Decrease of Operation Costs in Domestic Hot Water System in Multi-dwelling House

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Abstract – The content of this submission is to elaborate energy balance of domestic hot water system in multi-dwelling house before and after reconstruction of distribution pipes and then after optimization of circulation pump operation too. Energy savings are using further in order to analyse operation costs of domestic hot water system and to calculate finance savings of one dwelling-unit.

Key words – thermal losses, domestic hot water system, operation costs, multi-dwelling house.

I. Introduction

There was selected typical multi-dwelling house with 8 above ground floors, 1 basement floor and with flat roof for analysis purposes. The house consists of 72 dwelling-units (one-room and three-room flats) with total number of the population around 180 people. The object was built in 1975 and no reconstruction of distribution piping (water pipes, plumbing and gas distribution) was realised to this very day. External walls were insulated and all old windows were exchanged for new in 2008 (Fig. 1). The domestic hot water is supplied from district heating system. Hot water consumption in this multi-dwelling house is 40 litres per day and person. Distribution system in the house consists of main horizontal pipes that are placed in basement floor and of vertical rising pipes placed in vertical shaft. There are used steel galvanized pipes with thermal insulation from felt strips by thickness 4 or 8 mm (Fig. 2). Circulation loop of distribution system is in operation constantly (24 hours a day) nowadays.

II.Energy Balance of System – Old State (24 Hours of Circulation a Day)

Energy balance of domestic hot water system in multi-dwelling house consists of energy need for domestic hot water and thermal losses from distribution pipes. By actual hot water consumption 40 litres per person and day the energy need for domestic hot water is 153 360 kWh/year (hot water temperature is 60°C). The standard STN EN 15316-3-2 [1] was used in order to calculate thermal losses from distribution system. The thermal losses were calculated by using monthly method for actual state of distribution pipes (steel galvanized pipes, thermal insulation from felt strips) and operation of circulation pump 24 hours a day. Average temperature of hot water in circulation loop of multi-dwelling house is 50°C. Average monthly temperature for basement floor and vertical shaft separately was used as ambient temperature in calculation (Table I). These values are gained from energy simulation of multi-dwelling house in tool DesignBuilder [2].

Fig. 1. The view on analysed multi-dwelling house

Fig. 2. The view on origin distribuition pipes

The total thermal losses from hot water distribution system for actual (old) state are 99 768 kWh/year. The total energy balance of domestic hot water system is calculated in the amount of 253 128 kWh/year.

III. Energy Balance of System – New State (24 Hours of Circulation a Day)

In the view of unrealised exchange of distribution pipes there is needed to make reconstruction in the following rate:

- exchange of original distribution pipes for new plastic (material PP-R) in corresponding dimensions,
- new thermal insulation from polyethylene (PE) by thickness 20 mm,
- installation of thermostatic circulation valves at the bottom of vertical circulation pipes.

The thermal losses are calculated for the same boundary conditions of hot water temperature, ambient air temperature and for operation of circulation loop 24 hours a day.

The total thermal losses from hot water distribution system for new state (24 hours of circulation a day) are 40 213 kWh/year. The total energy balance of domestic hot water system is calculated in the amount of 193 573 kWh/year.

TABLE 1

AVERAGE MONTHLY AIR TEMPERATURE

Month	Basement floor [°C]	Vertical shaft [°C]
January	10,5	17,5
February	11,1	17,7
March	13,3	18,5
April	15,7	19,4
May	19,6	22,4
June	22,4	25,9
July	24,0	28,1
August	24,6	28,9
September	20,4	24,0
October	16,4	19,6
November	12,9	18,1
December	10,8	17,6

IV. Energy Balance of System – New State (6 Hours of Circulation a Day)

The operation time of circulation pump was 24 hours a day in the above states. This operation of circulation loop has some advantages and disadvantages too. The advantage is e.g. permanent delivery of hot water by required temperature during the whole day. The disadvantage can be advanced heat losses from distribution pipes and bigger consumption of auxiliary (electric) energy for operation of circulation pump. Our goal is to optimize the operation of circulation pump so that the required temperature of hot water at user outlet will be assured (45-55°C). Reduction of thermal losses from distribution pipes in multi-dwelling house should be result of this optimization.

The first step to optimization of circulation pump operation was to calculate time of hot water temperature drop from initial level 55 °C to value 45 °C in hot water distribution system. The value 45 °C is minimal level of hot water temperature that is supplied final users by valid legislation [3]. Analytical calculation was done on the base of standard STN EN 15316-3-2 [1] for used pipes material (PP-R) and thermal insulation (PE, thickness 20 mm). Average monthly temperature for basement floor and vertical shaft separately was used as ambient air temperature in calculation (Tab 1). The hot water distribution system consists of pipes with different dimensions and different length. Therefore following approximation way was selected. There was applied weighted average of pipes dimensions and lengths in order to determine one dimension for vertical pipes (PP-R 32x5,4) and one dimension for horizontal pipes (PP-R 40x6,7).

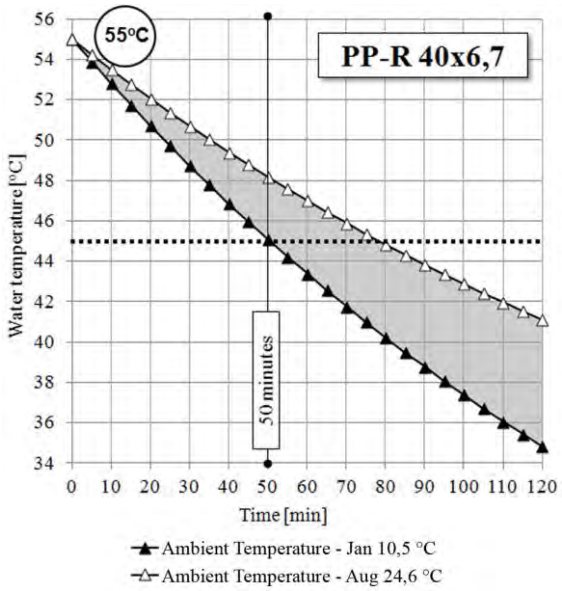

Fig. 3. Hot water temperature drop in horizontal pipes 40x6,7

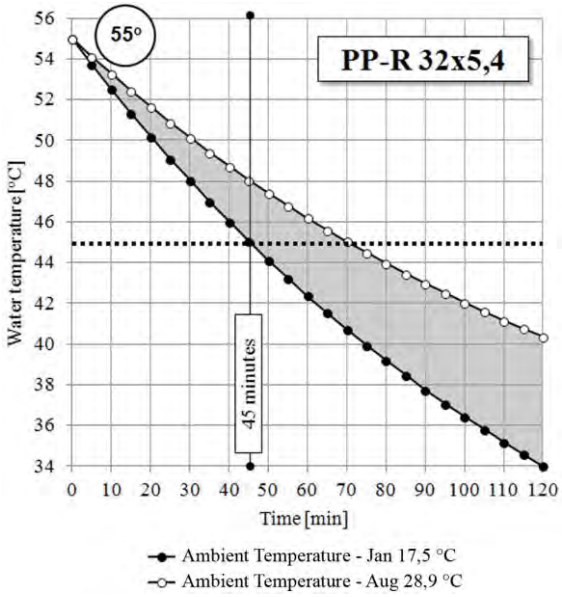

Fig. 4. Hot water temperature drop in vertical pipes 32x5,4

The hot water temperature drop in time was calculated for selected dimensions of pipes and for average monthly ambient temperature. The gained results are shown in the following graphs (Figs. 3 and 4). There was monitored time of hot water temperature drop from 55 °C to 45 °C during single months. In the case of horizontal pipes the time of hot water

temperature drop is at interval 50 – 80 minutes in terms of ambient air temperature during a year. In the second case (vertical pipes) this time is at interval 45 – 70 minutes in terms of ambient air temperature during a year. The result of this time analysis is the option to operate circulation pump intermittently with maximal time-out 45 minutes.

In the second step the goal was to determine operation time of circulation pump on the base of hot water volume flow over circulation pump (0,57 m3/h). The circulation pump has to be in operation 15 minutes in order to achieve hot water temperature on level 55 °C.

On the base of the above results it is taking intermittent operation of circulation pump into account in energy balance. The operation time of circulation pump is 15 minutes; pause between single operation cycles will take 45 minutes. It can come to maximal drop of hot water temperature about 10 K during pause (mainly in time winter months).

The total thermal losses from hot water distribution system for new state (6 hours of circulation a day) are 23 921 kWh/year. The total energy balance of domestic hot water system is calculated in the amount of 177 281 kWh/year.

V. The Results from Energy Balance of Domestic Hot Water System

The results from energy balance of domestic hot water system for three compared variants are shown on the following graph (Fig. 5). It follows from results that the exchange of distribution pipes and using of new thermal insulations bring energy savings in domestic hot water system in the amount of 59 555 kWh/year what is 24 %. By optimization of circulation pump operation it is possible to increase this energy savings to the amount of 75 847 kWh/year what is 30 %.

VI. The Results from Financial Analysis

The goal of financial analysis is to quantify the operation costs of domestic hot water system. The generation plant TEHO Kosice supplies with heat energy the multi-dwelling house. The price of heat energy is calculated by actual valid price list in 2013 [4]. The total prices of delivered heat for three analysed variants are shown on the following graph (Fig. 6).

It results from analysis that exchange of distribution pipes and using of new thermal insulation can bring financial savings by operation of domestic hot water system in the amount of 5 626 Euro/year what is 24 %. The next optimization of circulation pump operation can increase financial savings at the amount of 7 165 Euro/year what is 30 %. The original operation costs for one dwelling-unit are 332 Euro/year. If we apply the last variant, the operation costs will decrease in 232 Euro/year. The saving of operation costs in the amount of 100 Euro/year for one dwelling-unit is the clear result.

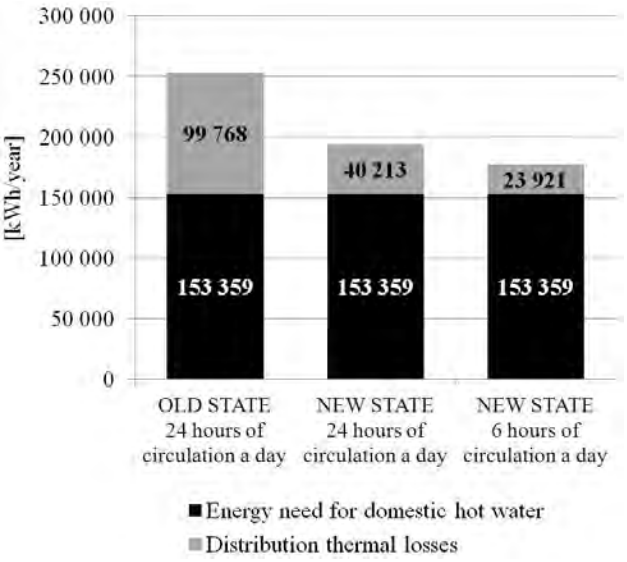

Fig. 5. Energy balance of domestic hot water system

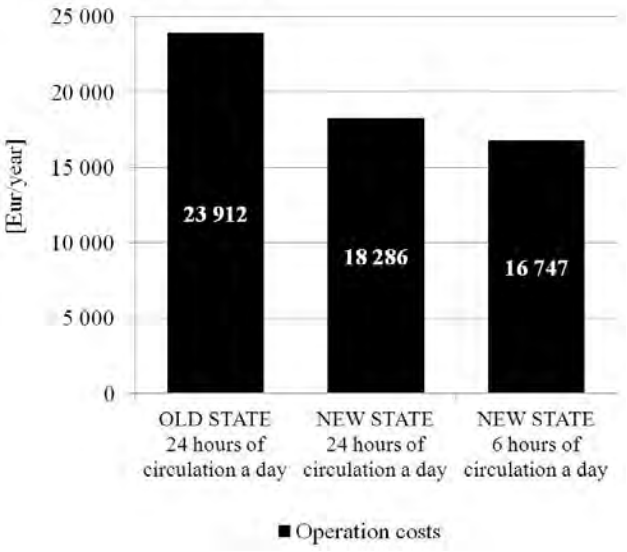

Fig. 6. The operation costs of domestic hot water system

Conclusion

The clear conclusion results from balances in this contribution. In order to reduce thermal losses from distribution pipes of domestic hot water system it is needed to pay attention not only to exchange of original pipes and to proposal of thermal insulation thickness but also to deal with operation time optimization of circulation loop.

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