Municipal Heating Network Simulation Experiments Based on Days with Similar Temperature

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Abstract: - This paper describes model preparation and subsequent experiments focused on heat supplies proposal which is based on seeking days with similar outdoor temperature behavior. There is model of distribution system for heat consumption prepared but the main questions still remain. When, how much and in what heat condition to deliver into the urban agglomeration? The first and simplest answer could be the similar conditions as we used yesterday or better, day alike the one we want to control now. The main task is to maintain all needs associated with heat consumption. From the information we got from previous (similar) day, the new control could starts. The idea is to make the model more precise and offer possibility to learn and improve control which worked, but perhaps would function better.

Key-Words: - Heat, consumption, model, temperature, experiment, simulation.

1 Introduction

This paper describes practical experiment which utilizes Municipal heating network simulation model [5] which offers possibility to describe distribution and consumption of heat energy in the municipal heating systems. There are many different approaches to simulation models and operational optimization of heating networks [1]; [2] and heat-load modeling [3]. Our approach is to use data mining combined with simple model of heating network [4]. The adaptive parts of the model utilize real data measured in distribution systems to set up its internal structures for subsequent use in prediction and regulation.

For our model, the chosen city was simplified and model was trained on real measured data. The main aim of this experiment, facing the question: When, how much and what temperature to set-up for hot water supply, is to find day whose outside temperature is close to one we are just going to control. Such, for "tomorrow" we need to know weather forecast and based on it to seek database to pick up day with likely the same values. The found day is base for "tomorrow" heat supply proposal. The expectations are that the data from that day are telling us consumption needs and also provide information about trace in time.

Simulation and control can be described in these steps:

- obtain weather forecast for day to propose,
- seek and choose best matching day from the past
- train the model
- predict behavior for proposing day

2 Training samples

The training experiments described below are based on real data measured by the heat producer and distributor company. The city about eighty seven square kilometers with about sixty seven thousand citizens has been chosen for setting up model [1] and identification of its parameters [4]; [5]. Location has been split into four parts to embrace the whole area, shown on Fig. 1.

The simulation model basically contains two types of parameters:

- static, e.g. length and diameter of the pipes,
- variable.

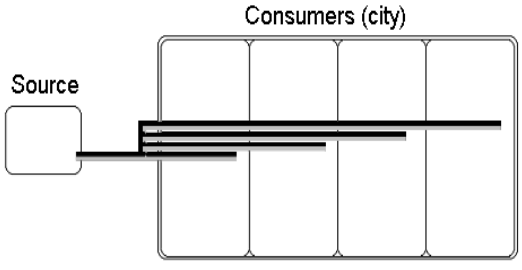

Fig. 1 Location split (4 parts with supply and return pipe lines)

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The variable parameters are covering variables which are adapted by the evolution algorithms during model training. Those variables held information about amount of heat mass needed for particular time. The evolution algorithm used in this model is described in detail in [4].

2.1 Particular tests

The above mentioned design came from series of experiments. There were tested variant samples.

2.1.1 Month and more

The main idea of those tests was to cover variety of weather during a winter season and model identified on such long period will enclose the most situations. As shown on Fig.2., the prediction coming from such trained model has many inaccuracies. Even the identification was not able to adapt to all abnormalities.

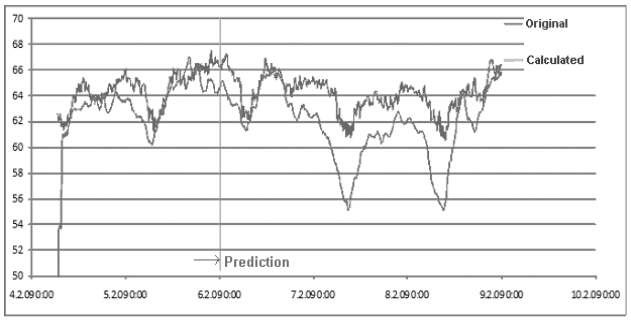

Fig. 2 Month adapted and subsequent prediction

2.1.2 14 days

Subsequent alteration comes up with the same ideas as Month experiment – to adapt model parameters for long period but train model for short prediction, just after trained samples. The results are quite better compared to month samples but disadvantage of this approach is high sensitivity to outside temperature changes.

For example, if temperature changed into values which were not included in training samples, the subsequent prediction for these cases is inaccurate.

2.1.3 Week

Another cut in training samples length brought another improvement. The model is adapted more accurate but problem with incoming days which are markedly different still remains. See Fig. 3.

2.1.4 Day

As can be seen from previous experiment the best result could be obtained if the model is adapted for a small time period but subsequent conditions must be met. This approach will be described and developed further in the chapter “Similar day”.

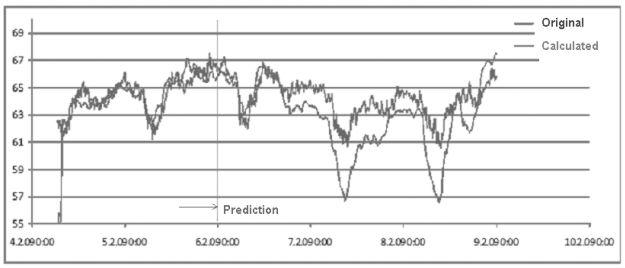

Fig. 3 Week adapted and subsequent prediction

Difference between Original (measured) and Calculated (predicted) course, which can be seen in Fig.2 and 3 is reduced when shorter time period is used for training. Output values, shown in those figures are returned water temperatures (water in the return line).

3 Similar Day

Unlike previous experiments, the examination of the period just prior to the desired section of prediction is not required. This improvement is based on the principle of finding similar days (periods), and application of its relevant model parameters on the stretch of the same nature.

The advantage of this approach should be also that, having regard to the accuracy of weather forecasts for the period length of 24 hours. So there should be no unexpected fluctuations and thus should be removed error caused by previous procedures inappropriateness of the samples used to identify the model.

To determine whether the day (period) is "similar" to another, the minimum variations of outdoor temperature were used. The day called “similar day” to day we just want to predict is considered such a day when outdoor temperature forecast deviation from the measured temperature will be minimal.

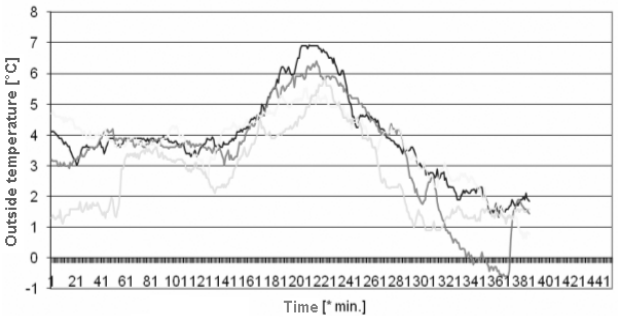

Fig. 4 Course of the outside temperature in similar days

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There are several ways to verify the approach. Since we have real measured data available, the prediction was carried out for the day already gone, and therefore there was not required for outdoor temperatures forecast. Forecast has been replaced by the real temperature record. Two figures 4 and 5 show the example of selected similar days, Fig. 4 illustrates the outside temperature and Fig. 5 shows the values of mass flow supplying the particular location.

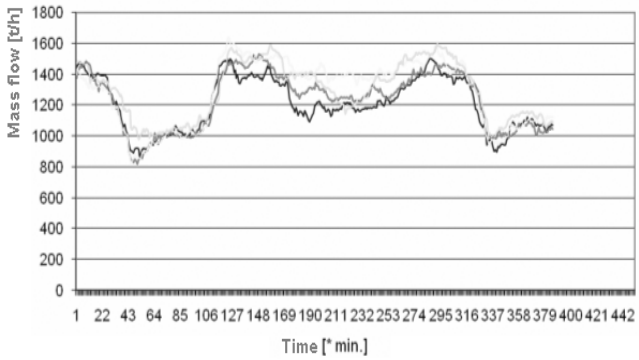

Fig. 5 Course of the mass flow in similar days

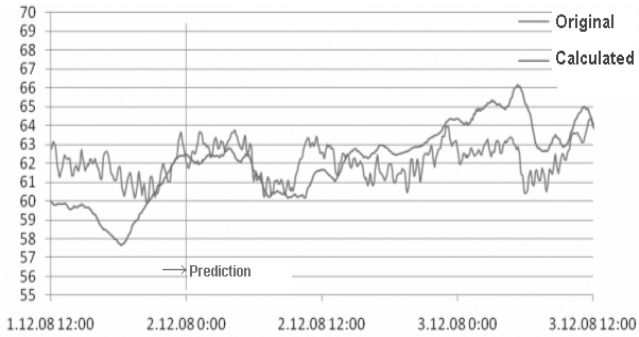

Fig. 6 Similar day adapted and subsequent prediction

The main idea was to identify the model for one of those days, and then verify that provided parameters. The method gives as accurate results in the field of prediction for the similar days. As can be seen on Fig. 6, the good agreement of expected and actual returned water temperature has been reached. With regard to the results of all previous experiments the similar day methods appears to be the most effective.

4 Conclusion

The experiments focused on adaptation for longer periods (week, month, etc.) suggest the increased need for finding the parameters reflecting the diversity of the system behavior on a different course with the outside temperature. Tests show that the most appropriate method of identification and prediction of returned water temperatures into the model can be considered an application of similar days method. In subsequent experiments, it would be useful to examine the possibility of establishing different ranges of similarity search. Described results show merely "day" meant in common view from midnight to midnight of the following day. However, the model which takes into account most important parameters affecting the amount of the heat and the experiments carried out so far showed good performance.

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