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POWER REGULATION PROCEDURES AND ALGORITHMS OF GAS BURNER IN THERMOENERGETIC SYSTEMS

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Abstract **– The problem of electronic power regulation of gas burners in thermo-energetic systems have a double importance, due the influence on the gas consumption and deterioration of the thermo energetic equipment. In this paper the power regulation procedures and algorithms are proposed based on the mixed method, that will permits to decrease the inutile temperature oscillations of the heating process and as a consequence the additional gases consumption and impacts on the thermo-energetic equipment.**

Keywords: **regulation procedures and algorithms, gas burner, thermo-energetic equipment.**

1. INTRODUCTION

The high level of natural gases consumption in the industry and other field of the economy and the price increasing demands a revision of the traditional technologies by another approach of the energy generation problem. Now in this field is observed a tendency of large implementation of digital regulators, which are realized on the microcontrollers. This is due of the large possibilities to realize digital regulation algorithms, which in turn warranties a high precession and sufficient speed of data processing with discrete regulators [1, 2]. The algorithms of digital regulation are a component part of microcontroller's programs, that sensors data acquisition and processing, parameter values calculation and on base of regulation laws the control commands are realized.

In this paper the power regulation procedures and algorithms are proposed based on the mixed method, that will permits to decrease the inutile temperature oscillations of the heating processes and, as a consequence, the additional gases consumption and impacts on the thermo-energetic equipment are excluded.

2. THERMO-POWER REGULATION OF GAS BURNER

The gas burners, been implemented in the diverse thermo-energetic systems (heating boilers, parawaterheating, steam boilers, etc) must to modify its thermo-power in dependence of loading of the respective systems. There are some approach to solve this problem. The most simple approach is the using of the known open-loop and closed-loop regulation methods of 2/3 power level gas burner. It is known that this approach have some disadvantages and cannot be obtained the optimum of gas consumption [1]. An another approach is continuous variation of the thermo-power of gas burner. As a rule, the power regulation is realized on base of deviation process parameter value from reference level: the thermo-agent output temperature or pressure of the boiler[3, 5]. For realizing of this discrete regulator based on this principle, it is needed the development of PID algorithm and program, using a time discrimination in the PID equation. Purposely, it is set up a small time discrimination period T_c to transform the PID equation in the discrete form without significant approximation errors. The continuous integration of PID equation may be substituted with a discrete based on right angle or trapezium methods. For example, using a right angle or method, it is obtained the following equation in the discrete form [2, 4]:

$$u[n] = K_p\left[x[n] + T_c / T_i \sum_{i=1} x[i] + T_d / T_c (x[n] - x[n-1])\right] \quad (1)$$

On the base of this discrete equation it is possible to develop so-named nonrecurring algorithm, that need the following initial data:

a) *x(n), x(n-1),…x(1), x(0)* – set of deviations from reference in hole integration period;

b) K_p – proportional coefficient ;

c) T_i – integration period;

d) T_d – process variable derivation coefficient;

e) T_c – discrimination period of the regulation process.

The main idea of this algorithm consists in calculating of regulating signal $u[n]$, having the hole set of deviation on the integration period. This algorithm, been implemented in the thermo-energetic systems, have in quality of process variable $x(n)$ – temperature or pressure at out of boilers, named direct process variable and the thermo-power of gas burner in quality of regulation parameter [1, 3].

There is a weak link of this algorithm: due the monitoring of only deviation of direct temperature from reference value, without take into consideration other factors as the system inertia, the regulation process cannot be optimized and in more cases it have a oscillator character, that rule to the excesses of gas consumption and impacts on the thermo-energetic equipment. It is known, to exclude or decrease this problem, some adjusted procedures are makes with the goal to obtain of these parameters of regulator: K_p – proportion coefficient; T_i – integration; T_d – derivation coefficient of process variable; T_c – discrimination period of the regulation process, which warranted an appropriate of optimal regulation process. These adjustment procedures can be realized on two way: on base of simulation – it is easy, but not adequate to the reality or on base of experiments on real system, but it need additional expenses.

In this paper is proposed an approach, that consists in the following:

a) decentralization of the regulation processes – including in the each burner a thermo-power regulation;
b) monitoring a more parameters, for example, the input and output boiler temperature;
c) application of mixed scheme of regulation (open and closed loop).

If monitoring the deviation of the output boiler temperature T^{i}_{tur} with respect to reference T^{*}_{tur}, and introducing its in the precedent equation, it will obtain the follow equation for the first closed canal:

$$\Delta T[i] = T^{*}_{tur}[i] - T_{tur}[i] \quad (2).$$

$$\Delta P[i] = K_p\left[\Delta T[i] + \frac{T_c}{T_i}\sum_{i=1}\Delta T[i] + \frac{T_d}{T_i}\left(\Delta T[i] - \Delta T[i-1]\right)\right] \quad (3)$$

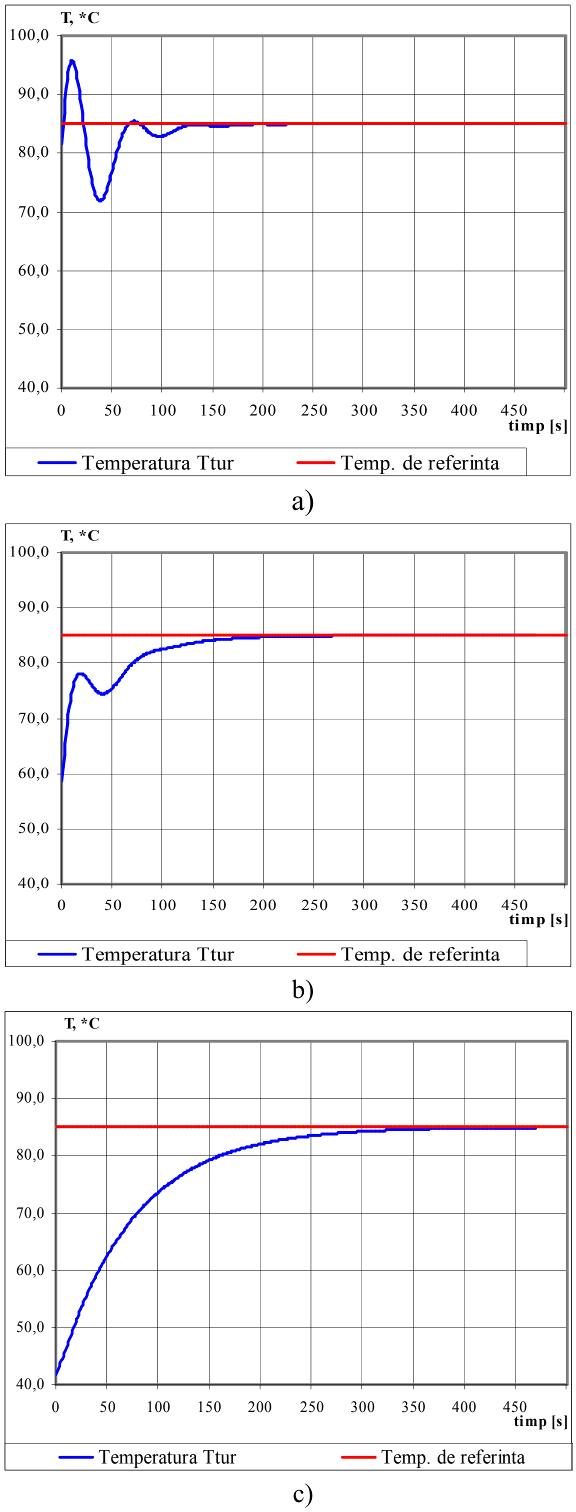

Fig. 1. Transient regimes of the regulation process:

a) with un unadjusted canal;
b) with two unadjusted canals;
c) with two adjusted canals.

where:

$\Delta P'(i)$ - modification of burner thermo-power in current moment for the follow discrimination period;

T^{i}_{tur} - current boiler out temperature;

T^{i-1}_{tur} – precedent boiler out temperature;

T^{*}_{tur} - reference boiler out temperature.

For the second canal of the regulator it is proposed monitoring the input boiler temperature with the reference to the T^{*}_{tur} - boiler out temperature. That is a deviation of input boiler temperature facing the reference boiler out temperature. It can obtain the following equation, that will considered the amount of current needed heating (power), i.e, the dynamics of the process:

$$\Delta P''(i) = K_a C_a m_a(T^{*}_{tur} - T^{i}_{ret}) + K_d C_a m_a((T^{*}_{tur} - T^{i}_{ret}) - (T^{*}_{tur} - T^{i-1}_{ret})), \quad (4)$$

where: $\Delta P''(i)$ - burner power variation in the current moment, depending only of second regulator; T^{i}_{ret} - current input boiler temperature; T^{i-1}_{ret} – precedent input boiler temperature; T^{*}_{tur} - reference boiler out temperature; $(T^{*}_{tur} - T^{i}_{ret})$ –current temperature difference between reference boiler out temperature and input temperature; $(T^{*}_{tur} - T^{i}_{ret}) - (T^{*}_{tur} - T^{i-1}_{ret})$ – precedent temperature difference between reference boiler out temperature and input temperature; C_a – the specific thermo capacity of the heat-transfer agent; m_a – mass of heat-transfer agent; K_a , K_d – proportion coefficients, [*kW/ºC*].

Finally, the regulator will enforce to modify the thermo power of the boiler:

$$\Delta P(i) = \Delta P'(i) + \Delta P''(i) .$$

The obtained algorithm was implemented in the electronic regulator of thermo-power for the DAVA type boilers [5] and was experimented on the diverse boiler types in some thermo-plants with various capacities.

It was especially verified the transient regimes:

- when the second canal was turn off and the first canal was unadjusted (fig. 1.a);
- with two unadjusted canals (fig. 1.b);
- with two adjusted canals (fig. 1.c).

In the first case it appraises significant oscillations of the process variable, that overflow the reference temperature, but in the second case, been unadjusted the two regulator canals have a small oscillations without significant overflowing the reference value.

In the third case it was used the well known Ziegler-Nichols methods for the regulator adjusting, that permits to obtain a near to optimal results.

The results of experiments shows that the regulation processes of the thermo-power are sufficiently effectiveness, including the case of transient periods. In the fig. 3 are presented the results of un experiment of thermo-power monitoring of the gas burner type DAVA 3500 installed on the boiler with thermo-capacity of 3500 kW. These results reflects the regulating of burner power, maintaining during 1 h a boiler out temperature with simultaneous changing of reference boiler temperature at 50, 60, 80 and 70 °C, beginning with initial boiler 25 °C temperature. It is observed that thermo-power was increased step less until the reference temperature was succeed, after this was decreased smoothly until the stationary regime was obtained.

3. CONCLUSION.

The proposed algorithm is a more sophisticated visa typical PID regulator, but due the fact the modern burners have more complex command controllers with a power microprocessors, it not more problems to realize these algorithms wit real teal execution. From the other hands, it was simplified the adjusting procedures, because the stabile working diapason is significantly large on the same amplification coefficient. Finally, the thermo-power of the burner is regulated smoothly with small oscillations, that exclude the excessive consumption of the gas.

4. **References**

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