INTEGRATED APPROACH TO WATER DISTRIBUTION MODELLING

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ABSTRACT

The paper gives information on the technical aspects and the results of numerical modelling of water supply and water distribution systems. Considering the technical and traditional circumstances that are similar to those found in Yugoslavia, these projects serves good examples to be followed in the rehabilitation process of water distributions systems in Yugoslavia's major cities.

Key words: water distribution systems, water supply, numerical modelling

INTRODUCTION

Numerical modelling of water supply and water distribution systems has become a standard and an inevitable practice in any serious attempt of evaluating hydraulic, water quality, and economic aspects of these complex systems. Modelling capacity of well-suited models, featuring advanced technologies including linking the models to GIS systems and telemetry systems, accurate fire flow calculations, water quality analysis, and leakage reduction is incomparable with any alternative approach for these purposes.
Hydraulic modelling of water supply and water distribution network is used for planning linking-up consumers to the network and evaluating the remaining capacity of the network, modelling of network’s breakdown, modelling of various loading and operational states of the system including fire flow analysis, reconstruction of existing and planning of new pipes, pressure zone optimisation, leakage reduction and others.
Linking the hydraulic model to GIS and telemetry systems allowing the modelling of hydraulic, water quality and economical parameters is of a growing interest nowadays. The integrated model allows quick build-up from the GIS database and help to maintain the data integrity. The OnLine model monitors the pressure and flow conditions in the network in an automatic fashion; the economical parameters are evaluated in a parallel and their optimisation is enabled. Thus, any breakdown in the network can be readily identified,

evaluated and rectified. Such model also assists the practitioner to determine the most appropriate response to unusual operating conditions

Water quality modeling is becoming an issue in most of the present studies. Simple transport problems (non-reactive tracers, source blending, water age), disinfectant decay (chlorine, chloramines), and disinfections by-product formations (THM) are the most frequent parameters to be modeled.

Leakage has become a major concern and the industry has reviewed all of its methodologies and procedures in order to produce realistic estimates on which to base major investment decision. Leakage management is one of the most important subjects in the industry. Leakage can be reduced by a variety of means including leak detection (location and repair), rehabilitation (replacement and relining), metering, and pressure reduction. Use of leakage hydraulic models as a part of the leakage control significantly enhances the efficiency of the leakage management.

Based on this technological and methodological foundation, DHI has conducted several important projects in the cities of central and southeastern Europe, such as Leakage Modelling in Daruvar (Croatia, 2001), Växjö, Gothenburg (Sweden 1999-2000), Real-time Modelling (Czech Republic), and Prague Water Supply and Water Distribution Model (Czech Republic, 1999-2001).

CASE STUDIES

Prague: water supply and water distribution model

Water supply and distribution network of Prague with nearly 1.3 millions of inhabitants is a complicated large-scale network. It is divided into 160 separate pressure zones. The database model of the network includes all network elements such as main pipes, valves, gate valves, air valves, hydrants and service branch pipes. Data is stored in GIS system; operational data in SCADA system and the data link to MIKE NET is the key premise for a pipe network hydraulic modelling.

Hydraulic modelling of water supply and water distribution network is used for planning linking-up consumers to the network and evaluating the remaining capacity of the network, planning of network's breakdown and miscellaneous loading states such as fire flow analysis and their impact on water supply system, reconstruction of existing and planning of new pipes, pressure zone evaluating and in comparing measured and simulated data.

Most critical parts of the distribution network are being reconstructed; hydraulic modelling is already seen as a necessary step in the planning process. A conceptual model with all important water tanks, pumping stations and water sources is being developed for the whole Prague water supply system. Such a model will greatly assist in formulating and answering supply strategies and providing high reliability of the system.

Daruvar: leakage modelling and control

The water supply system in Daruvar was mostly built in 1971, and it supplies ca. 20,000 inhabitants and industry whose biggest consumer is the Daruvar Brewery. By the end of the 1970s it was observed that there was a shortage of water during the summer months. The problem was partially solved in 1982 when pump installations were built which increased the capacity of the pipeline. In 1996 the gadget for measuring the quantity of produced

water was installed on the water-conditioning unit. By comparing the produced quantity of water with the conveyed (invoiced) quantity of water we found out that the losses in 1999 were 46.50% on average.
The project is focused on assessing and improving the water supply system as well as recovery of water loses (46 %). The municipal service company and partners developed a hydraulic mathematical model of the water supply system as a base for detecting leakage areas.

Main activities:

Develop a hydraulic mathematical model of the water supply system as a base tool for identifying areas with main leakage problems
Provide a technology for hydraulic and water quality modelling
Provide a methodology for hydraulic mathematical modelling of the Daruvar water supply and water distribution system (field data availability, monitoring conditions, real time operations, customer database system) including the model development and calibration
Perform the systematic leakage modelling and leakage identification
Perform the systematic testing of the system using the instruments for detection of cracks on the pipes (testing areas selection according to the leakage modelling results)
Use mobile meters for the flow and pressure in order to establish the leakage of water in individual zones of the system
Reconstruct of all the detected leakage points by using our own human and technical resources
Create the quality basis to improve our services, and applying new experiences and technologies.
Prepare a study (written documentation) to carry out the project on the ground of the obtained information, readings and established situation of the water supply system
Make periodical reports and a final report with presented results of the implemented project

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Växjö, Gothenburg: water quality modelling

The result from one of the cities, Växjö in the southern part of Sweden is analised. It shows the connection between calculated water age in MIKE NET, Chlorine content and amount of heretofore bacteria in the water. The measurements ware taken place just outside one of the tanks. The result clearly shows the connection between the measured parameters and the calculated water age.
The chlorine content is at nighttime high (water is entering the tank) and then decreases as the tank level turns and water is leaving the tank. At the same time the amount of heretofore bacteria is growing. The connection between bacteria growth and water age in the tank is quite clear in this example.
Another example is from Gothenburg. The analized diagram shows water level in the tank together with temperature at a location near to the tank. The quite rapid temperature variation from time to time shows that the flow direction is changing in the pipe (sometimes

supplied from the tank, sometimes from other sources). This gives us some knowledge of the hydraulics in the area.
The temperature of the water is clearly affected by its origin. In this case the water temperature is lower in the tank than in the pipe system. This is due to the low air temperature outside, cooling the water in the tank. The change in temperature can then be viewed along with other parameters such as redox- potential, oxygen and chlorine. This may give us more information about for example risks of bacteria growth in the area.
The brief examples above clearly show that we not only are able to better understand quality processes but also more of the hydraulics of the system with this kind of approaches.
The examples are part of a recent water quality project consisting of 5 participating cities. Each city has of course its own network characteristics and problems. Therefore, different aspects had to be considered during the measurement campaign. A report with conclusions from each city has been documented. It includes a thorough discussion regarding the relation between all measured parameters and calculated water age and trace studies in MIKE NET.