Heating technology

Thermostatic valves

Upon the replacement of boilers the hydraulic solutions of old systems reduced the saving potential

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According to the findings of the Ministry of Economy nearly 90% of the energy consumed in private households is used for heating water and buildings (1). In order to save energy in a long-term one should find as many solutions as possible and start with the premise that the household saving potential is approximately at the level of 50% (2). Most buildings do not fulfil the provisions of the Decree on saving heat from 1982.

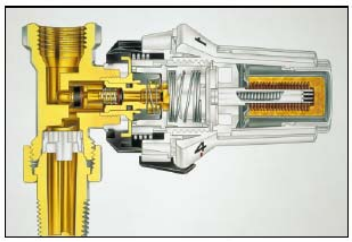

Photo 1
A section of a thermostat valve

Neither is the condition of the exhaust fumes values from numerous boilers very good. The renovation of heating boilers is in fact an efficient step to obtain savings of energy in buildings. The stricter regulations concerning the values of exhaust fumes from heating boilers that where put into effect in 1998 are a step in the right direction. Since 2004 according to the amended Decree on the emission of exhaust fumes in the following years some of the heating boilers will be withdrawn from use, which concerns about one or two million heating boilers. In order to obtain a heating system that is actually economical in terms of energy consumption and emits small amounts of exhaust fumes the exchange of an obsolete boiler is not sufficient in a long-term.

The energy analysis of a heating installation makes it clear

Prior to the construction of a new boiler the energy analysis of a new building and its heating system should be carried out, since only by knowing exactly all technical elements of a system can a modern heating system with low energy consumption be installed.
If this is not taken into consideration, a large part of the saving potential of energy will not be realized. It needs to be remembered that the system to be modernized should be treated like a new one – hence all binding standards and regulations are to be complied with. After that the control of the efficiency of an installed boiler is to be conducted, in view of the fact that since the first installation some changes might have occurred. In the meantime the thermal insulation of the building may have improved as the new windows with insulating glazing have been fitted. The heating demand of individual rooms is consequently lower than the initial installed efficiency. The next step should be to check the network of pipes and its individual elements. After that it needs to be ensured that the installed heating surfaces are adequately adjusted to the numerous modern heating systems with lower initial temperatures. Obviously, the efficiency of installed pumps and thermostat valves needs to be also controlled. Moreover, the verification of the correct hydraulic setting of the system should take place. One of the most significant regulations in

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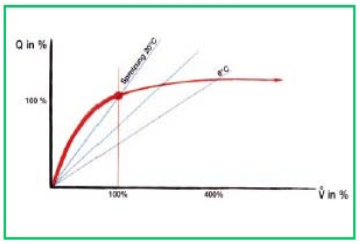
this regard is the Decree of the German Industrial Standard no. 18380 that recommends in Item 3.5.1 as follows: '(…) parts of a system are to be set in such a way as to obtain the required functions and efficiency and the statutory requirements should be reached.' After that the Decree says: 'A hydraulic setting should be conducted in such a way that when the functions are in accordance with the regulations, that means also in the cases of the drop of temperature in rooms or a break in operation, all the consumers should be provided with heat adequately to their expectations.'

Thermostat valves for the control of temperature in rooms

'The operation in accordance with regulations' means, according to the Decree on heating systems that concerns the majority of systems, the control of the initial temperature depending on the external temperature and the control of temperature in a room through thermostat valves. A thermostat valve operates basically by controlling independently the supply of water in accordance with the temperature in a room. The valve of a thermostat consists of the body of the valve and a sensor (Photo 1). The main part of a sensor is a corrugated pipe usually filled with gas or liquid that extends in higher room temperatures and consequently limits the supply of water to a radiator. If the temperature in a room falls, the corrugated pipe shrinks and the supply of hot water increases. For the proper operation of a thermostat valve the proper location of the sensor is significant. In order to ensure the correct measurement of temperature in a room depending on the conditions the following types of thermostatic valves are available: valves with a built-in sensor, valves with a separate sensor and an element fitted at a distance.

Photo 2
A sensor installed at a distance, ideal for inaccessible radiators

The most commonly applied are the valves with a built-in sensor. They are used in the situation when the valve is mounted at an accessible place and can be surrounded by the air of the room. However, it is common that a valve is located in the spaces where heat gathers, e.g. behind thick curtains, under a deep windowsill and behind furniture.



In such cases a valve with a detached sensor should be applied. If a thermostatic valve is mounted in an inaccessible place, e.g. behind a housing or under a table top of kitchen furniture, the use of elements fitted at a distance is recommended. In this form of the sensor the servicing parts and the sensor may be installed in accessible places and far from the valve (**Photo 2)**.

Faulty hydraulic adjustment and its consequences

When the initial temperature at night is reduced automatically by the control of heating, the thermostatic valves may open entirely – depending on the temperature in rooms and the setting. When heating is restarted but the system has not got the proper setting, the radiators with better hydraulic locations are provided with a larger amount of water. Those radiators with worse positioning obtain smaller amounts of water, which leads to the long period of heating. Users of such radiators may complain about the chill. Such consequences of the lack of proper setting involve the increased efficiency of pumps and the higher initial temperature. In properly designed systems the consumption of fuel by a circulating pump may vary due to the setting (4).

Photo 3
If a thermostat valve is not adjustable, the amount of water flowing through it may be larger than expected. Only by providing the planned amount of water in a radiator can the optimal saving of energy be reached

Photo 4
When a thermostat valve is adjustable, varied values can be set without the use of any tools in an easy and simple way

The increased efficiency of a pump as a solution to the problem may influence the consumption of fuel. The double flow of water results in the increase of pump efficiency by eight times (5). The increased fuel consumption in addition to the higher pump efficiency result in the situation when radiators located in good hydraulic positions get even more water. When such radiators receive more water than it is required, the efficiency of the pump becomes so high, that ultimately even the radiators located in worse hydraulic positions receive sufficient amounts of water. This situation is illustrated in the diagram of radiator efficiency. If the amount of water increases by four times, the pressure on the heating surface is reduced to only 6K compared to 20K at the place of distribution. Respectively the temperature in the reverse circulation increases by almost 15K (**Photo 3**).
It is not hard to imagine what influence this has on the level of profitability of the boiler combustion value. As a result there is no chill to complain about but the user of the system virtually burns loads of money. As there is no possibility of comparison, it often remains unnoticed how expensive the use of such a faulty setting of the heating system is.
Therefore, the regulations provide exact guidelines concerning the application of settings. In Item 3.2.8. they say:

Photo 5
The pressure difference regulator on an ASV valve manufactured by Danfoss Company

'When heating with hot water there must be an option to reduce the volume of flow on each heating surface.' This means, for example, that thermostatic valves need to be set exactly on the heating surface with the maximal flow. The required amount of water is the result of the heating demand of a room and the planned pressure of the heating material. The body of the thermostat has to be therefore set for the exact amount of water and the possible pressure difference. To calculate this the number of flow value represented by *kv* value is used. The *kv* value is understood as the volume of the stream in m^3/h with a defined stroke and the 1 bar pressure difference over the valve. Using the well-know formula:

$$kv = \frac{V}{\sqrt{\Delta p}}$$

one can easily calculate the proper value of kv for a specific valve. A very comfortable possibility of reducing the flow directly at the radiator is given by the thermostat valves that have the option of an external setting, such as the ones offered by the Danfoss company, without any additional charges. A fitter may conduct the setting of such a valve without doing a lot of work. Such setting is easy to check after dismantling the valve. Later adjustments when the system is modified are also very easy. To conclude, all radiators are supplied with the equal volume of water and the abovementioned problems do not occur. In most cases the replacement of the existing thermostatic valves with more modern, adjustable valve bodies is recommended in order to reduce the heating demand (**Photo 4**).

The proper pressure is the key
Another obvious requirement for the proper operation of a heating system is, apart from the proper bodies of valves, the correct distribution of pressure in the system. The Decree of the German Industrial Standard explains in Item 3.1.1.: 'Circulating pumps, accessories and pipe efficiency should be regulated in such a way that within the foreseen variations of operating conditions the sufficient amount of water supply is ensured and that the permissible level of noise in the water-level gauge is not exceeded. If, for example, the excessive value of pressure difference is foreseen when the operation is weak, proper steps are to be taken, e.g. devices regulating the pressure difference should be fitted.'
In order to meet such requirements when the heating system is operating, the pressure difference at the thermostatic valves should not exceed 0.1 bar for acoustic reasons. In order to control the pressure difference for a smaller system the pump controlling pressure difference is sufficient. For larger systems the demand for the pressure difference at the pump is so high that on the barriers situated near the pump the pressure difference is higher than permissible. However, even on the barriers situated farther from the pump the pressure difference for the reverse flow may rise above the acceptable level. There are many causes of the reverse stream. As it has already been explained thermostat valves control the temperature of a room by changing the volume of water. If the temperature

rises, the valve of the thermostat reduces the supply of water to the radiator. Nevertheless, thermostat valves also receive heat from other sources, such as sunshine, heat emitted by bulbs, electric stoves and from other sources. The presence of a larger number of persons in a room also leads to the increase of temperature and results in the reverse movement of a certain amount of water. Another cause of the reverse stream are the excessively high initial temperatures. If the set temperature of a room has been reached, the passive mode turns on. This means that the thermostat valve provides such an amount of water as is necessary to cover the loss of heat in a room. If the initial temperature is higher by only 5 degrees, the reverse stream of up to 70% of the assumed amount of stream takes place. Of course the habits of occupants also lead to the reduced amount of water. Some rooms, for example a bedroom, are more rarely heated or the temperature is lowered there temporarily. The combination of all these effects leads to the situation when in most heating systems only 50-60% of the designed volume of water flows. In modern heating systems the starting point is always the diverse stream of flow. In order to counteract the effects of the reverse flow of the stream that increases the differential pressure, regulations recommend taking additional preventive steps in individual sections of the system. According to the regulations the common manual regulator valves used on barriers are not proper devices for regulating the pressure difference, even when the applied setting method based on computer technology suggests a high precision. This is due to the fact that such valves, when loaded only partially, lose their efficiency. The regulators of pressure difference on the valves, such as an ASV valve manufactured by Danfoss Company, maintain the constant pressure on the valve according to the value set once – depending on the conditions in which the system operates (**Photo 5**). Hence it will not be possible to exceed the permissible pressure difference and the thermostatic valve will not have to perform functions related to limiting, which are not its primary functions. The latest generation of regulators has been designed especially for such applications. Thanks to the use of its own control membrane for each width and the arrangement of the operation elements in a 90-degree angle bar it is characterized by the optimal qualities of control and an exceptional compact construction, so that it is possible to use it in small rooms, e.g. in old buildings. The combination of the thermostat valve, that has the setting capacities, with the regulator of pressure difference in a valve seems to be the best solution to obtain the efficient functioning of a heating system, also when evaluating the energy aspect of a hydraulic system (7). By using this solution one can avoid complaints due to the distribution in a network and obtain savings on the system operations.

Summary

In order to meet the strict standards concerning the emission of exhaust fumes when modernizing a heating system it is not sufficient to exchange only a boiler. In order to have a heating system that is energetically economical, it is necessary to conduct the analysis of the whole system. Matching elements of comparable prices, such as e.g. thermostat valves, has a large importance for achieving this aim. The adjustment of the stream of the heating medium to the actual state by adjustable thermostat valves, or the connection with the regulator of pressure difference on the valves, as well as the proper selection of the thermostat sensor, are also ways of achieving the proper operation of a system.

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