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Optimizing the state of the power system by taking into account the losses in the network by calculating their output

T.Sh.Gayibov, K.M.Reymov, B.A.Uzakov

Doctor Professor (DSc), Department of "Electric Power Stations, Networks and Systems", Tashkent State Technical University, Tashkent, Uzbekistan
Assistant Professor (PhD), department of "Power Energy" Karakalpak State University, Nukus, Uzbekistan
Senior teacher, department of "Power Energy" Karakalpak State University, Nukus, Uzbekistan

ABSTRACT: The article examines the impact of various methods and algorithms for calculating waste products on the results of optimization in optimizing the state of the energy system. Taking into account the losses in the power grid leads to significant changes in the distribution of the active load of the power system between stations, in general. In this process, optimization occurs not only due to the optimal distribution of losses in the power grid between stations, but also due to its reduction. In addition, an effective algorithm for determining the waste products based on the decomposition of a system of linear equations in the optimization of the state of power systems is proposed.

KEYWORDS: Power System, Optimization, Power Flow, Load Schedule, Load Optimal Distribution, Fuel Costs.

1. INTRODUCTION

The calculation of power and electricity losses in the main electrical networks provides for the determination of all regime parameters that can be determined based on the calculation of their normal modes. The initial (set parameters) for such calculations, usually, are, in addition to the electrical network diagram and their calculated parameters, active and reactive powers of the nodes. In some cases, active powers and voltage modules are set for generating nodes. Such nodes are called anchor nodes.

A number of methods and algorithms for calculating the normal modes of electrical networks are known from the literature [1-6]. They have characteristic features. Each of these algorithms is effective only for calculating the normal modes of electrical networks in certain specific tasks. Therefore, it is important to choose the appropriate methods for calculating normal modes for typical electrical networks.

Optimizing the state of the power system taking into account the losses in the network will be to ensure the fulfillment of the optimality condition (1) in the absence of functional boundary conditions.

$$\left.\begin{aligned} &\eta_1 b_1 = \eta_2 b_2 = \cdots = \eta_n b_n = -\mu, \\ &P_1 + P_2 + \cdots P_n = P_н + \pi. \end{aligned}\right\} \qquad (1)$$

In this case, the determination of losses and their derivatives is based on the calculation of the stabilized state of the power grid.

The classic algorithm for optimizing the state of the power system taking into account the losses in the network is based on the gradual introduction of the network factor. According to it, after each step of optimization, based on the calculation of the stabilized state of the network, the total active power loss, the product of losses and network factors for all stations involved in the optimization are determined, the relative growth characteristics of stations $b_i(P_i)$ is formed, η_i $\eta_i b_i(P_i)$ is formed. The next step in optimization is then performed using the newly reconstructed characteristics of the stations. This iterative process continues until condition (1) is satisfied [7-10].

The results of the study show that in the presence of long and overloaded lines in power systems, the values of η_i vary sharply from iteration to iteration and in some cases oscillate, so the iteration process can also be oscillating, sometimes distant.

There is a more effective way and algorithm to solve the problem to overcome these difficulties, the essence of which is as follows. Regardless of the network factor (the first stage of optimization), the load schedule is distributed between stations. Then, based on the calculation of the stabilized states of the power grid for each hour or characteristic

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time intervals, the corresponding total active power losses, product of losses and network coefficients are determined. In this case, the characteristics of the dependence of the network coefficients on the active capacity of the corresponding stations $\eta_i=\varphi(P_i)$ are formed, because the capacity of each station is variable throughout the day and the calculation of stabilized states determines the corresponding network coefficients. In this case, the initial relative growth characteristics of the stations are formed by multiplying $b_i=f(P_i)$ by the corresponding bonds $\eta_i=\varphi(P_i)$ in the form of $b_i=f(P_i, \eta_i)$. Subsequent optimization is performed using the last relative growth characteristics generated.

II. EXPERIMENTAL PART

The scheme of efficiency of optimization algorithms taking into account the state losses of the power system and their derivatives by calculations using the above methods was studied in the example of optimization of the state of the EET shown in Figure 1.

In this case, the load schedule with five characteristic intervals requires optimal coverage, taking into account the losses in the network using IESs with the following conditional fuel consumption characteristics located at nodes 0, 1, 6, 7, t.o.e./hour:

$$B_0 = 60 + 0{,}12P_0 + 0{,}00055P_0^2, \quad B_1 = 90 + 0{,}1P_1 + 0{,}0007P_1^2,$$
$$B_6 = 70 + 0{,}11P_6 + 0{,}0004P_6^2, \quad B_7 = 80 + 0{,}15P_7 + 0{,}0005P_7^2.$$

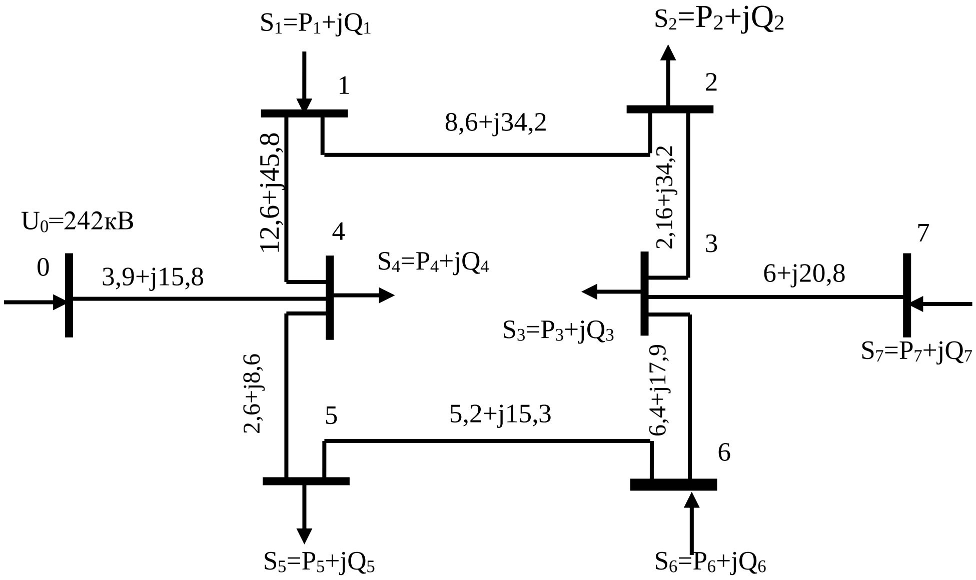

Figure 1. Schematic of the power system

There are consumers at nodes 2, 3, 4, and 5 of the EET, and their, accordingly, total load graphs are given in Table 1. The active power coefficients are 0.85 for station nodes and 0.9 for load nodes.

Table 1. Consumer download schedules.

Total download P_N, MW	P_2, MW	P_3, MW	P_4, MW	P_5, MW
1100	230,0	400	130	340
1300	280	470	150	400
1500	330	520	200	450
1600	350	550	230	470
1680	350	580	260	490

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To compare the computational-experimental results, Table 2 shows the results of the optimization of the EET state without taking into account the network factor and taking it into account by calculating the waste products by the method of small increments. In this case, the optimization results can be taken as the reference result using the small increment method.

Table 2. Optimization results.

P_n, MW	Optimization results without considering the network factor					
	π, MW	P_0, MW	P_1, MW	P_6, MW	P_7 , MW	B, t.o.e./h
1100	35,108	267,167	224,203	379,855	263,884	602,825
1300	53,425	318,407	264,462	450,309	320,247	699,335
1500	77,072	370,897	305,705	529,483	377,987	810,961
1600	93,680	398,265	327,208	560,115	408,092	874,248
1680	105,494	419,814	344,140	589,745	431,796	926,613
Results of optimization taking into account the network factor using the method of small increments						
1100	34,680	259,256	225,830	384,431	264,663	602,684
1300	52243	305,721	267,630	458,590	320,302	698,802
1500	74,258	352,741	312,196	530,065	373,256	809,774
1600	88,336	374,752	336,713	578,672	398,194	871,856
1680	98,246	393,530	355,224	613,013	416,403	923,153

The results of the calculations show that the economic effect achieved by taking into account the network factor is not so great when the load on the EET is small, and as it increases, the efficiency also increases. In the example considered, when the total load is 1100 MW and 1300 MW, the efficiency of the total conditional fuel consumption at all thermal power plants does not exceed 0.1%, while at 1500 MW, 1600 MW 1680 MW, respectively, 0.15%, 0, We see that 28% and 0.38%, respectively.

Table 3 shows the results of optimizing the state of the EET by taking into account the losses in the network by calculating their derivatives using linear expressions and the algorithm proposed here. By comparing them, we find that the proposed algorithm allows optimizing the EET state by taking into account the losses in the network with greater accuracy, while significantly reducing the computational operations.

This feature, in turn, shows that this algorithm can also be used effectively in solving problems of operative optimal control of the EET state.

Table 3. Results of optimization taking into account the network factor.

P_n, MW	Results of optimization by calculating waste products according to a linear formula					
	π, MW	P_0, MW	P_1, MW	P_6, MW	P_7, MW	B, t.o.e./h
1100	34,63	258,24	225,22	385,20	265,36	602,68
1300	52,11	304,28	268,32	459,79	319,72	698,87
1500	74,44	353,94	312,26	535,80	372,44	809,85
1600	89,48	380,18	334,90	575,07	399,33	872,29
1680	100,3	401,98	352,14	606,23	419,98	924,01
Results of optimization by calculating waste products according to the proposed algorithm						
1100	34,69	259,23	225,84	384,95	264,67	602,69
1300	52,10	304,23	269,33	461,65	316,88	698,88
1500	74,00	351,04	314,56	540,95	367,45	809,80
1600	88,22	374,10	336,61	579,73	397,77	871,81
1680	98,27	393,61	355,23	613,02	416,41	923,21

To compare the accuracy of the obtained results, Table 4 shows the quantities of cost-effectiveness achieved in optimizing the waste products by calculating the above methods.

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Thus, as a result of optimizing the waste product by calculating the proposed algorithm, the cost-effectiveness in terms of total ball fuel consumption is significantly greater than when using the linear product formula.

Table 4. Equivalent fuel savings, taking into account wastage in the networks.

P_N, MW	Absolute economic efficiency, taking into account the network factor, $\Delta B_{e.aee}$, t.o.e./h.	Optimization with calculation of σi by linearized expressions			Optimization with calculation of σi according to the proposed algorithm		
		ΔB_e t.o.e./h.	ΔB_e, % (relative to B)	ΔB_e, % (relative to $\Delta B_{e.aee}$)	ΔB_e, t.o.e./h	ΔB_e , % (relative to B)	ΔB_e, % (relative to $\Delta B_{e.aee}$)
1100	0,141	0,14	0,02	99,29	0,135	0,02	95,7
1300	0,533	0,462	0,07	86,27	0,467	0,07	87,6
1500	1,190	1,115	0,144	93,7	1,157	0,14	97,2
1600	2,428	1,996	0,23	82,9	2,426	0,26	99,9
1680	3,49	2,599	0,28	74,5	3,402	0,37	97,2

III. CONCLUSION

1. The existing methods and algorithms for taking into account the losses in the power grid by calculating their product in the optimization of the state of power systems were studied.
2. An effective algorithm for determining the waste products in the optimization of the state of power systems on the basis of decomposition of a system of linear equations is proposed.
3. A comparative analysis of the results of computational experiments on the optimization of the state of power systems taking into account the losses revealed that the proposed algorithm based on the decomposition of wastes by decomposition of a system of linear equations has a high efficiency.

REFERENCES

[1] Automation of dispatch control in the electric power industry // Ed. ed. Yu.N. Rudenko and V.A. Semenov. -M.: MEI Publishing House, 2000.
[2] Fazylov Kh.F., Nasyrov T.Kh. Steady regimes of electric power systems and their optimization. - T .: "Moliya", 1999.
[3] Gayibov T.Sh. Methods and algorithms for optimizing the modes of electric power systems. - T .: Ed. Tashkent State Technical University, 2014,
[4] J.C. Carpentier: Optimal Power Flows: Uses, Methods and Developments. In: IFAC Proceedings Volumes. 18(7), pp. 11-21. https://doi.org/10.1016/S1474-6670(17)60410-5. (1985).
[5] Tulkin Gayibov, Sherxon Latipov, Bakhodir Uzakov. Power System Mode optimization by piecewise-linear approximation of energy characteristics of Power Plants. E3S WoC 139, 01086 (2019). doi.org/10.1051/e3sconf/201913901086.
[6] Tulkin Gayibov, Behzod Pulatov. Taking into account the constraints in power system mode optimization by genetic algorithm. E3S Web of Conferences 264, 04045 (2021). https://doi.org/10.1051/e3sconf/202126404045.
[7] Hardiansyah, Junaidi, Yohannes. An Efficient Simulated Annealing Algorithm for Economic Load Dispatch Problems. TELKOMNIKA, Vol.11, No.1, March 2013, pp.37-46. http://dx.doi.org/10.12928/telkomnika.v11i1.880.
[8] El Hachmi Talbi, Lhoussine Abaali, Rachid Skouri, Mustapha El Moudden. Solution of Economic and Environmental Power Dispatch Problem of an Electrical Power System using BFGS-AL Algorithm, Procedia Computer Science, Volume 170, 2020, pp. 857-862, https://doi.org/10.1016/j.procs.2020.03.144.
[9] Ismi Rosyiana Fitri, Jung-Su Kim, Economic Dispatch Problem using Load Shedding: Centralized Solution, IFAC-PapersOnLine, Volume 52, Issue 4, 2019, pp. 40-44. https://doi.org/10.1016/j.ifacol.2019.08.152.
[10] B. Shaw, S. Ghoshal, V. Mukherjee, and S. P. Ghoshal. Solution of Economic Load Dispatch Problems by a Novel Seeker Optimization Algorithm. International Journal on Electrical Engineering and Informatics, Volume 3, Number 1, 2011. doi:10.1016/j.eswa.2011.07.041.

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AUTHOR'S BIOGRAPHY

Gayibov Tulkin Shernazarovich

Head of department "Power stations, networks and systems" Tashkent State Technical University

Reymov Kamal Mambetkarimovich

Head of department "Power Energy" Karakalpak State University

Uzakov Bakhadir Abdikarimovich

Karakalpak State University. Assistant teacher of the department "Power Energy"