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Hot Water Recirculation and Control, a Solution to Reduce Energy Consumption

For the energy consumption reduction in the buildings sector, EU proposes guidelines regarding energy performance. EU Member States must take measures to ensure the conversion of buildings into nearly zero energy buildings, which should also include measures to optimize installations for domestic hot water (DHW). From this point of view the present paper deals with issues regarding hot water recirculation and control aiming to reduce fuel consumption necessary for DHW preparation. To this end the benefits of DHW preparation process optimization were analyzed, in order to ensure a theoretical constant temperature having values in a narrow domain and an efficient thermal fluid distribution in the network for better controlling hot water temperature.

Keywords*: domestic hot water, temperature, flow, energy, recirculating pump*

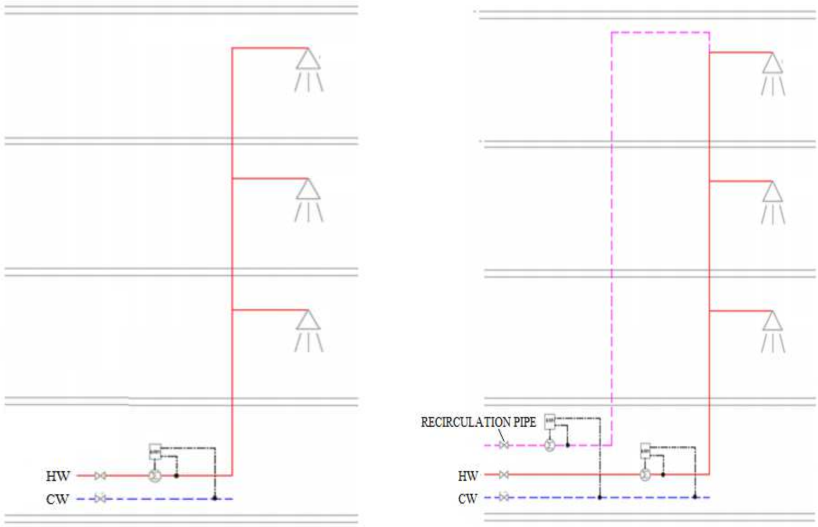
1. Introduction

The role of indoor domestic hot water supply installations is to provide water supply flow and pressure, required to all consumers under energetic efficiency conditions. Thus, it is necessary to implement the most efficient solutions regarding design, thermal rehabilitation and modernization of these installations for energy efficient utilization [1].

In order to reduce the energy consumption for domestic hot water (DHW) preparation, an efficient alternative is represented by using regenerable sources, such as: solar or geothermal energy. Although the hot water consumption during all the year is relative constant, the regenerable sources are variable. Therefore, in order to prepare hot water there are required supplementary energy sources.

For the building global energetic balance, plumbing installations intervene directly through the thermal energy required for hot water preparation. On the other hand they indirectly intervene through the pumping energy given by the water consumption volume and simultaneousness and by pressure losses through friction. A secondary aspect of the energy consumption is quantified by uncontrolled water losses in the installations.

Into the hot water supply installations with no recirculation (Fig.1a) frequently appear situations when after a certain time period (from 5 to 20 minutes) water reaches the required temperature at the consumers [2].



a) without recirculation   b) with recirculation

Figure 1. Plumbing installation for domestic hot water supply

In centralized systems, this quantity of water is metered at the hot water price and directly discharged into the sewer systems. The loss is assessed both by large water quantities lost at every waiting period and by the costs for the unused water quantity circulation.

Inside the most existing buildings with no rehabilitation, the major drawbacks of indoor plumbing installations are structural, namely with no recirculation pipes and if there are recirculation pipes these are not equipped as to ensure an optimal operation.

From energy and water consumption reduction point of view, inside the indoor plumbing installation for DHW a solution is to equip it with DHW recirculation installations (Fig. 1b). Thus, the hot water recirculation installation can lead to a significant water loss reduction and to the increase of comfort degree.

2. The hot water recirculation installation balancing

In order to increase the hot water recirculation installation efficiency, a necessary condition is represented by the achievement of the minimal temperature value at the beginning of the normal consumption period in all the connection points at the supply network.

This condition can be accomplished both by a proper hydraulic balance and by the correlation between the hot water consumption and the installation operation.

Thus, unbalanced hydraulic recirculation installations have the disadvantage that water flows only through minimum resistance pipes circuits, while on the other circuits it will be at a standstill. This situation is similar with the operation of plumbing installation with no recirculation.

The recirculation installation adjustment can be performed by selecting during the design phase the convenient diameters of the return pipe and equipping these pipes with regulators, control valves, diaphragms and control systems or through the control valves adjustment at the putting into service of the installation (slow and not recommended adjustment). The final goal is the energy economy achievement [1], [2], [3].

In Figure 2 it is presented the schematic diagram of a DHW plumbing installation with recirculation, heat exchanger (HE) and recirculation pump (PC). In this case it is obvious that the water circulation on some recirculation circuits will be advantaged compared to other circuits leading to a water temperature into the last columns lower than the required value.

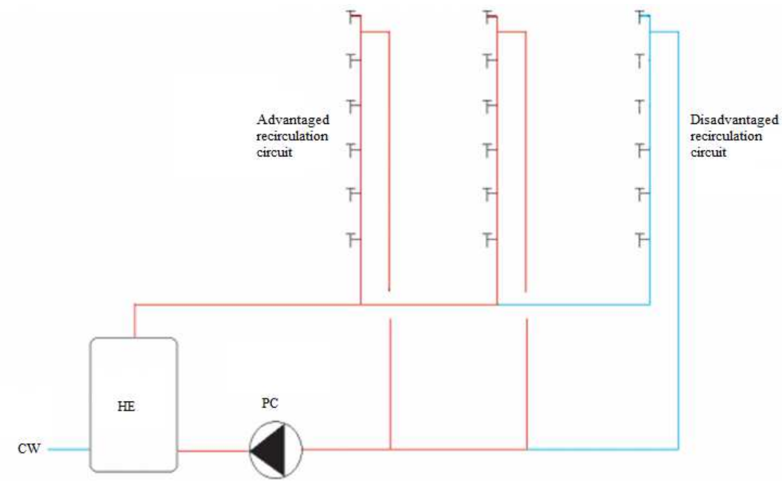


Figure 2. DHW plumbing installation with recirculation, heat exchanger and recirculation pump [2]

This phenomenon can be prevented by mounting the balancing recirculation valves (VC) on each column and a Partner valve on the main pipe (Fig. 3). The Partner valve (VP) indicates the differential pressure exceedance. The pump rotation speed can be accordingly reduced and the Partner valve will reopen. The pressure drop in the Partner valve and the pumping height can be reduced which lead to a considerable decrease in pumping costs. The optimal balancing is obtained when the balance valves will support the minimal load loss, allowing an accurate flow measurement. The exceeded pressure is overtaken by the Partner valve [1].

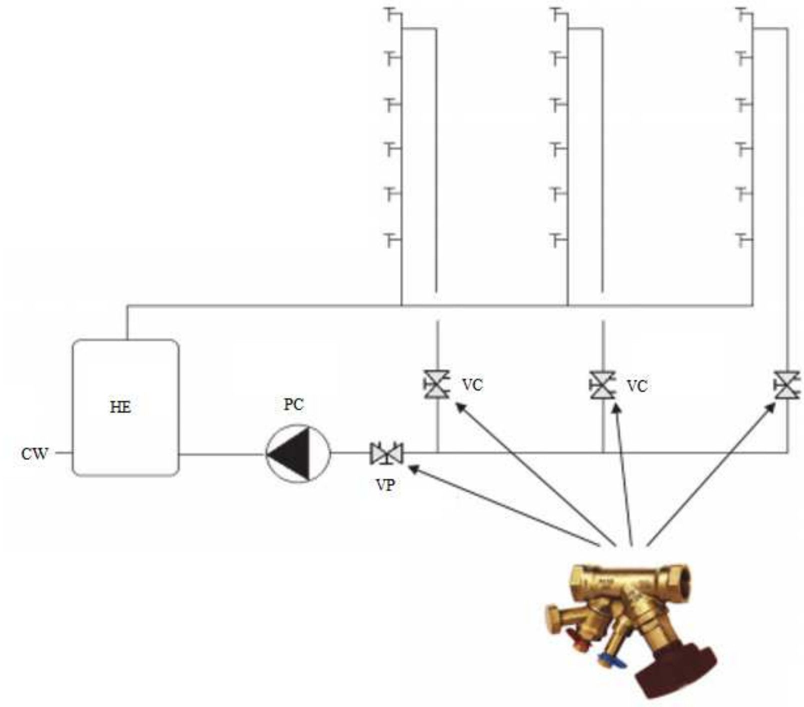


Figure 3. DHW plumbing installation with recirculation, heat exchanger, recirculation pump, balancing valves on columns and Partner valve [2]

The balancing can be performed by using balancing taps with flow and differential pressure measurement inlet by TA (Tour&Andersson) method, using balancing computers and dedicated software. In this situation the calculation of the recirculculation flows which must be adjusted on each column is difficult to accomplish because these depend on a series of factors such as: air and water temperature inside the pipes, pipes diameter thickness and material, insulation type and thickness, etc. [2], [4]. In conclusion this system does not take under consideration the water temperature inside the recirculation columns which implies the use of water temperature control and automation equipment in order to ensure the recirculation only when it is requested. The solution can become expensive and complex.

Therefore by using the recirculation installation during the consumption period will lead to an useless electric energy consumption. During the period when the energy source provides no heat for DHW preparation, using the recirculation installation will determine significant energy losses inside it. For this reason the recirculation installation automation is very important. In order to obtain hot water at the utilization temperature on the distribution pipe up to the connection point at the recirculation installation it is necessary that the recirculation pump to be programmed as to enter into the operation after the starting of the DHW supply installation and before the beginning of the hot water consumption [3].

A solution for solving these inconveniences regarding the water temperature control and the flow calculation on each recirculation pipe (Fig. 3) is the use of valves with pressure inlet (VPP) combined with thermostatic taps (VT), solution presented in Figure 4 [2], [3].

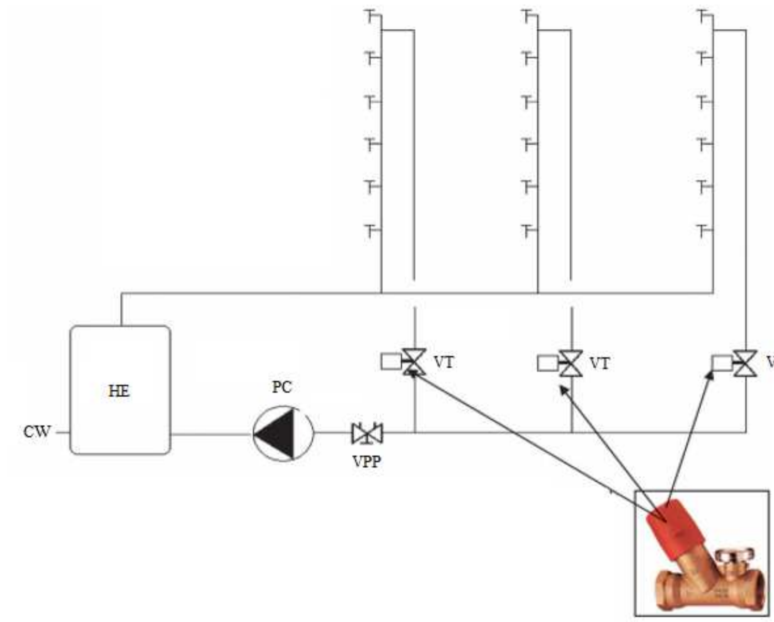


Figure 4. DHW plumbing installation with recirculation, heat exchanger, recirculation pump, valves with pressure inlet and thermostatic taps [2]

This system presumes only the total flow calculation on the Partner valve because the required temperature is prescribed on each thermostatic tap. This tap will open only when the water temperature in the recirculation column decrease under the prescribed value and thus the balance both from the hydraulic and thermal point of view is achieved [2], [5].

3. The optimization of DHW plumbing installations equipped with recirculation system

Regardless, the adopted domestic hot water recirculation system, the design will be based on norms so that domestic hot water to be available at the tap after 10 seconds at operating temperature (45°C) and prevent stagnation of water in recirculation pipes [6], [7], [8], [9], [10]. Hot water supply installations may have sections without recirculating systems if it fulfills the user's comfort. Circulating DHW pumps have an important role in ensuring these conditions.

Regarding the recirculation pump in DHW installations, it is necessary to ensure the consumers comfort (hot water is always available and at the same time to all the consumers) [5]. The pumps must meet standards requirements, applicable rules and regulations, high demands on hygiene and corrosion resistance performance under conditions of operation. Pumps that have adaptive system to the installation performance requirements (modern pumps high efficiency), consume a small amount of electricity, since it works all the time at full load.

The savings potential that results from the use of high efficiency pumps is experimentally demonstrated and shows a reduction in electricity costs by 58% [5].

Thus, for a properly designed installation, recirculation pumps are a guarantee of comfort and quality. Because of the energy costs, a pump reduced power consumption is another priority criterion to take under consideration when a pump is chosen [5], [11].

A few efficient recirculating pumps solutions are presented in Figure 5 and Figure 6.

One of the main factors that reduces energy consumption and increases reliability of supply hot water installations is the circulators pump operating time reduction. In housing and office buildings are recommended only circulators pumps with daytime operation. Currently, there is a limited range of hot water circulation pumps that use temperature as a control factor's operation time reduction, temperature sensors being mounted on the pipe near the end of the circulation loop. A more effective solution is to limit the operation time of circulator pumps by mounting them at the last consumer [13], [14].

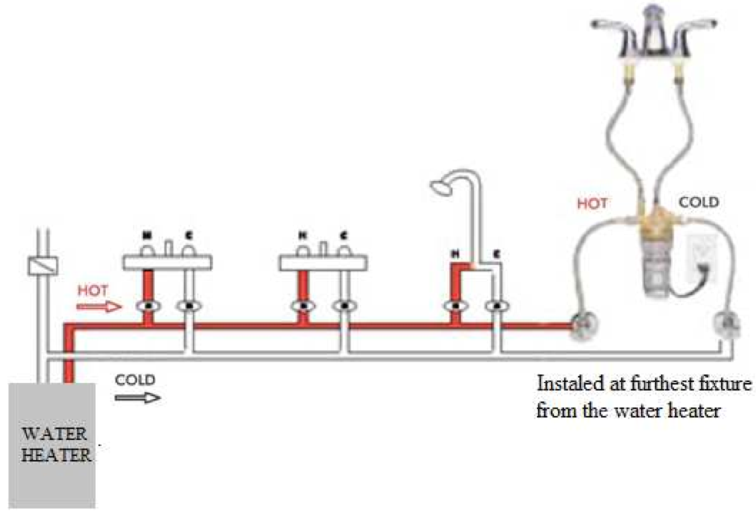


Figure 5. Recirculation pump without recirculation pipe [12]

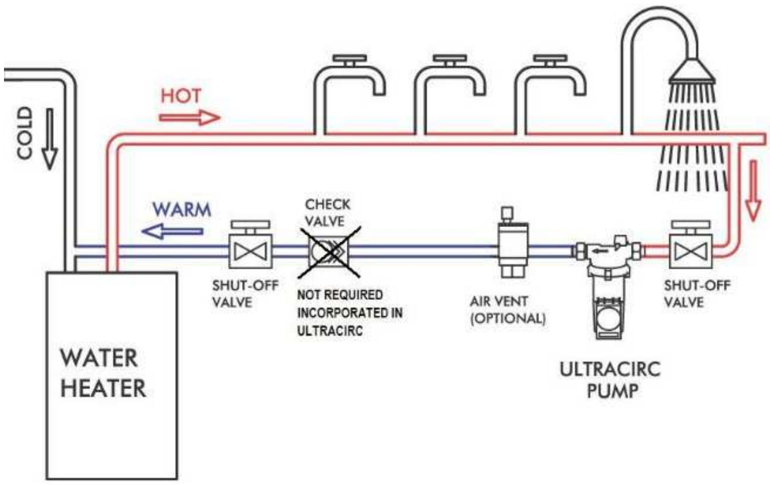


Figure 6. Recirculation pump which requires recirculation pipe [12]

Systems using cold water pipes as return pipes recorded a series of problems caused by considering only the flow control factor. To prevent the flow from the cold water line to the hot water one, these systems are mounted on control valves, valves and thermostatic elements (Fig. 7) [15], [16].

The thermostatic valve remains open as long as the water temperature is below 50°C.

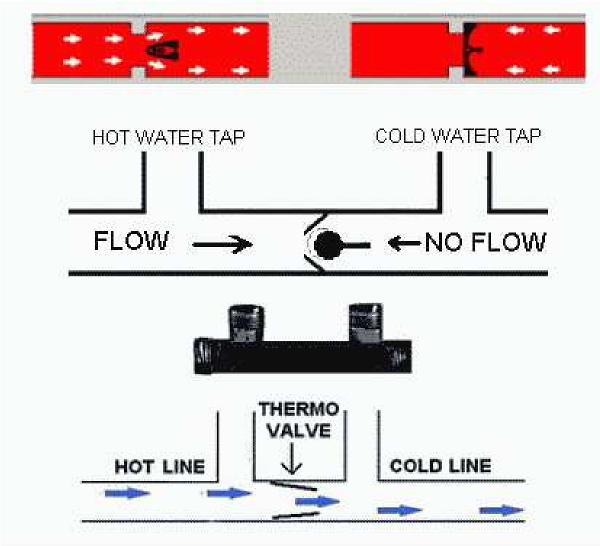


Figure 7. Fittings and sensors for flow control, mounted on pipes [15]

Due to siphon phenomenon (Fig. 8), the water flows from the hot water pipe when the valve is opened. When a cold water tap is opened (CW), there is an instantaneous drop in pressure in the cold water pipes so that due to the high-pressure hot water (HW) it passes through the control valve and opens the thermostatic valve. Following this process, the mixing of the hot water with cold or at room temperature water is achieved.

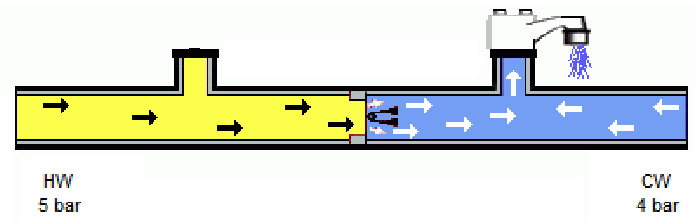
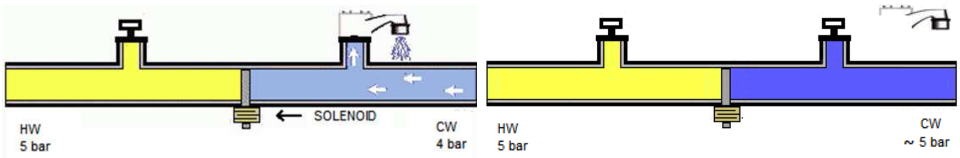


Figure 8. Cold water siphon phenomenon [15]

Regarding the use of thermostatic comfort valves for hot water circulation (COMFORT thermostatic VALVES - TCV), these are used in systems where pumps are installed in heat exchangers connected to the hot water supply pipe. Connecting cold and hot water pipes under the sink is achieved through TCV valves. Opening and closing the TCV is achieved as a result of material contraction respective expansion of the valve due to water temperature limit values (35°C), water which is in contact with the valve.

When only cold water is used, the high pressure from the hot water pipe causes water siphoning in the cold water pipe through the opened TCV. If the water temperature from the heat exchanger do not reach 35°C, the valve remains closed and hence the waiting time of cold water at the consumer increases. This problem is solved by using a silent solenoid, which when it is closed prevents siphoning of hot water in the cold water pipe (Fig. 9).



a) b)

Figure 9. The solenoid utilization for optimizing the installation [15]
a) unbalanced, b) balanced

As it is shown in Figure 9, the advantage of using this solenoid is the installation hydraulic balancing [15].

4. Conclusions

In conclusion, by taking into account the necessity of energy consumption reduction for hot water preparation in buildings, DHW recirculation installations is required to be optimized. The continuous technological development has led to the equipment and valves upgradation for adjust and control water recirculated temperature.

In this regard, by using modern control and adjusting devices, water circulation pumps operating time is reduced and prevents water non-siphon phenomenon in pipelines concomitantly with system hydraulic balancing.

Not least the adjustment and control of water flow and temperature in the pipes increase the installation energy efficiency and improve the consumer's safety and comfort

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