Heating curve corrections based on behavior in the consumption of the heat

DOLINAY V., VASEK L.
Faculty of Applied Informatics
Tomas Bata University in Zlin
nam. T.G.Masaryka 5555, 760 01 Zlin
CZECH REPUBLIC
vdolinay@fai.utb.cz, lvasek@fai.utb.cz http://www.fai.utb.cz

Abstract: - This paper deals with benefits of heat curve corrections. Number of heat distributors use simple weather compensation heating curve to set temperature of heating water in their systems. In such system the water temperature value is directly proportional to outside temperature. From the natural behavior of the system is evident that the heat requirements during the day change but not only depending on outside temperature but time plays an important role. A typical example of this behavior is the morning rush hour. Regardless of the constancy of outside temperature, system consumes an increased amount of heat. The reason is simple in this case, consumer (house) loses heat during the night because the temperature at night is controlled to a lower value but when switching to the daily operation, it is a logical that heating system tries to attempt to supplement this heat deprivation. One possible solution would be to do intelligent appliances at the time of these changes and the distribution spread more in time. These methods, however, would require greater investment but that the most consumers are not in the current economic situation willing to accept. The second solution, presented in this paper, leaves the current system of weather compensation curve and only complements correction terms. These corrections ensure that at critical moments the system temperature will be increased/decreased and the system will better spread required heat flow between the quantity (mass flow) and quality (temperature). Proposed method was applied on real heating system and subsequent behavior was closely monitored. Obtained results show improved behavior, which is evident from the reduction of shock and peaks in the system.

Key-Words: - Equithermal curve, heating curve, heat consumption, prediction

1 Introduction
Preparin g the heating curve is suitable in most task of heating system. The aim is to determine the temperature of heating water to provide enough heat for the consumer but also to eliminate unnecessary losses in the pipeline and at the same time use the minimum energy to transport the heat medium from source to consumer [1, 3]. Higher temperature increases the loss of heat during the transfer medium, vice versa low temperature does not transfer as much energy and it is therefore necessary to increase its quantity. Increasing the quantity of course increases the cost associated with the transport [2]. Simple consideration mentioned above shows that in the determination (calculation) of suitable heating curve must be found the optimum ratio of the parameter. The above description is of course a considerable simplification, because the values of both parameters are also dependent on time and at especially the systems where the heat transfer medium is transported over long distances has timing an essential role.

In practice, the heating curve is often obtained experimentally and generalizes heat requirements in the system after a certain time of day, typically day time and night. In this article will be devote just to the systems with a fundamental heating curve, whose shape is directly proportional to the value of outdoor temperature. This type of heat curve management is usually called an equithermal, or weather-compensated control.

The aim of this paper will be to present improvements correcting curves depending on the specific periods of the day. Such period is usually morning or evening rush hours. Number of authors deals with system behavior prediction [4, 5]. It is not easy to determine suitable parameters, because heating consumption is effected by users behavior (house residents) and outside weather adds stochastic behavior as well. In the first part of the article the appropriate of modifying the basic heating curve will be presented. The simple experiment to confirm some basic links in the heat distribution system will be shown subsequently.
2 System behavior
First of all it should be shown how the real system reacts during the one day. Mentioned behavior is better seen in the data from the end of the heating season when outdoor temperature is able to significantly reduce heat requirements especially during the sunny afternoons. Following pictures show outside temperature course, corresponding heating water temperature, measured consumed heat and mass flow. Courses are show for two house stations (red and blue).

![Fig. 1 Outside temperature.](image)

![Fig. 2 Heating water temperature.](image)

![Fig. 3 Consumed heat.](image)

![Fig. 4 Mass flow.](image)

2.1 Selected location
System behavior is presented based on data measured in the secondary distribution network of Prerov town (CZ). Network contains one heat exchanger stance and fifteen house station. See fig. 5. Each house consumes heat energy for heating of dwelling and other space in house and for hot water preparation.

![Fig. 5 Schematic consumers lay-out.](image)

2.2 Flow smoothing
The required heat can be supplied in two ways. Quality - the heating medium temperature and quantity - amount of the heat media transfer in pipes. In real systems it is necessary to find a good balance between these ways. The usual objective is to minimize costs while complying with the required quality.

One of the components affecting the cost is the price of pumping work. Price in case of pumping work is related to the use of optimal pump level. The pump should operate at the optimum load and it is also not appropriate that there are shocks when the desired performance is changed.

The effort to reduce the cost of pumping work is one of the current tasks. The first step of the experiment was to calculate and see the temperature requirements in a situation where the mass flow is constant. For this experiment was not considered time delay of the consumer. With this simplification could be applied equation (1). Set course of mass flow is shown in fig. 6. Fig. 7 shows the calculated temperature, while holding the amount of consumed heat. The mass flow was set to constant from 6AM to 8 PM. Values are shown for second house station (blue curves on fig. 2, 3 and 4),

\[ Q = (T_v - T_{pw}) \cdot m \cdot c \]  (1)
where:
\[ T_v \] heating water temperature (input)
\[ T_{rv} \] returning water (output)
\[ m \] weight
\[ c \] thermal capacity

initial experiment, the value of heating water in the morning rush hours has been increased by 2 °C above the values calculated from equithermal curve. Obtained values are shown in fig. 9.

![Fig. 6 Modified – smoothing flow.](image)

Fig. 6 Modified – smoothing flow.

![Fig. 7 Heating water temperature.](image)

Fig. 7 Heating water temperature.

### 2.3 Real system experiment

Previous example illustrates only basic ideas. The methods are preferable to verify in real operation, where they are exposed to many influences. The experiment was carried out on 20th of April and the differences in behaviour will be shown in comparison with the data from 19th of April. These two days had a similar course of outdoor temperature. See fig. 8.

![Fig. 8 Outside air temperature.](image)

Fig. 8 Outside air temperature.

The real technology at selected location only allowed manual intervention to variable \( T_v \). For the initial experiment, the value of heating water in the morning rush hours has been increased by 2 °C above the values calculated from equithermal curve. Obtained values are shown in fig. 9.

![Fig. 9 Applied heating water temperature.](image)

Fig. 9 Applied heating water temperature.

![Fig. 10 Obtained mass flow.](image)

Fig. 10 Obtained mass flow.

#### 2.3.1 Results

Figure 10 shows obtained heating system behavior. As can be seen in this figure, the increase on input water temperature influenced mass flow requirements. Mass flow decreased and jumps in values were also eliminated.

### 3 Conclusion

This article presents the idea of weather compensation control corrections. If the heating control procedure depends only on simple curve, system is usually unevenly loaded. The critical points are usually morning and evening rush hour. In these points, it appears appropriate to modify the weather compensation curve. Because the real system did not allow more complex interventions, a simple correction was applied for the morning rush hour from 6 am to 8 pm. Temperature increase was set to 2 °C plus level obtained from the commonly used heating curve. The system behavior was then monitored. The result was then compared with the measured course from the previous day, when common control was used. From the results it appears that the increase in temperature has a positive effect on the flow behavior. Temperature increase caused only a slight
decrease in flow, but the peaks that arise during the morning rush hour were partly eliminated. The experiment showed that it makes sense to modify the heating curve, but it is certainly necessary to introduce more sophisticated methods for designing corrections. And this should be the future task – to continue on simulation experiments to prepare more sophisticated algorithms for modification of the heating water temperature with a view to achieve predictable and smooth mass flow. Goal for the next heating season is also preparing algorithms that implement the experiences from simulation so that they can be verified and applied on a real heating systems.

4 Acknowledgment
The work was performed with financial support of research project NPVII-2C06007, by the Ministry of Education of the Czech Republic and is also supported by the European Regional Development Fund under the Project CEBIA-Tech No. CZ.1.05/2.1.00/03.0089.

References: