OPTIMIZATION OF OPERATION MODES BULK ELECTRIC POWER GRIDS

Samsonov D.O.
graduate of the faculty of power engineering and automatics
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute»

Kuchanskyy V.V.
PHD, senior researcher
Institute of Electrodynamics of the National Academy of Sciences of Ukraine
UKRAINE

The problem of optimizing the parameters and modes of power transmission and distribution systems is very complex and multifaceted. The tasks of optimizing the parameters of objects have to be solved at the design stage of the development or construction of the electrical grid. The current optimization of the modes is carried out during the operation of the grid [1].

Design, construction of electric grid facilities and their operation are associated with high material costs. Therefore, it is important that these costs are used most efficiently. It should be borne in mind that the correctness of decisions on the development of power transmission and distribution systems, taken at some point can occur after a sufficiently long time, when the mistakes made is impossible or very difficult to fix. Additional difficulties in developing a solution are related to the fact that usually there is uncertainty and insufficient reliability of the initial information. For example, the prospective load at some grid nodes is usually not known in advance exactly [2]. With a simplified approach to solving such a problem, three levels of load are set (the highest possible, the lowest and the average possible) and parameters are selected for all these levels.
The final decision is made on the basis of the appropriate techniques described in the literature. In any case, to optimize the parameters, an optimization criterion had to be previously selected. In the most general approach, usually not one, but several criteria, i.e. it is necessary to solve a multi-criteria (multi-purpose) problem. For example, the criteria may be capital costs, energy losses, grid capacity, degree of reliability of power supply, its degree of impact on the environment, etc. Methods for solving multi-tasking problems of the electric power industry are described in the special literature. In the simplest case, the multicriteria problem is reduced to the single-criterion one in which the optimization of the object’s parameters is carried out according to one criterion taken as the main one, and the remaining criteria are taken into account in the form of restrictions.

In fact, they begin to solve the optimization problem of parameters already at the stage of choosing the main design solutions, such as, for example, choosing the grid configuration, the nominal voltage of the lines, the cross-sectional area of their wires, etc. The main goal is to achieve the required technical effect (necessary power transfer capability, reliability power supply, voltage quality, etc.) with the lowest possible costs. Depending on the problem statement, one of the criteria is used as a performance criterion.

After choosing the main parameters to achieve the desired technical effect, an additional (but no less important) problem is solved using some additional devices and optimizing their parameters, which is predominantly aimed at obtaining an additional economic effect. This effect, first of all, is achieved by reducing energy losses, although the technical capabilities of the grid can also improve along the way (for example, increasing throughput, reliability, etc.).

In operating conditions, optimization tasks are fundamentally different from design tasks in that the search for the best mode is carried out without additional capital costs. Therefore, annual costs are the most general criterion for optimization. However, given that the annual costs consist of constant deductions from capital costs and the cost of electricity losses, it is possible to move from economic to technical optimization criteria. If the optimization of the mode of the electric grid is carried out for a certain period of time, then the loss of electricity is used as a criterion [1,2].

Power transmission, as noted above, as an integral part of power transmission systems, can perform the following functions [3-5]: transmission of large power capacities from remote power plants to system substations and consumption centers; transit or reverse transmission of power from one part of a system-forming grid to another when operating in parallel with a shunted grid of lower nominal voltage; the implementation of interconnections between individual domestic and interstate energy systems.

The most important factor in the selection and optimization of extended power transmission parameters is their power transfer capability, which usually acts as an optimization criterion. All other factors in the optimization of design parameters and operating modes are additional, aimed at achieving the main objective of ensuring the given throughput ability in the best way. The power transfer capability is mainly limited by the limit of the transmitted power under the condition of static stability of the generators of power plants connected by this power transmission.

Another important task in the selection and optimization of parameters, powerful extended power transmissions is that they, as a rule, work with a time-variable load. Therefore, if the parameters are selected to ensure a given power transfer capability in the maximum load mode, then in other modes, especially in the low-load mode and no-load mode, the voltage along the line can be set outside the permissible limits. The
reason for this is the excess of line power over reactive power losses when the line is operated with sodium less than natural. Therefore, the principle of compensation of meters of a power line to a natural mode close to it may be attractive. However, to create such a regime in the entire range of preset power transmitted over the line requires adjustable devices.

The main sources of reactive power are generators of power plants, power lines (due to charging power) and transverse compensating devices [5], compensations connected in parallel with the load. As noted above, the inclusion of compensating devices in the nodes of the electric grid leads to unloading of the grid elements from reactive power, the consequence of this is a reduction in load losses of power and electricity. Thus, by changing the flows of reactive power (controlling them), it is possible to improve the economic performance of the grid.

The task of optimizing reactive power flow control is divided into two subtasks; design, associated with the selection of additional compensating devices, and operational, the solution of which requires the selection of optimal operating modes of compensating devices already installed in the grid. It should be noted that the energy systems of many developed countries have encountered this problem. In power systems with a branched high-voltage grid, automatic excitation regulators of generators, as a rule, cannot cope with the consumption of excess reactive power. The overexcitation mode is extremely unfavorable for all types of generators - for turbo-generators this mode is dangerous from the point of view of the thermal state of the extreme stator iron packets and frontal parts. The problem of charging power consumption of extra high voltage overhead power line manifested itself most clearly after the commissioning of long power lines of classes 500 and 750 kV [3-5].

The practice of using controlled shunt reactors showed that as a result of putting the reactor into operation in automatic voltage stabilization mode: voltage fluctuations at the connection point are limited to ± 1.5% relative to the set voltage, while reducing the number of switching transformers by about 100 times; during hours of the maximum load schedule, energy losses in the adjacent grid are reduced to 2.5 MWatt, which ensures the return on the reactor in less than 3 years; Uninterrupted power supply to consumers. At the same time: the volume of installation and commissioning is comparable with the amount of commissioning of a shunt reactor; in automatic mode, the reactor does not require the intervention of operating personnel.