THE IMPORTANCE OF HYDRAULIC BALANCE OF HOT WATER HEATING SYSTEMS FOR EFFICIENT ENERGY USE

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Abstract:

The purpose of this article is to emphasize the importance of hydraulic balancing of heating systems, to illustrate the effects of its omission and thus contribute to a better understanding of this procedure and a better quality of heating systems. A heating system operating properly assures agreeable living conditions, reduces excessive use of energy and lowers operating costs.

We would also like to point out various problems which occur in the preparatory and implementation phases of hydraulic balancing in existing buildings, especially residential ones.

Key words: Hydraulic balancing, central heating system, balancing valves, efficient energy use.

What is hydraulic balancing of heating systems and why is it necessary ?

Hydraulic balancing of heating systems is a procedure that is not similar to others such as installing the piping, fittings or other equipment. This procedure is often treated as of secondary importance, and is already left out of the planning phase or more frequently in the installation of the heating system.

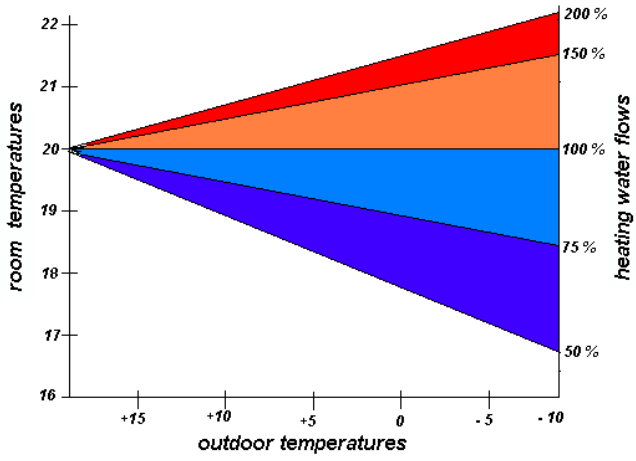
In determining the dimensions of heating elements is determined, key parameters in the process are heat loss and the required temperature of the room. The differing temperatures of the heating medium as it enters and leaves the system are also known. Those parameters define the heating element's mean temperature and the flow of the heating medium. Finally, the dimensions of the specific type of selected

heating element are determined according to the manufacturer's data, usually presented in tabular form. All parameters, except the medium flow are more or less accurate.

The heating medium (water) is a carrier of the heat. If its flow is insufficient, room heating cannot be satisfactory. What happens in a heating element with insufficient heating medium flow? The dimensions of element are determined according to parameters such as medium flow, as mentioned before. If the flow is lower than it was foreseen, the medium is cooler on its return. Therefore the mean temperature would be lower and the heating element would not be as hot as predicted. The energy balance between the element and the room is established at a lower room temperature, so the room heating is not adequate.

The situation is just the opposite when the flow of the heating medium is higher than predicted. Experience shows that such cases are usually not the subject of resident's complaints and claims, which are common in the case on lower heating medium flow.

Such a problem of hydraulically unbalanced heating systems is partially alleviated by the "benevolence" of heating elements. The interdependence between delivered heat and a room temperature is not linear, but follows a curve which is steep only at the start. For example: 100% flow leads to a room temperature of 20°C, 75% flow to 18.8°C, 50% flow to 16.7°C, 150% flow to 21.4°C, 200% flow to 22°C. This fact also results in lower requirements for flow accuracy, usually ±10%.



The priority task is to assure an adequate flow for the last heating elements in the system, which are deprived of warmth the most. On the other hand, one must ensure that the flow surplus does not cause overheating in nearer rooms. Specifically every 1°C results in higher costs for heating, +8% in central Europe or +12% in the case of southern Europe.

Consequently, only a hydraulically balanced system ensures a proper feeling of comfort and a normal cost for the central heating. The procedure is clearly of vital importance and is therefore necessary. The larger the hot water heating system, the more important is hydraulic balancing. The project's documentation must define elements needed, their settings, required measurements and the resulting costs. The required technical know-how and equipment are now available, so there are no objective reasons to neglect hydraulic balancing.

The negative consequences of neglect of hydraulic balancing are as a rule proportional to a building's size and take different forms:

- Non-uniform heating through a building's height and length. The more distant a room, the more evident the problem.
- Central regulation of the system is difficult because the heat flow is not distributed properly.
- A circulation pump which would otherwise be adequate is insufficient, so it is replaced with a more powerful one.
- The risk of noise in the part of installation closest to the circulation pump.
- Uneconomic operation of the system due to the more powerful circulation pump and overheating of part of a building.

The difference between theory and practice

So it is logical to ask how one could neglect such an important phase of the project?

The circulation pump causes the flow of heating medium by creating a difference in pressure between the inlet and outlet of the system. The difference is highest at the beginning of the system and lowest at the end of the system. The longer the branch, the bigger the deviation in pressure.

The required pressure difference for each heating element depends on its size, heating medium flow and location in the heating system's network. It is necessary that each element has the right pressure difference, according to it's flow. When hydraulically balancing the system, the pressure difference surplus is usually reduced at all vertical connecting pipes, except on the last, where a surplus doesn't exist. The same principle is applied individually to the heating elements on the same vertical connecting pipe.

There was no special equipment for hydraulically balancing in the past, so the process was demanding and sometimes almost impossible. This is also the reason, why planners and installers frequently abandoned the procedure. Attempts to do it frequently boomeranged in the form of complaints and claims due to the lower temperatures in the most distant rooms.

The problem was usually solved by the selection of a circulation pump with higher capacity. This resulted in higher flow in all the heating system and also higher pressure difference, according to the square root of flow value. The nearer vertical connections already had a flow surplus, which became even higher. The result of such a process was overheating of the nearest rooms and higher electricity consumption due to the pump operation. Both outcomes needlesslly raise operation costs and cause inefficient use of energy. This fact was usually concealed from residents, as long as no one felt cold.

It is evident that the problem of hydraulical balancing cannot be properly solved just by installing a larger circulation pump. This way of solving the problem is nowadays less expectable, because the know-how and the equipment are available, e.g. quality products for balancing the pressure at vertical and horizontal connections, computer planning, measuring instruments for pressure difference and flow, new methods for implementig the procedure, etc. In spite of this German technical literature reveals "surprisingly unexpected" statistics: 95% of heating systems are not hydraulically balanced. Circulation pumps are over-dimensioned by factor of 2 to 4! It should also be mentioned that required power of circulation pump grows by the power of 3 of the flow increase.

This issue is often neglected because people think there is no point in hydraulically balancing the system if it works without it. The other aspect of the question (what are the consequences and who will pay for them?) is naturally missed out.

Pressure difference regulators on the vertical connections

If the system has a constant flow of circulating medium (in the case of manually regulated valves), special regulating valves should be installed on the vertical and horizontal connections to eliminate the flow surplus and thereby hydraulically balanced them. This technical solution is not appropriate for systems with variable flow, for example, where elements with thermostatic valves are installed.

These are permanent hydraulic resistors, where pressure drop varies by the power of 2 of flow change. When reducing the flow of the medium, their influence become insignificant. When selecting thermostatic valves for the system, the pressure difference on the valve should not exceed 20 to 30 kPa.

Regulating valves with constant resistance cannot provide that, so we need to install automatic pressure difference regulators on the vertical connections, which maintain the set value according to the thermostatic valves.

Larger systems use a combination of both valves. Regulating valves limit the upper flow value and pressure difference regulators ensure the proper functioning of the thermostatic valves. These regulating elements at the same time allow for additional functions on the vertical connections, such as their closure, releasing the medium, and measurements of the pressure difference and flow.

Conclusions

So, there are three main considerations which make hydraulic balancing necessary:

- The correct operation or functioning of the system,
- Regulations and conventions for installing heating systems,
- Efficient use of energy.

The correct and economical operation of heating systems depends also on hydraulic balance, regardless of whether the flow of the heating medium is constant or variable. The procedure is important and should be presented as mandatory to planners and installers, not just optional.

Some experts hold the opinion that systems with thermostatic valves do not need hydraulic balancing, because such a system is balanced already through the operation of thermostatic valves. This is partly true, but one important fact is missing. A non-balanced system doesn't work properly if it is started every day, and stopped at night or the heating medium temperature is reduced centrally, because nearer heating elements always have a surplus flow of the medium and the last element is short of it. The consequence of this situation shows in a fact that the most distant rooms start heating to a desired temperature only when the nearer rooms have reached the set temperature and the thermostatic valves in them start to reduce the flow.

Performing the process of hydraulic balancing in existing residential blocks of flats or

office buildings with many proprietors is very difficult, due to the requirement of consensus on the matter, which is not easy to acquire in practice. Only continually providing information, demonstrating energy savings, and educating the companies which manage residential and office buildings can bring significant results. Consultation with experts when renewing central heating installations is therefore very important. It has been demonstrated that the energy savings in heating buildings can reach up to 25%! And the improvement of living conditions in buildings with hydraulically balanced systems also cannot be overlooked.