THE CONTROL OF THE TEMPERATURE IN THE STEAM OVERHEATER

Camelia Maican, Matei Vinatoru, Eugen Iancu, Gabriela Canureci

Automation and Mechatronics Department
Univerity of Craiova
E-mail:camelia@automation.ucv.ro, vinatoru@automation.ucv.ro

Abstract: This paper present two methods for the control of the temperature in the steam overheater. In the first case it is use a control structure who use only one translator and one PI controler. In the second case it study a complex structure of control which makes the rise of the robust structure of control which deals with false information from the process, using three temperature sensors settled in equivalent positions.

Keywords: overheat, steam, injection flow, boiler, translator.

1. INTRODUCTION

For the imposed power needs of power group through steam capacity furnished by boiler, the steam must be at some pressure and temperature. This measure must be holding on in some limits to not appear problems at boiler and turbine:

-for turbine a huge steam expansion may generate steam condensation in turbine;

-for boiler, which , from dynamic point of view, is a slow process different from turbine and generator, the sudden variation of steam debtor may produce serious perturbation in water-steam cycle which puts in order the interblock system.

Thinking at boiler like an automate object, setting the pressure and temperature's steam becomes system's charge which must be local charges for dynamic duties and boiler's safety. Setting the live steam temperatures made through injection capacity command INJ 1 and INJ 2, and setting of pressure is made through combustible capacity command. Local charges consist in:

-setting the burning process, ensuring the burning air for a complete and economic burn of combustibles and exhausting burned gaze;

-setting the water level in tambour's boiler with cylinder.

From analysis of flow sheet results complex charges for automate systems of power groups and keeping in mind that thermal energy and, in a special mood, electric energy which are produced, can not be stocked (that is the reason for stocking, which must be equal with the consumption anytime).

For a high efficiency and lead's steering, the automatic's equipment are grouped depending on charges which are made. Their function are based on receiving information from the process through sensors and gages and this actuated concerning process through actuator with continuous and discontinuous action.

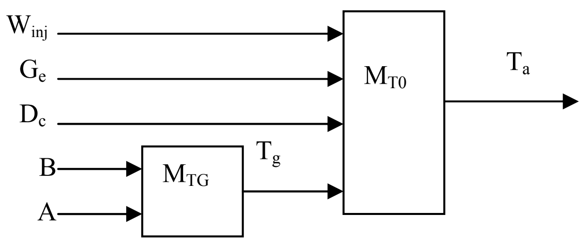

Fig. 1. The block scheme of temperature Ta

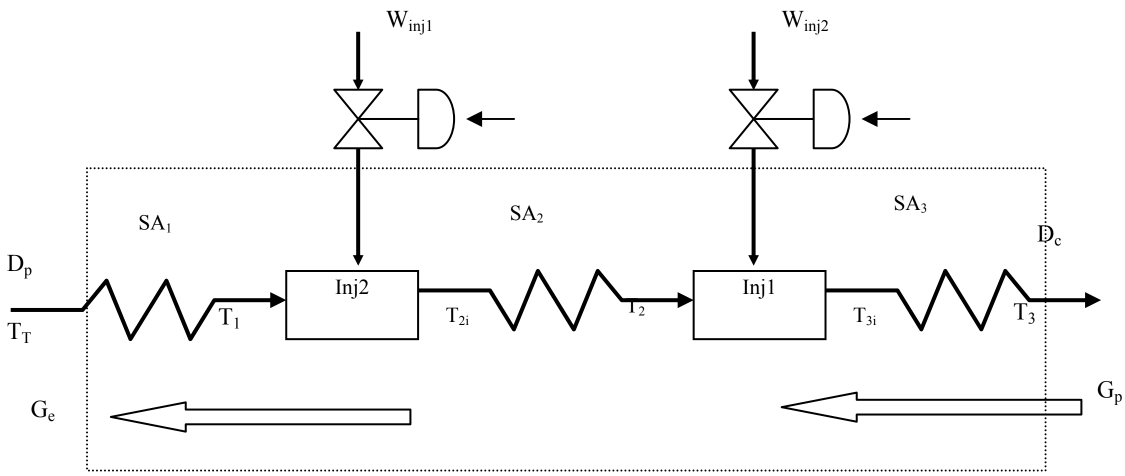

Fig. 2. Structure of superheater

For setting the live steam's temperature, the superheat is divided in two or more parts, in connection's points it is assembled apparatus which could permit the steam condensation's injection.

Because of the modern steam boiler with huge capacity, a single way of superheating with one contrivance of injection are inefficient for setting the temperature in a low limits, usually there are three ways of superheating with two injections.

2. THE EQUIVALENT MODEL OF THE STEAM OVERHEATS

The simplified scheme of the overheats from steam boiler is in figure 3, where the heating pipes SA1, SA2, SA3 and the respective zones of the gases SG1, SG2, SG3, are approximated with concentrated parameters elements.

Because of practical reasons we consider the next data which will be used in the automated regulation structure:

-The temperatures T_{a1}, T_{a2}, T_{a3}, at the outputs of every overheated area measured with their adequate translators.
-The injection flow W_{inj1} and W_{inj2} used as command magnitude for the regulation of the temperature T_{a2} and T_{a3}.
-The steam flow at the entrance in the turbine, F_t, representing the main measurable disturbance;
-The temperature of the burning gases T_{gi} and the gas flow F_g, at the input of the overheats area, which hide immeasurable disturbances but which can give information on the faults in the fuel burning process.
In these conditions the mathematical model is given the next equations in which the numerical coefficients were calculated based on the stationary regime data for a 420 tons (hour steam boiler, supporting 13,7 MPa, carbon based fuels and oil products.

$$T_{ta1}\frac{dT_{a1}}{dt} = (a_{a1i}T_{a1i} - a_{a1}T_{a1})\cdot F_{a1} + b_{a1}(T_{g3} - T_{a1}) \quad (1)$$

$$T_{ta2}\frac{dT_{a2}}{dt} = (a_{a2i}T_{a2i} - a_{a2}T_{a2})\cdot F_{a2} + b_{a2}(T_{g1} - T_{a2}) \quad (2)$$

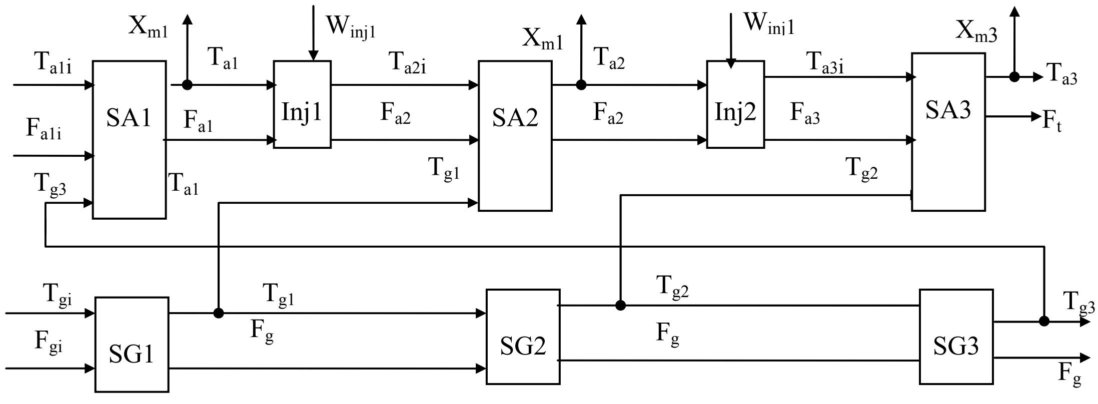

Fig.3. Block scheme of the steam overheats

$$T_{ta3}\frac{dT_{a3}}{dt}=(a_{a3i}T_{a3i}-a_{a3}T_{a3})\cdot F_{a3}+b_{a3}(T_{g2}-T_{a3}) \quad (3)$$

$$T_{tg1}\frac{dT_{g1}}{dt}=(a_{g1i}T_{g1i}-a_{g1}T_{g1})\cdot F_{g1}+b_{g1}(T_{g1}-T_{a2}) \quad (4)$$

$$T_{tg2}\frac{dT_{g2}}{dt}=(a_{g2i}T_{g2i}-a_{g2}T_{g2})\cdot F_{g2}+b_{g2}(T_{g2}-T_{a3}) \quad (5)$$

$$T_{tg3}\frac{dT_{g3}}{dt}=(a_{g3i}T_{g3i}-a_{g3}T_{g3})\cdot F_{g3}+b_{g3}(T_{g3}-T_{a1}) \quad (6)$$

$$T_{Fa1}\frac{dF_{a1}}{dt}=-F_{a1}+F_{a2}-W_{inj1} \quad (7)$$

$$T_{Fa2}\frac{dF_{a2}}{dt}=-F_{a2}+F_{a3}-W_{inj2} \quad (8)$$

$$T_{Fa3}\frac{dF_{a3}}{dt}=-F_{a3}+F_{T} \quad (9)$$

$$T_{a2i}=T_{a1}-1.97034*K_1.W_{inj1};$$

$$T_{a3i}=T_{a2}-1.97034*K_2.W_{inj2}\,; \quad (10)$$

$$T_{a1i}=T_{ai}=618{,}15K;\ T_{gi}=1183{,}15K; \quad (11)$$

Where:

$$T_{tax}=\frac{\rho_{ax}c_{ax}V_{ax}}{F_T c_T};\quad T_{tgx}=\frac{\rho_{gx}c_{gx}V_{gx}}{F_g\,\rho_{gi}c_{gi}};\ x=1,2,3.$$

and a_{ax}, a_{gx} and b_{gx} are constants determined from the boiler data.

The validation of the model and adjustment of some heat transfer coefficients have been mode through computer simulations and comparison of the variation ways of the steam temperature with the ones measured on the real boiler.

3. THE CONTROL IN THE STEAM OVERHEATER

The characteristic of the superheaters is one of the convection characteristic, the heat changing and the temperature of the steam to the output boiler are changing with the increasing power of the boiler.

The maintain of the constant temperature, assessed requirement by the turbine exploatation is made through cooling with water injections Winj1 Winj 2.

The control size is the temperature to the output superheater, the temperature from the entrance superheater is used as control auxiliare size.

Will be used two control methods of the steam temperature. In the first case it is used a simplificated control scheme (with low costs) as the one presented in the figure 4 who use only one translator and one PI controler. In the second case it studied a complex structure of control which makes the rise of the robust structure of control which deals with false information from the process, using three temperature sensors (T1, T2, T3) settled in equivalent positions (fig. 5). A simple scheme validates only those signals which values don't differ among them, with more than a value of convenient the shold fixed depending on dynamics process and precision of the measurements (fig. 6). The signals translators who are maintained invalid a long time, are stated faults and finally are isolated. Although are presented the disadvantages specifically hardware redundance (sensitive mass extension, rised consuming energy and useful engaged volume) the major vote method is used frequently because of its tolerance for fault condition.

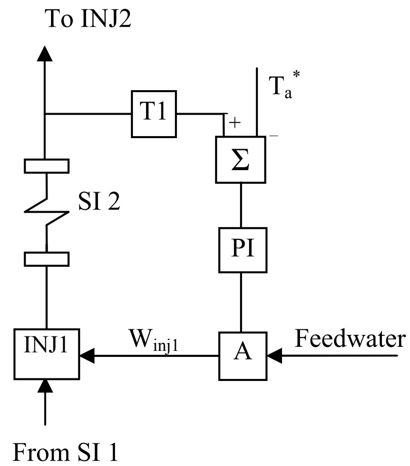

Fig. 4. The control structure for the first case

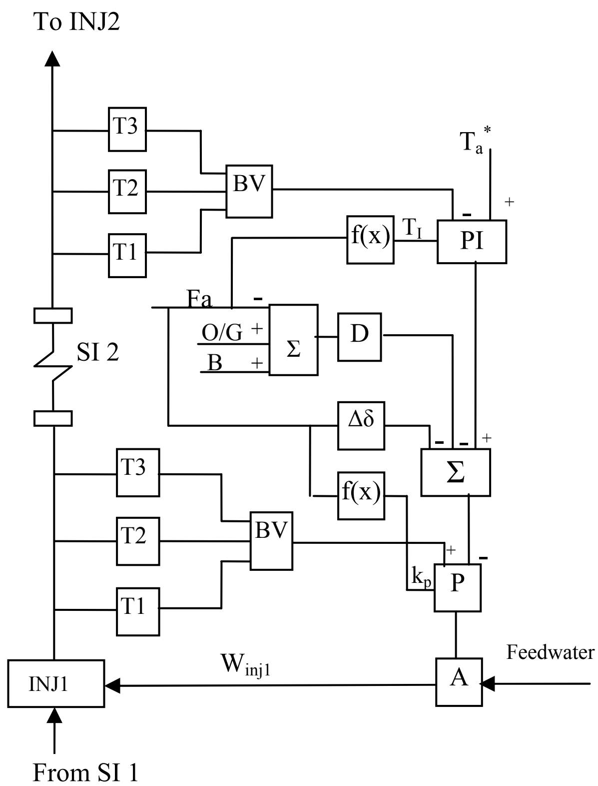

Fig. 5. The control structure for the second case

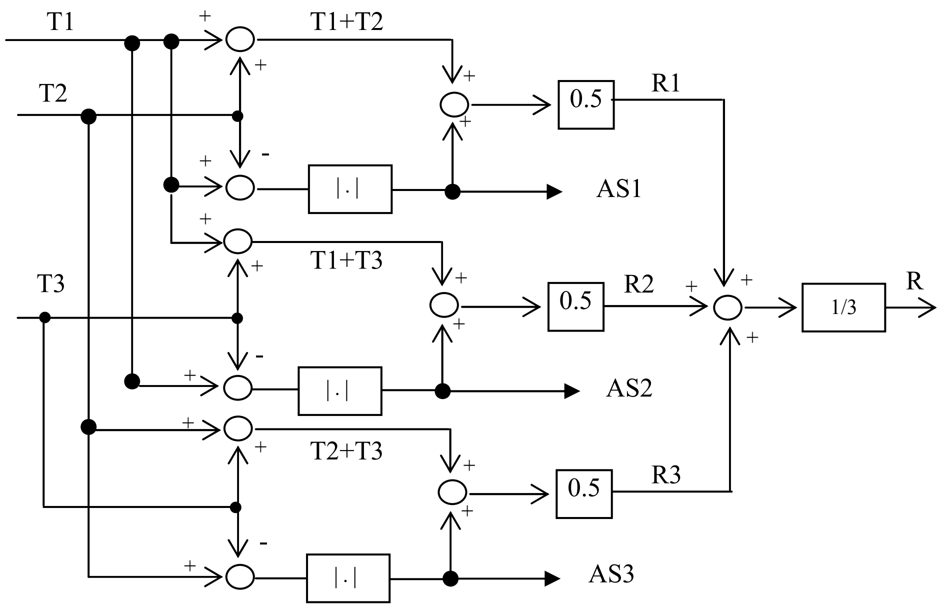

Fig. 6. The structure of the validation block

For the temperature control it is used an control scheme in cascade, with an intermediate regulator type P for local compensation of the perturbation effects (the steam temperature to out from the injection 1 and steam flow variation) and a main regulatater which maintains the value of the temperature when it comes out from superheating.

The structure includes some suplimentary corrections to be done to the signal board of the main controller of the steam and fuel flow.

This control structure which is presented here deals with thw constant modification of the PI and with the transfer factors of P in accordance with variations of the steam debit caused by the modification of the turbine power.

All these modifications ensure a more accurate control of the steam temperature when it comes into the pipe, ensuring a rise of the power made by the same consumation of fuel.

The theoretical scheme for the validation block BV is presented in figure 6. This structure permits a signal which is maintaine continuous on the reaction way even if the information provided by a translator disappears. When all the translators operate normally and their signals are aproximately equale, the reaction size has the following form:

$$R=(R1+R2+R3)\cdot 1/3$$

If the alarm systems ASi =0, then is normal function.

If the alarm systems ASi≠0 then we have fault condition.

3.1 Experimental results

The figure 7 presents the answer to the simulated process at the variation of the original conditions by integration (0-10 minutes) and the answer to perturbation Tg applied at t=10 minutes.

Figure 8 presents the response of the control system in close circuit for the two measurement temperatures and controlled Ta2 and Ta3 to a variation at 2% from prescripted size.

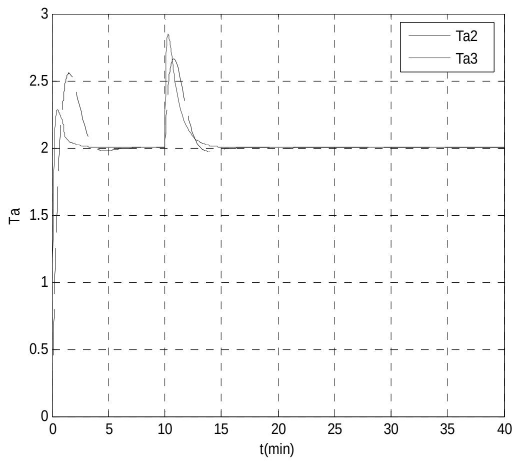

Fig. 7. The response to the disturbance Tg

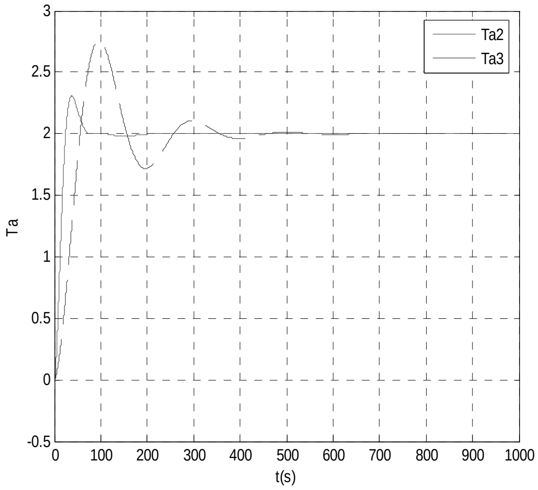

Fig. 8. The response of the control system in close circuit to step entrance

For the improvement control structure are obteined very good performances looking stability, adjustement and transitory time regime.

4.CONCLUSION

In the practical implementation of control systems for power plant, it is necessary to realize a lot of simulation experiments, to validate the synthesis programs.

This work gives solutions about new control structures for the components of the boiler, which ensure a higer rate of power group with an important effect on the reduction of the production costs**.**

A concrete elaboration of the boiler components allows the validation of some new control structures before including them in real processes on one hand, and on the other hand they allow to put on some advanced algoritms such as adaptive control based on standard model.

These aspects are the subject of recent and promising in my workshop for doctorate study.

ACKNOWLEDGEMENTS

The research included in this paper makes the development activity object from doctorate program and the others search contracts unrolled in the laboratory of the Industrial Process Control from the Automation Department-University of Craiova.

REFERENCES

Chow, E.Y., A. S. Willsky, (1984), Analytical Redundancy and the Design of Robust Failure Detection Systems, *IEEE Trans. Aut. Contr*., AC- 29 (7), pp.603-614.

Colosi T., S. Codreanu, I. Nascu and S. Darie (1995), *Numerical modeling and simulation of dynamical systems,* Casa Cartii de Stiinta, Cluj Napoca.

Knowles, J.B., (1989), S*imulation and control of electrical power station ,*John Willey &Sons, New York.

Iancu, E., M. Vinatoru, (1999), *Fault detection and isolation in dynamic systems*, Ed. SITECH, Craiova

Maican, C., M. Vinatoru, E. Iancu and C. Canureci (2007), Fault detection and control in the steam overheater, *16th International Conference on Control Systems and* Computer Science CSCS16, Univ. Politehnica Bucuresti, Proceedings vol. 1, pp. 351-357.

Marin, C., (2000), *Structure and automate control law,* Ed. SITECH, Craiova.

Marin, C., (2000), *System Theory*, Reprografia Universitatii din Craiova.

Vinatoru, C., M. Vinatoru, E. Iancu (2000), Modal Control of Distributed Parameters Heat Transfer Process, *International Symposium on System Theory, Robotics, Computers and Process Informatics,* SINTES 10, 25-26 May, pp. A118

Vinatoru, M., (2001), *Automatic control of industrial processes,* Ed. Universitaria, Craiova, pp. 278-280.

Vinatoru, M., (1994), *Control System Study for steam superheaters*, SINTES 7, vol.1, Craiova

Vinatoru, M., E. Iancu, C. Maican, (2004), Aspects Regarding Modelling and Control of Steam Power-Blocks, *Buletinul Stiintific al Universitatii "Politehnica" din Timisoara, seria Automatica si Calculatoare*, vol. 49 (63), nr. 2, pp. 173-178.

Vinatoru, M., E. Iancu, C. Maican, (2004), Modeling and Simulation of the Power Plant Steam Superheaters, *Annals 2004 – Universitatea "Dunarea de Jos" Galati* pp. 55-59.

Vinatoru, M., E. Iancu, C. Maican, (2004), Modeling and Simulation of the Power Plant Steam Superheaters, *The 12th International Symposium on Modeling, Simulation and Systems' Identification SIMSIS 12 –* Universitatea "Dunarea de Jos" Galati 24-25 septembrie , Proceedings pp. 155-159.

Warwick, K. and D. Rees, (1988), *Industrial Digital Control Systems,* Peter Peregrimes, Ltd., London.