IJDIAS International Journal of Discoveries and Innovations in Applied Sciences

| e-ISSN: 2792-3983 | www.openaccessjournals.eu | Volume: 3 Issue: 11

Automatic Control Systems for Combustion Process

Yusuf Shodievich Avazov
Doctor of Technical Sciences, Professor of the Department of Automation of Production Processes, Tashkent State Technical University, Tashkent, Uzbekistan

Nasriddin Xasanovich Bobomurodov
Doctor of Philosophy in Technical Sciences, Associate Professor of the Department of Information Processing and Control Systems, Tashkent State Technical University, Tashkent, Uzbekistan

Abstract:

The article examines the construction of adjustment systems to ensure economy in the process of fuel combustion and to adjust the combustion process. Structural schemes of automatic adjustment systems for different modes of the combustion process are proposed.

Keywords: combustion process, automatic adjustment, consumption, regulator, quality of combustion, oxygen, air.

Introduction

Controlling the process of burning fuel in furnaces is a complex process. A certain level of scientific research has been conducted on fuel combustion control research. In [1], the results of the operation of an extreme system for regulating the air supply to the furnace using as an input signal the ratio “gas fuel consumption – superheated steam consumption”, which has an extreme character depending on the air flow supplied to the furnace, are presented. The disadvantage of this system is that the signal for the flow of superheated steam is not invariant to injections of cooling water and the maximums of the signals for efficiency and evaporation may not coincide, and, therefore, optimization according to this criterion can lead to undesirable consequences. In [2], it is proposed to measure fuel consumption, and determine a fixed value of the amount of heat supplied to the furnace by integrating the measured fuel consumption, and at the same time, additionally, integrating an indicator characterizing the combustion process. In [3, 4], as a signal for searching for the maximum value of the system efficiency, it is proposed to use a signal based on the rate of drop in the temperature of the medium behind the point of phase transformation in the object or a signal based on the rate of pressure drop, which vary depending on the amount of supplied air. Thus, in [5], the optimizer reduces the air supply until the rate of steam pressure drop to a given value is reached, after which a reverse occurs and the extreme regulator increases the air supply. In works [6,7], the authors propose to maximize the efficiency by maximizing the heat perception Q, which is calculated using a mathematical model into which all measured disturbances are introduced, except for the measured impact on fuel consumption. In [8], the EMF value that occurs on two parallel conductive rods placed in a flame was chosen as a signal that maximizes efficiency. The authors argue that the magnitude of the EMF depends on the excess air and load, and, therefore, can characterize the combustion process in the object. In [9], it is proposed to replace the EMF of the flame by measuring the pulsation of its electrical conductivity and additionally measure the pulsation of pressure and temperature of the flame. The disadvantage of these schemes is their complexity and low reliability. In [10] it is proposed to measure the physical properties of the flame using a non-contact method. In the control scheme proposed in [11], the change in air flow occurs based on the results of comparing the increment of two signals based on the dispersion of the torch pulsation, obtained at different points of the combustion space. To optimize the combustion process, it is proposed in [12] to use a signal based on the mixture temperature.

In order to increase the accuracy and efficiency of the combustion process, work [13] proposes to use an automatic control system. There are known methods [14] for constructing systems for automatic optimization of the combustion process, in which the excitation current of the feeder electric motor is minimized. These schemes have not found wide application due to the instability of the characteristics of the feeders, the number of revolutions of which does not clearly determine the amount of dust entering the furnace. In [15], in order to increase the efficiency of the combustion process and reliability, the combustion process control system additionally included a nonlinear element of the “insensitive” type and a dynamic link.

The main part

Extreme system for regulating the efficiency of the combustion process. Figure 1 shows the implementation diagram of the method. The system operates as follows. From sensor 1 of fuel consumption and from sensor 2 of the quality indicator of the combustion process, signals are simultaneously sent to integrators 3 and 4. After integrator 3 reaches the set point, which means the specified amount of fuel enters the object, at the command of control device 5, integrators 3 and 4 stop integration is performed, and the extreme controller 6 compares the integral value of the quality indicator in the next cycle with the value of this indicator in the previous cycle and generates a search action, which consists of changing the task of the air regulator 7 on the fuel-air ratio. After confirmation of the search action, the device 5. sets integrators 3 and 4 to the required initial state and gives the command to start a new cycle.

Thus, control device 5 sets the cycle duration of the system depending on the fuel integrator setting and controls the operation of integrators 3 and 4 and the extreme regulator.

After the search impact on the object, the air flow regulator 7 reduces or increases the air flow depending on which direction from the extremum the search impact is directed, and the extreme regulator, based on the change in the integral indicator of the quality of the combustion process, evaluates this change in air flow and ensures the search for the extremum. The above diagram is cumbersome to construct, which makes it difficult to configure and reduces the reliability of the system.

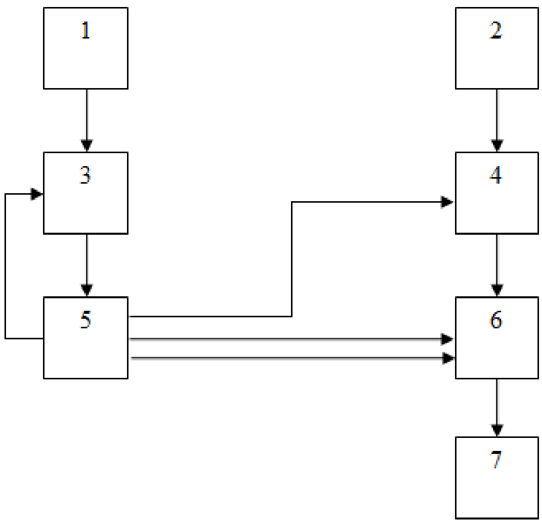

Figure 1. Extreme economy control system combustion process: 1 - fuel consumption sensor; 2 - quality indicator sensor; 3.4 - integrators; 5 - command device; 6 - extreme regulator; 7 - air flow regulator.

At constant pressure and temperature of the primary air, the mixture temperature t is inversely proportional to the fuel consumption. The *t* signal shows how much fuel enters the firebox. Experimental studies have shown that the static characteristic $t = f(\alpha)$ has an extremum - a maximum that coincides with the maximum efficiency.

The main disadvantages of this system include: low sensitivity to changes in the calorific value of the fuel, large inertia in measurements associated with the installation of temperature sensors.

Automatic combustion control system

Figure 2 shows a diagram of the automatic control system for the combustion process. The system works as follows. When the load of the power unit changes, the temperature of the air mixture behind the mill – the fan – changes. The signal of this change from the sensor 2 through the measuring unit 3 is sent to the regulator 1, which moves the actuator 4 of the flue gas additive damper 5. If the temperature of the air mixture reaches one of the limit values, i.e. Comparison unit 6, comparing the actual value of the air mixture temperature with the set one, outputs a signal to element “I” 9, and the actuator element of the flue gas additive gate is in the specified position, then after a delay time determined by block 11, unit 12 is activated, carrying out movement of the actuator 13 of the regulatory body 14.

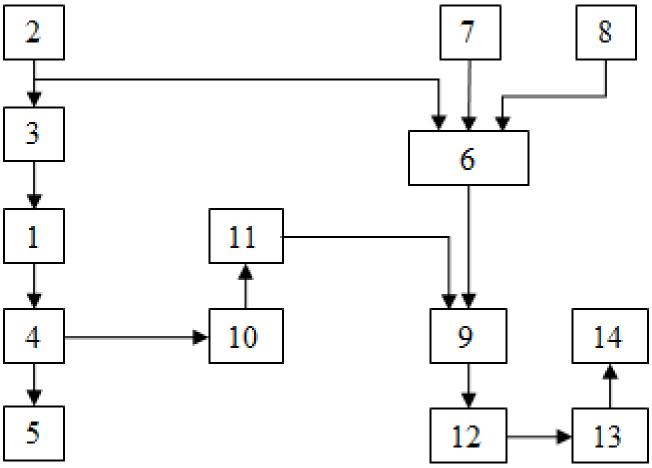

Figure 2. Automatic control system for the efficiency of the combustion process: 1 - regulator; 2 - temperature sensor; 3 - measuring block; 4 - actuator; 5 - flue gas additives; 6 - comparison unit; 7, 8 - setpoints; 9 - logical element "AND"; 10 - signal generation unit; 11 - delay block; 12 - control unit; 13 - actuator; 14 - air supply regulators.

The amount of movement is determined for a specific system after technological tests. Moreover, to achieve the maximum temperature of the air mixture, organ 14 moves towards ventilation, and the minimum temperature - towards increase. By changing the amount of drying agent entering the dust system, the temperature of the air mixture behind the mill fan changes and the regulator reduces the share of the low-temperature agent additive, which leads to optimization of the load on the recirculation exhaust fans and a reduction in electricity consumption for its own needs. Optimization of smoke exhauster loading is carried out by a smoke exhauster performance regulator.

IJDIAS International Journal of Discoveries and Innovations in Applied Sciences
| e-ISSN: 2792-3983 | www.openaccessjournals.eu | Volume: 3 Issue: 11

The considered system of automatic temperature control of the air mixture allows for economical operation of the unit during deeper unloading with a constant number of fans and increases the efficiency and reliability of the unit.

The implementation diagram of this method is presented in Figure 3 and works as follows. Fuel-oxidizer ratio meter 3 generates a signal of the current ratio value.

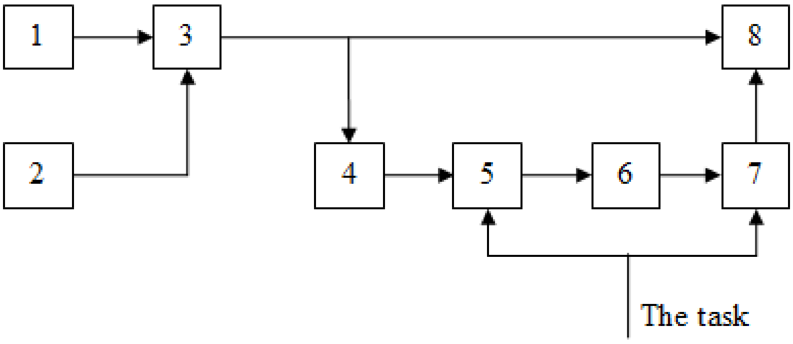

Figure 3. Automatic system for regulating the efficiency of the combustion process using nonlinear and dynamic links: 1, 2 – fuel and oxidizer consumption meters; 3 – fuel-oxidizer ratio meter; 4 – nonlinear element; 5 – active relay; 6 – dynamic element; 7 – adder; 8 – regulator of the fuel-oxidizer ratio.

When there is an excess of oxidizer, active relay 5 has a zero output signal. Adder 7 receives only the main task signal. When working with chemical underburning, a single signal is generated at the output of the active relay, which is supplied to the input of dynamic element 6. This signal is supplied to adder 7, where it is summed with the main task signal, and the total signal is supplied to the input of regulator 8. Nonlinear element 4 prevents high-frequency switching of the active relay 5. Regulator 8, using the total signal, forces the air supply until the additional signal disappears at the input of the dynamic element 6, which is made in the form of an integrative-differentiating link, and the magnitude of its output signal at the moment of its appearance and the law of its change are determined when setting up the control system.

To increase the efficiency of the combustion process, it is proposed to measure fuel consumption and use it as the main signal to fuel regulators, measure the content of oxygen and underburned products in the fireboxes, and calculate the difference in signal values based on the content of underburned products. Depending on the sign of the resulting difference, a correction signal is generated to the corresponding fuel regulator. Calculate the difference between the signals based on the O_2 content, which is used to form the limitation of corrective signals to the fuel regulators, calculate the half sum of the signals based on the O_2 content, underburning, and use them to change the air flow.

Automatic system for regulating the efficiency of the combustion process for boilers

Figure 4 shows a diagram of the implementation of this method, which works as follows. Regulators 1, 2 and 21 change the position of the air and fuel supply controls in accordance with the thermal load.

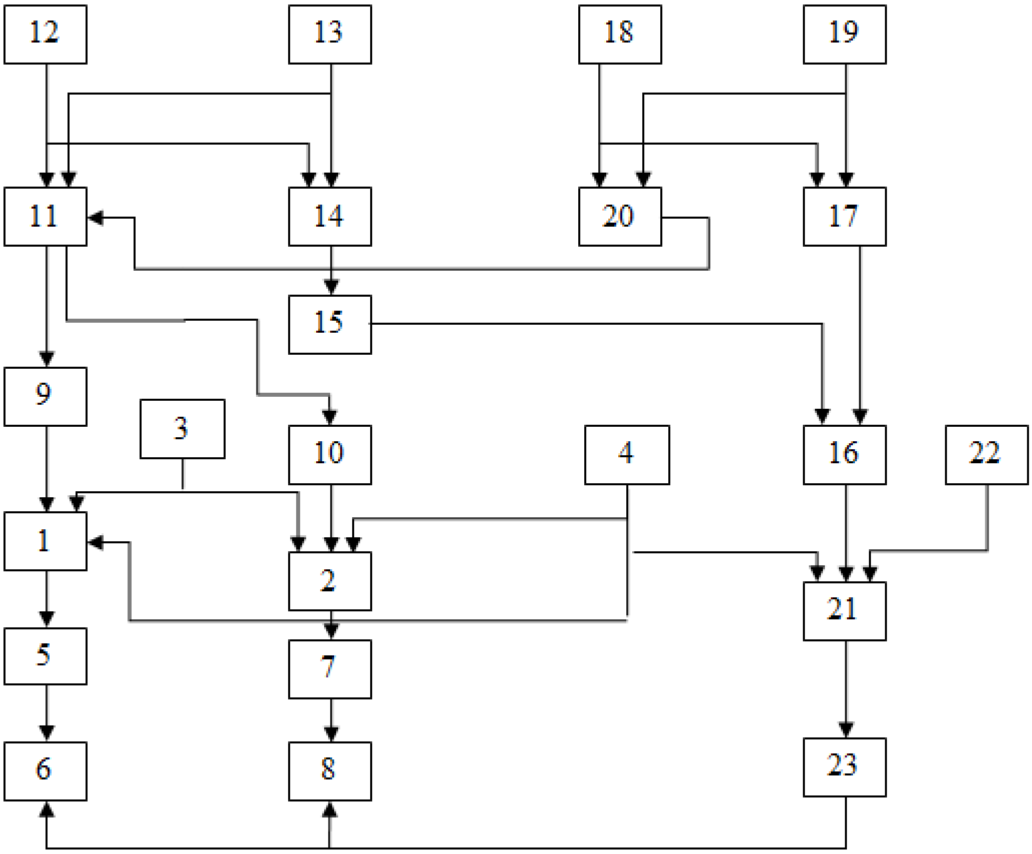

Figure 4. Automatic system for regulating the efficiency of the combustion process for boilers equipped with fuel regulators: 1,2 – fuel regulators; 3 – power setter; 4 – fuel consumption sensor; 5,7,23 – regulatory authorities; 6.8 – groups of burners; 9,10 – corrective regulators; 11 – logical device; 12,13 – chemical underburning sensors; 14,17 – adders; 15 – corrective regulator of chemical underburning; 16.21 – regulators; 18,19,22 – oxygen content sensors; 20 – logical device.

To quickly adjust the task to the total air regulator 21 in order to achieve the optimal excess air coefficient, the corrective regulator 16 for the oxygen content in the flue gases will serve, which receives a signal based on the average oxygen content in the combustion products from the left and right sides of the furnace.

During the operation of the combustion device, due to the uneven distribution of fuel on the sides of the furnace (from coking of the nozzles, erosion and from changes in the proportion of air suction, errors in measuring the oxygen content), a imbalance occurs in the combustion modes. As a result of this, an attempt to maintain the minimum permissible coefficient of excess air in the firebox leads to the fact that on one side of the firebox combustion occurs with an increased oxygen content, and on the other with chemical underburning.

To eliminate the skew, chemical underburning sensors 12 and 13 measure underburning values on the right and left, respectively; in logic device 11 the difference of these values is calculated, and depending on the sign of the difference, signals are sent to corrective regulators 9 and 10. On the side where the chemical There is more underburning, fuel consumption decreases, and on the other side it increases. The overall fuel consumption does not change. If there is no chemical underburning or its values on the right and left are equal (the difference is zero), the command to change fuel consumption is not given.

Due to the fact that the optimal α changes its value depending on the boiler load, the uneven distribution of fuel and air across the burners, the proportion of air suction, and the error in measuring the oxygen content, the corrective regulator 16 is not able to maintain the optimal combustion mode only according to information from the adder 17 o the average oxygen content in the flue gases to the right and left of sensors 18 and 19. Therefore, the corrective regulator 15 for chemical underburning changes the task of the corrective regulator 16 for oxygen content in order to ensure fuel combustion with a minimum excess air ratio and to prevent chemical underburning.

Serious disturbances in the quality of fuel atomization and the formation of its mixture with air in some burners can cause significant differences in combustion modes on the right and left sides of the firebox. Elimination of distortions in automatic mode using regulators 9 and 10 can lead to large thermal distortions. To prevent this, in the logical device 20 the absolute value of the difference in oxygen content on the sides of the furnace is calculated and the excess above a given level is a command signal sent to the logical device 11, which stops further redistribution of fuel on the sides of the furnace. The main disadvantage of this scheme is the use of an unreliable and inertial corrective regulator of the oxygen content in the flue gases.

Conclusion

The considered systems for automatic control of the fuel combustion process ensure economical operation of the unit and increase the efficiency and reliability of the unit.

References

1. Pomeransev V.V., Arefev K.M., Axmedov D.B. Osnovi prakticheskoy teorii goreniya. (1986)
2. Abramovich G.N. Teoriya turbulentnix struy. (1984).
3. Smulskiy I.I. Aerodinamika i protsessi v vixrevix kamerax. Novosibirsk: «Nauka». (1992). – 301 p.
4. Vulis L.A., Yarin L.P., Aerodinamika fakela. Energiya. (1978). - 218 p.
5. Ippolitov A.S., Safronov SP., Dvoynishnikov V.A. Razrabotka i issledovanie visokoforsirovannogo topochnogo ustroystva s peresekayushimisya struyami // Gorenie tverdogo topliva. Chapter I. Novosibirsk: Nauka (1969).
6. Arxipov A.M., Lipov Yu.M., Proxorov V.B. Ispolzovanie pryamotochnix gorelok i sopl v topkax kotlov: innovatsionniy opit MEI. (2013). 240p.
7. Bryuxanov, O.N., Mastryukov, B.S. Aerodinamika, gorenie i teploobmen pri sjiganii topliva. SPb: Nedra (1994). – 317p.
8. Cristiano V. da Silva, Maria Luiza S. Indrusiak, Arthur B. Beskow. CFD Analysis of the Pulverized Coal Combustion Processes in a 160 MWe Tangentially-FiredBoiler of a Thermal Power Plant // Journal of the Brazilian Society of Mechanical Sciences and Engineering, Vol. XXXII, No. 4. (2010). pp. 427-436.
9. Yun A.A., Krilov B.A. Raschet i modelirovanie turbulentnix techeniy s teploobmenom, smesheniem, ximicheskimi reaksiyami i dvuxfaznix techeniy v programmnom komplekse FASTEST-3D. (2007). 116p.
10. Karthik T.S.D. Turbulence models and their applications / 10th Indo German Winter Academy (2011).
11. Poinsot T., Veynante D. Theoretical and numerical combustion. - 2nd ed. R.T. Edwards. (2005). 522 pp.

12. Filkoski Risto V., Petrovski Ilija J., Karas Piotr. Optimisation of pulverised coal combustion by means of CFD/CTA modelling // Thermal Science (An International Journal), Vol. 10. No. 3. (2006). pp. 161-179.

13. Darvell L.I., Ma L., Jones J.M., Pourkashanian M., Williams N. Some aspects of modelling NOx formation arising from the combustion of 100% wood in a pulverised fuel furnace // Combustion Science and Technology, No. 186 (4-5). (2014).

14. Chungen Yin. On gas and particle radiation in pulverized fuel combustion furnaces // Applied Energy, Vol. 157. (2015).

15. Chittatosh Bhattacharya, Nilotpal Banerjee, Hari Sadhan Sarkar. Economics of removal of coal moisture in thermal power generation with waste heat recovery // International Journal of Emerging Technology and Advanced Engineering. Vol. 3. No. 3. (2013). pp.22-28.