Intelligent Control of Heating Processes

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Abstract: The contribution introduces possibilities of application of neuro-fuzzy approaches for optimalization equitherm regulation. Fuzzy algorithms are used for adjusting equiterm regulation of heating. It is used for tuning fuzzy algorithms by using learning principle with helping artificial neuronal networks too.

Keywords: neuro-fuzzy systems, equiterm regulation

1 Introduction

On the present at the raising of energy prices is given marked emphasis on thermal energy saving for heating of buildings. For thermal energy saving is regarded already in time of design of building. It is important its pattern, turning, material that is used for building and moreover. In our geographic conditions also act large role way of heating control. One scope alternative how to avoid futile waste of energy is usage of progressive method of control with utilization of knowledge systems and unsymbolic approarchs of artificial intelligence.

2 Equithermic Regulation

Heating we can define like continual system with large dead time, depended from various disturbances (external temperature, opening windows, building population, intensity of wind etc.), of which there is a lot of direct non-measurable. In consequence of these facts is uncertain modelling of this process and synthesis of control alone too. If we are cantered on optimalization of mentioned processes, we can state, that is concerned about multicriterion optimalization [2].

Equithermic regulation is towing regulation working by static characteristic so-called as „equithermic line“. Is concerned about control in opened opened loop,

where required value of heating water is derived from value of external temperature. For observance of required temperature in heating elements most often takes care PI regulator that represents „low“ level of equithermic regulation. On the basis of external temperature is by heating line-determined temperature of water to the heating system, so that heating space was warmed to required temperature. Heating line we describe with steepness and displacement. Steepness of heating line depends on concrete conditions, e.g. location of building, insulating properties, inertia of heating systems etc. Near the change of required temperature e.g. from comfortably to the dissipation, temperature of heating water is decreased (line is parallel displaced down) Fig. 1. Good many times are equithermic line simplified and given by straight line. Every building can have several equithermic lines. Each of lines respons another atmospheric conditions that singular by slope. The greater angle of slope, the more unfriendly atmospheric conditions. Whole heating system works by setting of required temperature that we can define and prevent in time to change. This temperature is compared with actual temperature of air in room. On the basis of this comparation boiler starts [2].

Boiler warms the water to the temperature that is justified by exterior temperature with selected equithermic line. Approximative scheme of this process is depicted on Fig. 2.

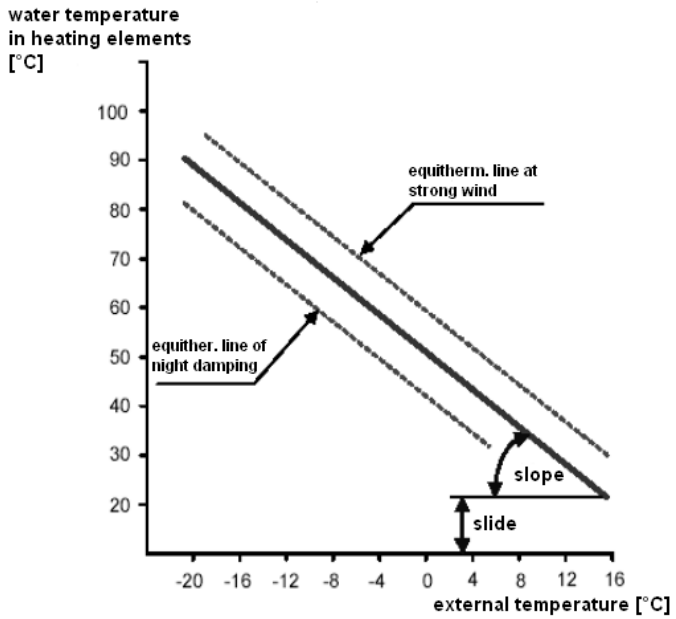

Figure 1
Approximative equithermic line

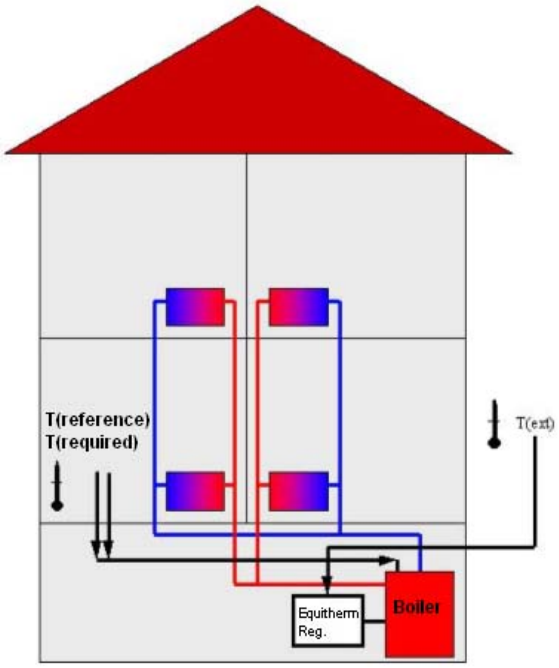

Figure 2
Principle scheme of control by equithermic regulation

For creation of equithermic regulation model with correction to reference temperature was used a principle of correction based on idea that classical equithermic regulation is supplemented by superior control loop, that provide adjustment of real temperature in room to the required value, that will be justified for comfortable and dissipation mode. The block scheme of equithermic regulation model of heating with correction to reference temperature is depicted on Fig. 3. On figure are presented behavior of simulated values near equithermic regulation with correction on reference temperature [5].

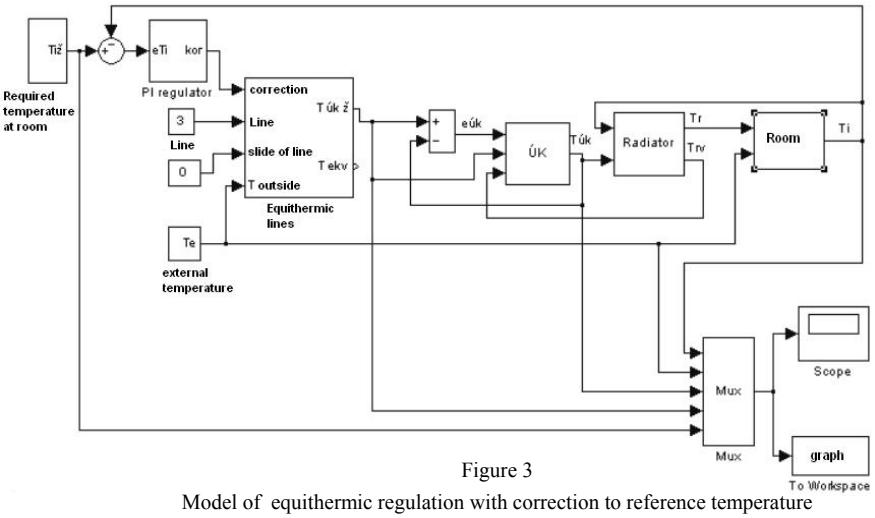

Figure 3

Model of equithermic regulation with correction to reference temperature

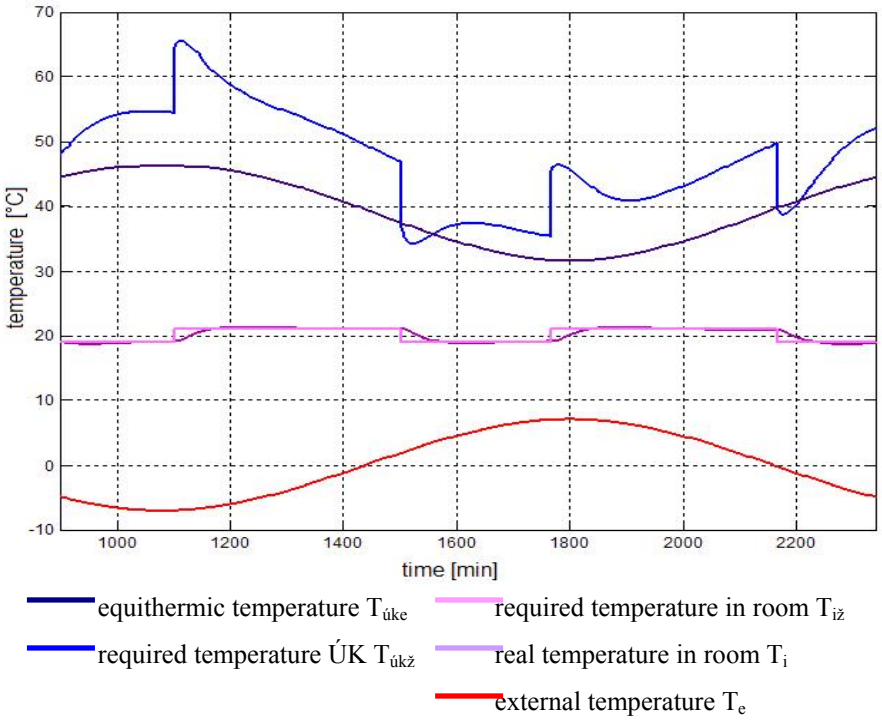

Figure 4

Chosen behaviours of equithermic control simulation with correction on reference temperatures with line no. 1

3 Intelligent Control of Building

It stands to reason that saving of energy we reach by two ways. By construction of building and quality of control. Control of involved plants like heating yield to solve plants of differential equations. Solution of this plant is however mathematically serious. But for all that are practically many solutions like e.g. thermostats, regulators and another control unit. Of late years are occurred on the marked also so-called intelligent regulators, intelligent control unit. They are classical regulators that include of intelligent blocks or control units that exploit age methods and practices of artificial intelligence. Most often they are elements that use fuzzy logic, net of neurons, or genetic algorithm. They change the classical control to auto tuning, adaptive or simply learning control [6]. Best known of group is combination of fuzzy logic and neuron. It together combines advantages of fuzzy systems and neuron nets. Resultant system may work with in determination and on the other side is able to learn. It exists in two types combination of approaches:

- Fuzzy-neuron systems
    - They remove main negative of fuzzy systems, what is inability to learn. It deals about implementation of fuzzy systems by resources of artificial intelligence. They are so-called adaptive fuzzy regulators. Following systems are representative: ANFIS, NARA, FALCON.
- Neuro-fuzzy systems
    - These systems are especially oriented for addition ability of work with indeterminable ness to neuron nets. We try to fuzzy of neuron nets.

Because these systems can be characterized with mathematical seriousness, then incurred so-called hybrid systems. It dealt about dividing of tasks to two groups, during which time and second by adaptive fuzzy regulators. Property of whole system is not same as, about as if we sum up properties of neuron net and fuzzy systems – it up raise emergent ion [1].

Equithermic regulation do not direct regard dynamic changes of external and internal conditions of heating (effect of wind, sun radiation, population of building, opening the window etc.). Only by indirect and with delay is able to regard internal conditions of heating by reversible water temperature measurement that is outgoing from heating zone like disturbance value. These wattages are solving by switching of mentioned version of equithermic line by needs, eventually equithermic regulation is supplemented with optimalization algorithm for précising parameters of equithermic line by external and internal conditions at building (at zone).

For optimalization of equithermic regulation we can use several ability. One of them is replacement of human (fireman) by fuzzy regulators that retrieve dates about state of heating from sensors and decode them by rules that are nearby of human decision at operator activity. Likewise fuzzy regulator can use also archived process dates. Optimal method how to fill up of listed regulator is used a superior level of control (dispatch workstation presented as PC), that present become standard in modern technologies. With this that equithermic regulation become retained is related to minimal outlays for complement of this optimalization to the existing control of technology. Advantage keeping of conventional method of regulation on process level is also reliability of control system and its function also in not optimal conditions. It is possible able this optimalization insert to the process level by using of modern programmable process stations [3].

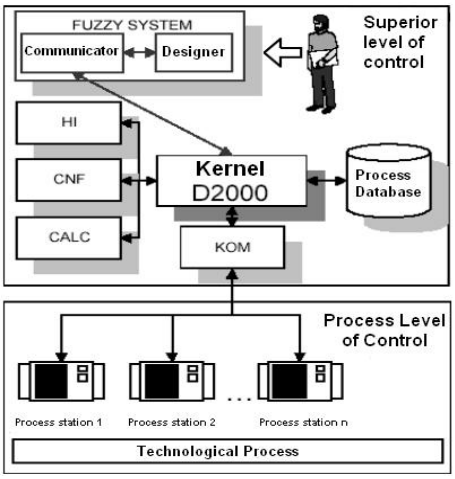

Figure 5
Positioning of fuzzy regulator fuzzy for optimalization of process in chain

On Fig. 5 is graphical depicted structure of control by using of fuzzy regulator to superior level of control. By this method we create „black box“, that it will be tuned on concrete technology of heating and it is possible consequently backwards rewrite to the fuzzy regulator. This method can be use only at existence of qualified fireman that regularly executes interventions to the control of heating. Main disadvantages are impossibility thus prepared fuzzy regulator use in another building. Another possibility is to design of fuzzy regulator direct with categorical information for concrete case. This possibility is very difficult, because without either of tests is practice impossible correct tune in fuzzy regulator for concrete application. Optimal appears solution is to joint both of mentioned possibilities to one unit. It matters that we must to use categorical informations at design of fuzzy

regulator. Consequently like that prepared fuzzy regulator we must rewrite to neuro – fuzzy system and to tune in regulator on concrete application. In this case we must to use during tuning reinforcement learning, seeing that is assumed existence of qualified operator. For concrete application is needed to tune them [3].

It is also possible optimalization of equithermic regulation on process level and seeing on fuzzy regulator like on expert's system of real time. Increasing quality of regulation process of equithermic regulation is possible to reach by completion about fuzzy block that will be to modify parameters of classical PI regulator by actual regulation state of heating plant. Such regulator would be possible to apply also in modern regulation systems, what increase technical level of these systems. We are making „knowledge oriented adaptive control"[4]. There can be used besides another fuzzy regulator in two possibilities on following:

- Continuous (on line) adaptation parameters of PI regulator,
- Optimalization of PI with evaluates character of transient.

It is possible to use advantageous properties of neuron nets for calculus of adaptives for individual levels of heating and leads. For upgrading of control algorithm is possible to use following types of adaptives:

1 Adaptive on lead of transition from attenuation on heating, that fined that time needed for heating of room on required temperature from lead out of attenuation to the heating past required temperature.

2 Adaptive on correction, next that is use for correction of heating water for next interval of heating or attenuation.

Conclusion

This contribution deals about in today's very actual question saving of energy by usage method of artificial intelligence. Perspective of exploitation artificial intelligence near automatization of control process of heating with usage of equithermic regulation should by provide decrease of demands on operation qualification technology of heating as well as increase of user comfort.

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References

[1] BABJAK, J.: *Hybrid intelligence* (15.10.2004) <URL:http://www.scienceworld.cz/sw.nsf>

[2] BÍROVÁ, D.: *Application of fuzzy regulation in automated heat production,* Graduant rigorous work, TU Košice, 1996

[3] HOLIŠ, M: *Usage of neuro-fuzzy systems at control of continuous processes in conditions of indetermination,* Dissertation thesis, STU Bratislava 2001

[4] RIMÁR, M., PITEĽ, J.: *Heating control based on equithermic regulation and regulation of thermal output, Acta Mechanica Slovaca*, 2004, year 8, n. 3-A/2004. pp. 277-280, ISSN 1335-2393

[5] PITEĽ, J.: *Heating control based on equithermic regulation*, AT&P Journal, 2004 year, XI., n. 3, pp. 39-41, ISSN 1335-2237

[6] SALOKY, T., Some Problems of AI Impelmentation (pp. 165-194), In: Tauer, I., Hrubina, K., Eds*: Optimal control of processes based on the use of informatics methods*, Informatech Košice, 2005, ISBN 80-88941-30-X