\text{=44057,41 grn./year.}$$

3. Determine the optimum value of expenses after a new consumer is connected [3]:

$$E_{opt} = \text{42647,255 grn./year.}$$

4. Define deviation value : $\xi = \frac{E}{E_{opt}} - 1 = \frac{44057{,}41}{42647{,}255} - 1 = 0{,}032$.

If $\xi < \xi_d$, than the solution is acceptable and in given case it is non expedient to correct input reactive power for active consumers.

Conclusions

1. Connection of new consumers to power supply networks requires corrections of input reactive power of active consumers.
2. The input reactive power correction is expedient to perform taking into account economical stability of optimal solution of the problem of reactive power compensation that allows to reduce the number of corrections and accordingly expenses for their realization.

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