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Optimization of Short-Term Modes of Power System that are Part of Interstate Energy Associations

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ABSTRACT: One of the important problems of international joint power systems short-term modes dispatching management is maintenance in each interval of considered cycle of regulation the optimal power flows on the interstate electrical power transmission lines, corresponding to interests of the participant states. Such optimal power flows can be defined on the base of using the specially developed algorithms for these purposes. In the given paper the algorithm of optimal power flows calculation on interstate intersystem electrical power transmission lines, at planning of short-term modes of the power systems which are included to international joint power systems is offered.

KEY WORDS: Power System, Optimization, Optimal Mode Planning, Power Flow, Load Schedule, Load Optimal Distribution, Fuel Costs, Intersystem Power Transmission Line.

I.INTRODUCTION

The electric power system (EPS) of the Republic of Uzbekistan (RUz) functions some years as a part of an interstate electrical power pool (EPP) of the Central Asia independent states, being its basis. In this conditions optimal planning of EPS modes of participant states, particularly of the RUz, have to be made taking into account specialties of its functioning.

Benefits from teamwork of EPS of the independent states approved with the long-period experience of functioning of some interstate EPP, such as, UCPTE, NORDEL, USA-Canada, etc. [1-3].

The conditions of participation EPS of the independent states in maintenance of joint power systems (JPS) functioning reliability and qualities of the electric power (in particular, participation in frequency regulation) is defined by in advance confirmed mutual agreements and contracts.

On the international practice of interstate JPS functioning one of the important requirements established to partners is necessity of providing of ability to cover own loadings at any time at the expense of own stations and the electric power received from power systems of the neighbour states under contracts, including cases of simple emergency infringements, such as losses of the great on capacity generating block, the planned delivery of the electric power.

In these conditions optimal planning of mode of the EPS which is member of EPP should be carried out with simultaneous optimization of power flow on interstate intersystem power transmission lines (PTL).

In the literature there are no concrete methods and algorithms for decision of the considered problem. And existing algorithms of optimization of EPS modes, in particular, the algorithms resulted in [4-12], cannot be directly used for this purpose.

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II. EXPERIMENTAL PART

In the given work the algorithm of optimization of power flows on interstate intersystem PTL at EPS short-term modes planning is offered. The essence of the algorithm consists of following:

1) on the basis of use of data about cost of the delivered power, defined by interstate agreements for each of intersystem PTL (or for their groups) for each interval of the regulation cycle constructs the dependences of cost on delivered power;

2) each of the intersystem PTL (or their groups) are replaced, in the colculation sense, with corresponding fictitious stations and for their fuel cost characteristics the constructed dependences of cost on delivered power are accepted;

3) the optimal covering of the EPS load schedule by settlement and fictitious stations on its fuel cost characteristics is carried out.

Received schedules of loadings of fictitious stations are optimal schedules of power flows on interstate intersystem PTL.

Computing efficiency of the described algorithm is investigated on example of calculation of optimal power flows on intersystem PTL 6-3 and 10-4 for EPS-1 and EPS-2 which are forms EPP (Fig.1). In nodes 0, 3, 5 of EPS-1 and 7, 10, 11 of EPS-2 are available settlement thermal power stations with the fuel cost characteristics which have a square-law polynomial form, $/h.:

$C(P) = a+bP+cP^2$.

Factors of characteristics are presented in table 1 (for all of TPS accepted a=0).

Table 1. Factors of fuel cost characteristics of TPS

TPS	0	3	5	7	10	11
b	4,0	6,0	8,0	4,8	4,0	6,0
c	0,024	0,02	0,016	0,02	0,032	0,024

Nodes 1, 2, 4 with powers 500, 300, 200 MW in EPS-1 and 6, 8, 9 with powers 250, 450, 350 MW in EPS-2, accordingly, are consumers load points.

For convenience was accepted, that each of the EPS is ready to buy (or to sell) power at the cost equal to optimal cost for the consumers. In that case the cost characteristic of power sold by each of EPS to other one which is called as the characteristic of offer of the EPS is possible to define through simple summation of fuel cost relative increases characteristics of included settlement TPS, with its subsequent integration. As a result of such calculation for considered EPS following characteristics of the offer, i.e. dependence of costs on total power flows of intersystem PTL are received:

$C_{12} = 19{,}24P_{12} + 0{,}00649P_{12}^2$, $C_{21} = 22{,}09P_{21} + 0{,}00814P_{21}^2$,

where P_{12}, C_{12} (P_{21}, C_{21}) – total power flow from EPS-1 to EPS-2 (from EPS-2 to EPS-1) and its cost, accordingly.

Here it is necessary to notice, that last statement about reception of the characteristic of offer takes place in the conditions of absence of active functional limitations in the form of inequalities. At the presence of such limitations the characteristic of offer should be defined with their account on special algorithms

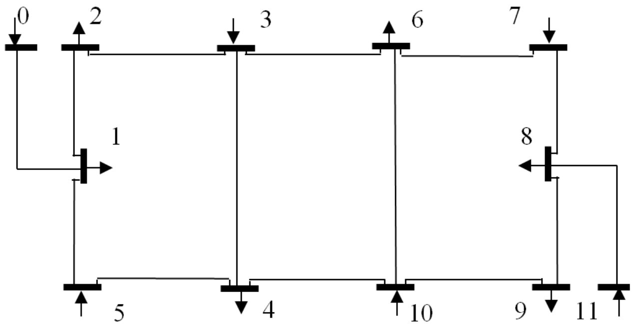

Figure 1. The equivalent scheme of JPS

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According to the offered algorithm for definition of the optimal power flow from EPS-2 to EPS-1 the following problem of optimization is solved:

to minimize criterion function

$C_I=C_0 (P_0) + C_3 (P_3) + C_5 (P_5) + C_{21} (P_{21})$

taking into account limitation

$P_0+P_3+P_5+P_{21}=P_1+P_2+P_4$.

Last problem, in this case, can be solved with the method based on equality of cost relative increases. The result of its decision is following: P_0=343,87 MW, P_3=362,64 MW, P_5=390,81 MW, P_{21}=-97,32 MW.

Similarly, the problem for definition of the optimal power flow from EPS-1 to EPS-2 is formulated:

to minimize criterion function

$C_{II}=C_7 (P_7) + C_{10} (P_{10}) + C_{11} (P_{11}) + C_{12} (P_{12})$

taking into account limitation

$P_7+P_{10}+P_{11}+P_{12}=P_6+P_8+P_9$.

The results of decision of the last problem: P_7=392,60 MW, P_{10}=257,87 MW, P_{11}=302,16 MW, P_{21}=97,37 MW.

Thus, as a result of optimal distribution of consumers loads of EPS-1 and EPS-2 between their real and fictitious TPS optimal total power flows on intersystem PTL are defined:

P_{21} =-97,3 MW, P_{12}=97,3 MW.

It means, that in a considered case for EPS-1 it is favorable to sell power 97,3 MW at cost which is optimal for its consumers. And for EPS-2, on the contrary, it is favorable to buy power 97,3 MW also at optimal cost for its consumers.

Let's notice, that optimal total power flows on intersystem PTL for separate EPS (both for EPS-1 and EPS-2) have appeared identical. Because on the condition accepted above both EPS are ready to sell and buy power at optimal cost for its consumers. Generally, cost of sold (bought) power can differs from optimal cost for the consumers.

For check the truth of the received results, in particular, optimal for both EPS-1 and EPS-2 power flows on intersystem PTL optimal distribution of JPS loading between all six TPS is carried out. The results of optimization: P_0=343,87 MW, P_3=362,64 MW, P_5=390,81 MW, P_7=392,61 MW, P_{10}=257,87 MW, P_{11}=302,16 MW.

On the last results we will note, optimal loadings of TPS have turned out same as a results of above solved problems for EPS-1 and EPS-2 separately. In that case from a condition of power balance in separate EPS we will receive, that the total power flow on intersystem PTL 6-3 and 10-4 (Fig.1) 97,3 MW. It confirms reliability received above results and conclusions.

III. CONCLUSION

1. The algorithm of optimization of power flows on interstate intersystem PTL based on replacement such PTL with fictitious stations is offered. Thus, as a power characteristics of fictitious stations accepts the appropriate dependences of costs of transferred from the neighbor EPS power on power flow of intersystem PTL (the characteristic of offer of the neighbor EPS).

2. In special cases when functional limitations in the form of inequality are absent and also separate EPS are ready to sell and buy power at optimal for its consumers costs, characteristics of offer of separate EPS (i.e. fictitious TPS power characteristics) can be defined through simple summation of abscises of settlement TPS in these EPS on fuel costs relative increases equality. Generally, such characteristics are defined by separate criteria for EPS which are included to EPP.

3. The optimal total power flows on intersystem PTL for EPS which is included to interstate JPP, generally, can be turn out different. In such cases the problem consists in a finding of the best compromise for both participants of the market at which the normal operating mode of JPS is provided.

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