Література

[1] Г. Буч и др., *Язык UML. Руководство пользователя. 2-е узд.* М: ДМК Пресс, 2006;
[2] Э. Уотсон. *"Visual Modelling: past, present and future"*. uml.org [Online]. Доступно: http://www.uml.org/Visual_Modeling.pdf. [Accessed].
[3] Ю. Волков, "Диаграммы для описания бизнес-процессов," *PC Week/RE*, но. (545) 35, сс. 39-40, Сентябрь. 2006;
[4] М. Фаулер., К. Скотт, *UML. Основы*, Спб: Символ-Плюс, 2002;
[5] IDEF Family of Methods. [Електронний ресурс]. Режим доступу: http://www.idef.com.
[6] О. Волков, "Стандарты и методологии моделирования бизнес-процессов," *Связьинвест*, no.6, pp., Июнь 2005;
[7] Businessstudio. *"Нотация IDEF0"*, businessstudio.com.ua. [Online]. Available: http://www.businessstudio.com.ua/bp/bs/overview/notation_idef0.php. [Accessed].

References

[1] G. Buch et al., *Yazyk UML. Rukovodstvo pol`zovatelya. 2-e y`zd*. M.: DMK Press, 2006;
[2] A. Watson, (2008). "*Visual modelling: Past, present and future"*. uml.org [Online]. Available: http://www.uml.org/Visual_Modeling.pdf. [Accessed].
[3] Yu. Volkov, " Dy`agrammy dlya opy`sany`ya by`znes-processov," *PC Week/RE*, no. (545) 35, pp. 39-40, September 2006;
[4] M. Fauler, K. Skott, *UML. Osnovy*, Spb.: Sy`mvol-Plyus, 2002;
[5] IDEF Family of Methods. http://www.idef.com;
[6] O. Volkov, "Standarty i metodologii modelirovaniya biznes-protsessov," *Svyazinvest*, no.6, pp., June 2005;
[7] Businessstudio. "*Notacy`ya IDEF0"*, businessstudio.com.ua. [Online]. Available: http://www.businessstudio.com.ua/bp/bs/overview/notation_idef0.php. [Accessed].

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IMPROVEMENT OF MANAGEMENT OF STEAM GENERATORS IN NUCLEAR AND THERMAL POWER PLANTS

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Abstract: The paper formulated optimization problem formulation production of carbon products. The analysis of technical and economic parameters that can be used to optimize the production of carbonaceous products had been done by the author. To evaluate the efficiency of the energy-intensive production uses several technical and economic indicators. In particular, the specific cost, productivity, income and profitability of production. Based on a detailed analysis had been formulated optimality criterion that takes into account the technological components of profitability. The components in detail the criteria and the proposed method of calculating non-trivial, one of them - the production cost of each product. When solving the optimization problem of technological modes of production into account constraints on the variables are optimized. Thus, restrictions may be expressed on the number of each product produced. Have been formulated the method of calculating the cost per unit of product. Attention is paid to the quality indices of finished products as an additional constraint in the optimization problem. As a result have been formulated the general problem of optimizing the production of carbon products, which includes the *optimality criterion and restrictions.*

Анотація: В статті запропонована альтернатива класичній трьохімпульсній системі автоматичного керування рівнем води в барабані парогенераторів. Розроблена система забезпечує інваріантність до збурення зміною витрати живильної води та виробленої пари, а також дозволяє суттєво зменшити час керування. Впровадження системи дозволить підвищити надійність та тривалість неперервної роботи парогенераторів і турбін ТЕС та АЕС.

Key words: Carbon products, optimization problem, optimization criterion, cost, energy consumption, product quality.

Ключові слова: *парогенератор, котел, трьохімпульсна, інваріантна, система керування, рівень, АЕС, ТЕС.*

Formulation of the problem

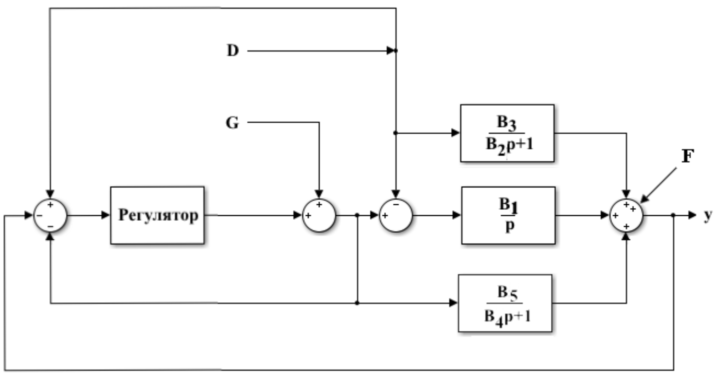
Improving the efficiency and service life of existing thermal and nuclear power plants is an important issue Energy of Ukraine. One simple and cost effective methods towards solving this problem is to improve the existing control systems of steam generators, which will improve the reliability and durability of continuous steam generators and turbines TPP and NPP. Reliability of steam generators is determined primarily by the quality control of water level in the drum - a parameter that characterizes the material balance of the process steam because maintaining the accuracy requirements for this option quite tough. Maximum tolerance of this parameter depends on the design of the steam generator and is 75-100 mm. Reducing leads to disruption of water supply, which in turn leads to disruption of circulation in the screen pipes, resulting in increased temperature walls and burnout can occur pipes. Increase reduces the efficiency of the separation device drum maligns water super heater and turbine, which can lead to hydraulic and thermal shocks, and to drift superheated salts.

Analysis of previous studies

The water level in the steam drum is required to stabilize the help of the control system. However, quality control is determined not only to maintain the level accuracy, but uniformity supply superheated steam and feed water. Therefore, the nuclear steam generators and boilers of large capacity power station using three impulse control system, which forms a control action based on three parameters - the water level, the cost of steam and feed water. Fundamental research of three pulse systems were conducted in 1970 [1-4]. The transition from analog to digital control systems allowed to develop more complex control system because research in this area continues to the present time [5-7]. Quality control may also increase due to the use of modern instrumentation, research opportunities through new channels management and improving already developed methods of calculating the parameters of control [8].

The wording of Article purposes

The article is to develop improved system level management of water in the drum steam generators, thermal and nuclear power plants, which ensures accurate controlled conditions invariance of parameter perturbations unbalance feedwater and manufactured couples and significantly improves the performance management process.
The structure of classical control systems trohimpulsnoyi
Block diagram of a mathematical model of the classic three pulse automatic control system shown in Fig. 1. A mathematical model of the channel that connects the water flow deviation G of deviation of water level in the drum seems to sum integral link $\frac{B_1}{p}$ and inertial links $\frac{B_5}{B_4 p+1}$. A mathematical model of the channel that connects the deviation D expenses pair of deviation water level in the steam drum nuclear and thermal power plants represented the sum of the integral parts $\frac{B_1}{p}$ of inertial $\frac{B_3}{B_2 p+1}$ and managers. In models B_1, B_2, B_3, B_4, B_5 – a factor whose values depend on the values of operational parameters of steam and p - Laplace operator [9].



G - deviation costs water, D - deviation consumption of steam
y -deviation level, F - no measurable disturbance

Fig.1 – Block diagram of the control system of classical tree impulse

Conditions invariance in this system has the form

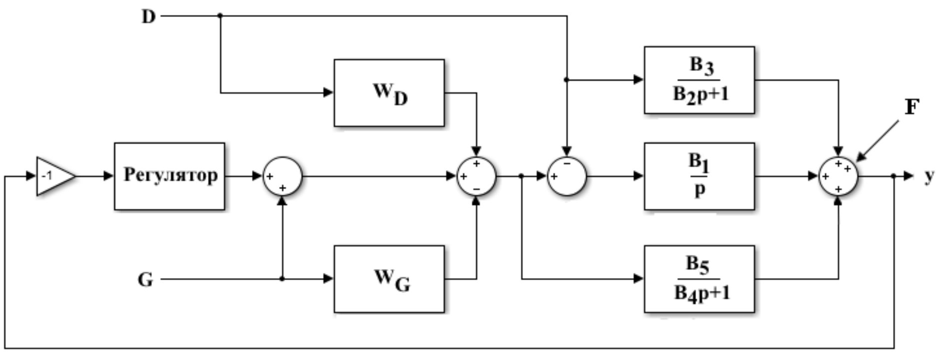
$$D\cdot\left(\frac{B_3}{B_2\cdot p+1}-\frac{B_1}{p}+R(p)\cdot\frac{B_1}{p}\right)+G\cdot\left(\frac{B_5}{B_4\cdot p+1}+\frac{B_1}{p}-R(p)\cdot\frac{B_1}{p}\right)=0,$$

$R(p)$ - transfer function regulator.

The main disadvantage of this system is not only that it satisfies invariance only provided when B3 = B2 and B5 = B4, which is not characteristic of the common designs of steam, but the fact that G & D must be changed simultaneously, which is not characteristic disturbances.

The structure of the invariant control systems

Develop invariant system with measuring disturbances compensator, which has these drawbacks. Block diagram of the proposed system is shown in Fig. 2.



G - deviation costs feed water, D - deviation consumption of steam
y -deviation level, F - no measurable disturbance

Fig. 2 – Block diagram of invariant control systems

Conditions P invariance relatively simple

$$G\cdot(1-\cdot W_G(p))=0,$$

In a relatively D looks

$$\left(\frac{B_3}{B_2\cdot p+1}-\frac{B_1}{p}\right)+W_D\cdot\left(\frac{B_5}{B_4\cdot p+1}+\frac{B_1}{p}\right)=0.$$

From these conditions we get transfer functions compensators $W_D(p)=\left(\frac{(B_1\cdot B_2-B_3)\cdot p+B_1}{(B_1\cdot B_4+B_5)\cdot p+B_1}\right)\cdot\frac{B_4\cdot p+1}{B_2\cdot p+1}$, $W_G(p)=1$.

Comparative analysis of control systems

To study the quality control of classical tree pulse and proposed invariant control systems by the example of boiler drum with the following values of coefficients: $B_1=3{,}4\cdot10^{-4}\,\text{m/kg}$, $B_2=26\,\text{s}$, $B_3=-2\cdot10^{-2}\,\text{m/(kg}\cdot\text{s)}$ $B_4=10\,\text{s}$, $B_5=-3\cdot10^{-3}\,\text{m/(kg}\cdot\text{s)}$. Calculation of coefficients performed by the method given in [9].

The transfer function of joints invariant control systems will be as follows: $W_D(p)=\left(\frac{(3{,}4\cdot10^{-4}\cdot26-2\cdot10^{-2})\cdot p+3{,}4\cdot10^{-4}}{(3{,}4\cdot10^{-4}\cdot10-3\cdot10^{-2})\cdot p+3{,}4\cdot10^{-4}}\right)\cdot\frac{10\cdot p+1}{26\cdot p+1}$, $W_G(p)=1$.

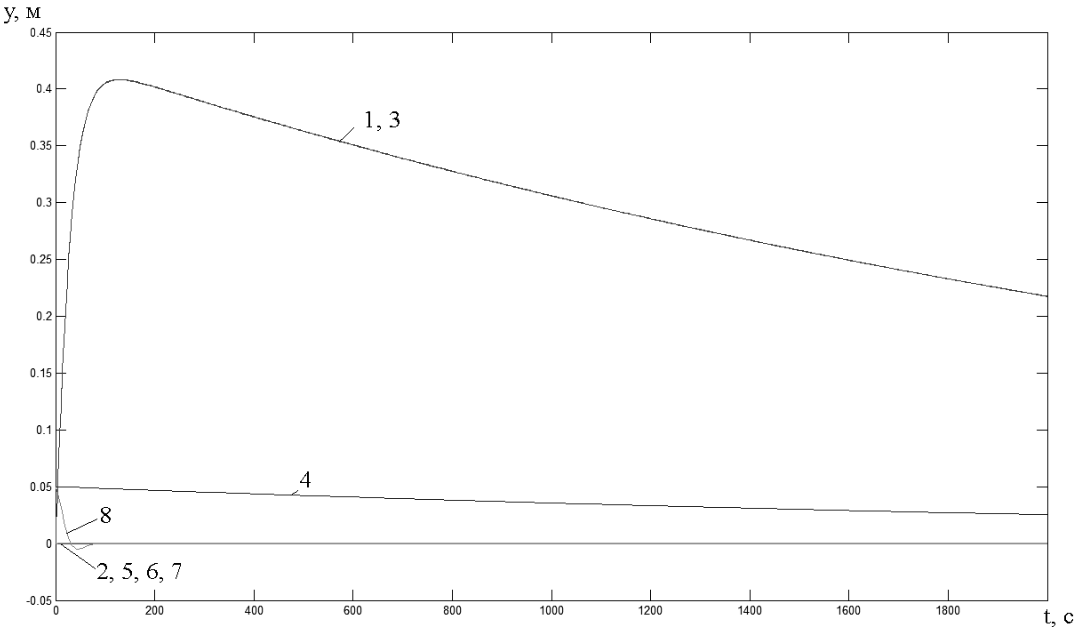
As the regulator will choose a typical PI regulator with the following notation:

$$R(p)=Kp\cdot\left(1+\frac{1}{Tu\cdot p}\right).$$

To set the PI controls in the two control systems use the frequency domain Matlab, which allows you to get the best options for object regulator arbitrary structure of phase margin to 60.

Explore the quality of both systems in the four cases, disturbance, change of nominal steam flow at D = 25 kg / s, changing nominal water flow at G = 25 kg / s, changing the nominal cost of steam and water simultaneously D = 25 kg / s and G = 25 kg / s, change to nominal level F = 0,05 m because of uncontrolled disturbances. By uncontrolled disturbances related conditions change heat transfer, temperature, errors in the sensors and actuators.

Transients systems are classical tree pulse invariant system, developed in Fig. 3.



1,2,3,4 - a classical system by the action of the perturbation D, G, D and G, F respectively,
5,6,7,8 - a system developed by the action of the perturbation D, G, D and G, F, respectively

Fig. 3 – Transients level in the boiler drum for various disturbances

Analysis of transitional processes reveals that developed invariant control system can effectively overcome all the above types of disturbances at a very fast time. Three pulse system effectively overcome only by changing power disturbances. When changing disturbance steam consumption and the simultaneous change of flow of water and steam drum level deviation beyond the limits of the regulations. Also, transient disturbance during the change of steam flow and change of the drum have poor time management - fully overcome the disturbance during the period approximately 3 hours. This is because in the classical system of three pulse feedback on power consumption sharply limits the ability of the regulator to compensate other disturbances, which significantly increases the control.

Conclusions

Developed invariant control system level in drum of steam generators and nuclear power station can be used as an alternative to classical tree impulse management system. The advantages of the developed system is more precise level maintenance at considerable disturbances and high speed control. The introduction of the system can improve the reliability and durability of continuous steam turbine and thermal power plants and nuclear power, which is important for the economy of Ukraine.

References

[1] A.S. Klyuev, A.G. Tovarnov, *Naladka sistem avtomaticheskogo regulirovaniya kotloagregatov*.M: Energiya, 1970. (Rus.);
[2] E.P. Serov, B.P. Korolkov, *Dinamika parogeneratorov*. M: Energiya, 1972. (Rus.);
[3] E.Z. Gurevich, L. I. Radyuk, *Sostoyanie, perspektivy razvitiya i texniko-ekonomicheskaya ocenka avtomatizacii pitaniya barabannyx parogeneratorov*. Minsk: BelNIINTI, 1974. (Rus.)
[4] MU 34-70-135-85. Metodicheskie ukazaniya po naladke regulyatorov pitaniya barabannyx parovyx kotlov.–M.:SPO PO «Soyuztexenergo», 1987. (Rus.)
[5] A. M. Proxorenkov, N. M. Kachala, "Parametricheskij sintez regulyatorov teploe'nergetícheskix ob"ektov s ispol'zovaniem informacionnogo podxoda" *Vestnik Murmanskogo gosudarstvennogo texnicheskogo universiteta*, vol. 14, no. 4, pp. 704-711, month 2011 (Rus.)
[6] G.T. Kulakov, "Matematicheskoe modelirovanie perexodnyx processov treximpul'snoj sistemy avtomaticheskogo regulirovaniya pitaniya vodoj parogeneratora na sbros nagruzki" *Energetika*, no.1, pp. 57-64, month 2014. (Rus.)
[7] Y.J. Lee, "Optimal design of nuclear steam generator digital water level control system" *Journal of Korea nuclear society*, vol. 26, no 1, pp. 32-40, month. (статья не найдена)
[8] V.A. Demchenko, "O svyazi tochnosti regulirovaniya urovnya vody v PG AES s vlazhnost'yu generiruemogo para" in *Materiali mizhnarodnoї konferencії z upravlinnya*, Avtomatika 2001, V.A. Demchenko, K.V. Beglov, L.D. Lyanko, pp. 192-193. (Rus.)
[9] V.A. Demchenko, *Avtomatizaciya i modelirovanie texnologicheskix processov TES i AE'S/V.A.* Odesa: Astroprint, 2001. (Rus.)

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