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ADAPTIVE CONTROL OF HEATING PROCESS WITH OUTDOOR TEMPERATURE COMPENSATION

ADAPTÍVNE RIADENIE PROCESU VYKUROVANIA S EKVITERMICKOU REGULÁCIOU

Abstract

The classical heating process control with outdoor temperature compensation may be supplemented with the temperature sensing in the reference room. Than the default heating curve is corrected according to desired and actual temperature value in reference room. The correction based on adding of the superior control loop on the base of PI controller was used. PI controller according to control deviation increases or decreases desired supply water temperature calculated from the default heating curve and actual outdoor temperature. But there may be problem with overshooting especially at transition between damped and comfortable desired temperature in reference room. This problem was solved by adaptability block, which provides heating curve adaptability on the change of desired temperature value in reference room and on the change of heating system parameters.

Abstrakt

Klasická ekvitermická regulácia vykurovania môže byť doplnená o snímanie teploty v referenčnej miestnosti. Nastavená vykurovacia ekvitermická krivka je potom korigovaná v závislosti na žiadanej a skutočnej teplote v tejto referenčnej miestnosti. Princíp korekcie založený na tom, že klasická ekvitermická regulácia sa doplní o nadriadenú regulačnú slučku na báze PI regulátora bol použitý pre riadenie. PI regulátor v závislosti na regulačnej odchýlke zvyšuje resp. znižuje žiadanú teplotu vykurovacej vody vypočítanú z nastavenej ekvitermickej krivky a vonkajšej teploty. Môže sa však vyskytnúť preregulovanie najmä pri prechodoch z útlmu do vykurovania. Tento problém bol riešený pomocou bloku adaptivity, ktorý zabezpečuje adaptivitu vykurovacej ekvitermickej krivky na zmeny žiadanej teploty v referenčnej miestnosti a na zmeny parametrov vykurovacieho systému.

1 INTRODUCTION

The classical verified approach to the heating process control is using of outdoor temperature compensation. The main goal of outdoor temperature compensation is to ensure the desired temperature into heated space according to different external conditions. For achievement of this requirement it is necessary to find equilibrium between supplied power and heat loss of building, i.e. to ensure the optimal temperature of supplied water.

The outdoor temperature compensation requires good control accuracy to ensure desired thermal comfort into heated spaces. Classic PID algorithms after good tuning are able to ensure desired accuracy while system is right identified and there isn't parameters change of controlled system in time. The one way for elimination of this problem is using of adaptive control.

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2 OUTDOOR TEMPERATURE COMPENSATION

Outdoor temperature compensation is a specific case of the follow-up control. The temperature of supply water is desired variable for control and it is operated by temperature of outdoor air according to default heating curve. Consequently heating curve describes dependency of supply water temperature on outdoor air temperature. This dependency is non-linear and is given by heat insulation facilities of building. For practical application there are several heating curves that are characterized by different steepness (number).

The heating curve with higher temperature of supply water is set up for heating systems dimensioned for higher temperature drop. For good insulated buildings it is possible to set up the curve with lower temperature of supply water. The temperature change into heated spaces is made by change of the shift of heating curve.

The classical heating process control with outdoor temperature compensation may be (especially in smaller buildings) supplemented with the temperature sensing in the reference room. It is possible than to reach more accurate indoor temperature control of the building. Such heating process control may be than called outdoor temperature compensation with room influence. The reference room must represent actual temperature in the building and therefore selection of the room for reference temperature is very important.

The classical outdoor temperature compensation ensures equilibrium between supplied power and heat loss of building while outdoor temperature compensation with room influence can extra ensure compensation on the other heat gains or losses into heated space.

There are several theoretical possibilities of the correction according to reference temperature. The principle of correction based on adding of the superior control loop on the base of PI controller was used for model design of the outdoor temperature compensation with room influence (Fig. 1). PI controller according to control deviation of desired and actual temperature value in reference room increases or decreases desired supply water temperature calculated from the default heating curve and actual outdoor temperature.

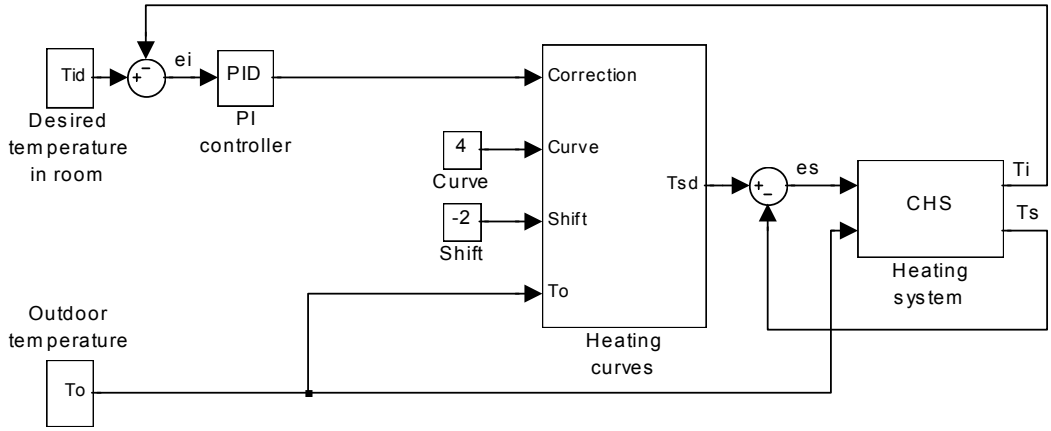

Fig. 1 Functional diagram of the outdoor temperature compensation with room influence

The variables in functional diagram on Fig. 1:

T_{id} – desired variable of indoor temperature [K],

T_i – indoor temperature [K],

e_i – control deviation of desired and actual value of indoor temperature [K],

T_o – outdoor temperature [K],

T_{sd} – desired variable of supply water temperature [K],

T_s – actual value of supply water temperature [K],

e_s – control deviation of desired and actual value of supply water temperature [K].

The major section of functional diagram on Fig. 1:

- superior control loop on the base of PI controller,
- heating curve consisting of functional block of default heating curves and blocks for option of heating curve number and shift,
- heating system block comprehensive of heating boiler, water temperature regulation (mixing valve, servomotor, 3-points controller for position control of actuating mechanism), radiator and room.

The model of the outdoor temperature compensation with room influence was simulated by program Matlab Simulink. It results from simulation that by using of PI controller it is possible to reach zero control deviation of desired and actual temperature value in reference room also by relative incorrect default heating curve.

On the base of simulation results the control algorithms for outdoor temperature compensation verification on the real heating system were designed. It resulted from verification that there is a problem with overshooting especially at transition between damped and comfortable desired temperature in reference room. This problem was solved by control algorithms with adaptability.

3 ADAPTIVE CONTROL OF HEATING PROCESS

The keynote of adaptive control of heating process with outdoor temperature compensation is based on the verified process for correct adjustment of classical outdoor temperature compensation for practical using, i.e. set up of the right heating curve shift for damped and comfortable desired temperature in reference room.

The functional diagram of the outdoor temperature compensation with room influence was supplemented with adaptability block (Fig. 2), which provides heating curve adaptability on the change of desired temperature value in reference room and on the change of heating system parameters.

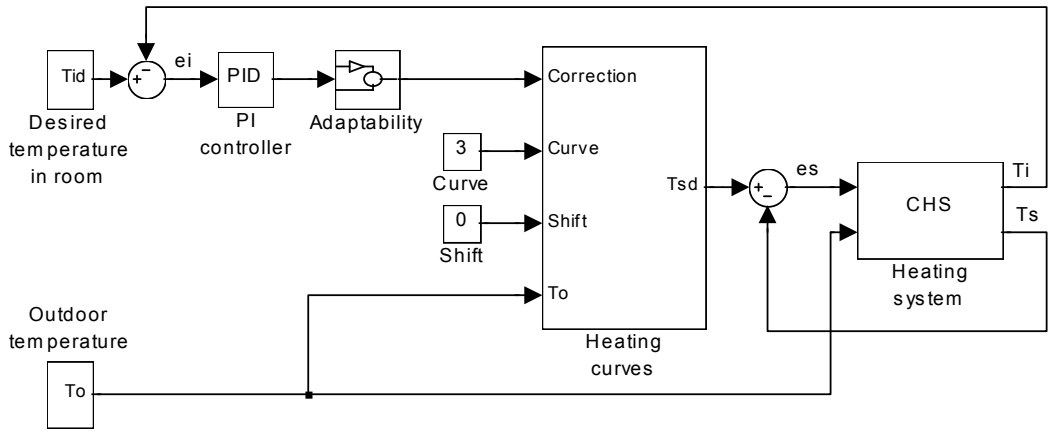

Fig. 2 Functional diagram of heating process adaptive control

The adaptive algorithm determines current adaptability, which through weight coefficient affects stored adaptability. The principle of adaptability calculation is on Fig. 3.

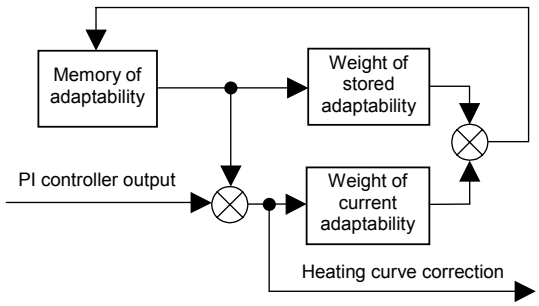

Fig. 3 Functional diagram of adaptability

4 CONCLUSIONS

It was proved from measured results of verification that control algorithms with adaptability provided required temperature achievement with shorter control time and smaller overshooting than control algorithms without adaptability. The adaptability favourably affects the heating process control especially from these reasons:

1. The basic PI controller can have smaller adjusting range (especially lower limit). It reduces the control time and overshooting at transition between damped and comfortable desired temperature in reference room. This smaller adjusting range ensues from adaptability support to basic PI controller (heating curve correction is a sum of adaptability and PI controller output).
2. The adaptability ensures step drop of supply water temperature at transition between comfortable and damped desired temperature in reference room. It reduces the control time and energy consumption for heating.

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