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ADAPTIVE OPTIMAL CONTROL OF ELECTRIC POWER SYSTEM OPERATION MODE ON THE BASE OF LEAST ACTION PRINCIPLE

Electric power systems (EPS) by their nature are inhomogeneous and this characteristic feature always leads to additional losses of electric energy in the process of its transport and distribution. Availability of the existing mechanism of the feedback, due to which self regulation of the system occurs, cannot provide the most profitable, from the point of minimal losses of electric energy and its quality, mode. Minimize these losses, i.e. move from natural state of EPS to optimal one, becomes possible only applying forced actions. There appears the problem how it is necessary to change the path of EPS states in accordance to its load change. Do this requires to evaluate the extent to which it is possible and expedient to improve EPS mode, taking into account mode parameters limitations.

In [1] it is shown that on the base of least action principle (LAP) system of optimal control of ESP operation modes can be built. In active-adaptive control system (AACS) of EPS normal mode, built in accordance with SMART Grid principles, where the model of its economic mode is used as a reference model and sources of electric energy are presented by the characteristics of economic resistances, optimal control in EPS is realized in such a way that current modes are directed and approach to ideal mode.

The problem is formulated as the problem of optimal control with limitations and fixed initial time t_0 and fixed final time t_f, where optimality criterion is minimum losses of electric energy[2]:

$$W_o = \min \int_{t_0}^{t_f} [\,F(\mathbf{P}, \mathbf{Q}, \mathbf{U}, \mathbf{u}, t) - F_e(\mathbf{P}_e, \mathbf{Q}_e, \mathbf{U}_e, \mathbf{u}_e, t)]dt,$$

under condition, that $\mathbf{P} \in \mathbf{D}_P$, $\mathbf{Q} \in \mathbf{D}_Q$, $\mathbf{U} \in \mathbf{D}_U$, $\mathbf{u} \in \mathbf{D}_u$,

where F, F_e – functional of active power loses in current and economic (ideal from the point of electric energy losses) modes correspondingly; $\mathbf{P}$, $\mathbf{Q}$ and $\mathbf{P}_e$, $\mathbf{Q}_e$ – active and reactive powers of current and economic modes correspondingly; $\mathbf{U}$ and $\mathbf{U}_e$ – voltages of EPS nodes in current and economic modes; $\mathbf{u}$ and $\mathbf{u}_e$ – EPS control parametrs, their change from $\mathbf{u}$ into $\mathbf{u}_e$ maximally approaches EPS mode to economic mode; $\mathbf{D}_P$, $\mathbf{D}_Q$, $\mathbf{D}_U$, $\mathbf{D}_u$ – admissible areas of mode $\mathbf{P}$, $\mathbf{Q}$, $\mathbf{U}$ parameters and control parameters $\mathbf{u}$ correspondingly.

To approach (optimize) losses of electric energy to idealy possible, it is necessary constantly in the process of operation to perform in the system optimizing actions by regulating facilities. It is possible to compensate additional losses in EPS by means of voltage regulation in EPS nodes and introduction of balancing e.m.f. in the loops. In this problem control variables are e.m.f. that must be introduced in all closed loops for realization of optimal current distribution. According to economic resistances of electric power plants and sources of reactive power (SRP), their optimal loads are determined. Unlike the existing systems of optimal control, where characteristics of relative increments and simplified model of EPS are used, in AACS sources of electric energy, including renewable ones, are modelled by the characteristics of economic resistances and EPS – by its equivalent *R*-circuit. As information support data base of on-line information complex of EPS is used. It should be noted, that in AACS, constructed in such a manner, complex optimization of EPS modes by active and reactive powers is realized.

Conclusions. The suggested approach to creation of active-adaptive control system of EPS mode, using its ideal (economic) modes enables to make optimal control process more rational. It is built in such a manner that EPS mode, using control facilities, is introduced in optimality area, i.e., it approaches to economic mode as close as mode parameters limitations (voltage of the nodes, flows of power in branches, etc.) allow. The advantage of the given approach is that the system of optimal control, built in such a way, does not require the determination of numerical value of optimality criterion and corresponding parameters of EPS mode.

References

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