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Mathematical modeling and analysis of dynamic changes in the water distribution system

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Abstract: The aim of the article is to present the analysis of dynamic changes in the water distribution system through the mathematical modeling process. An attempt was made to recreate the actual operating conditions of the Juchnowiec water supply network on the basis of a numerical model. The calculations gave a picture of the functioning of the water distribution system and showed the possibility of working with the modeling computer program EPANET, which allows periodic hydraulic simulations and insight into the preservation of water quality in a pressure pipeline network. In the process of creating the model, the results of field tests were used, which allowed to adjust the values and their parameters to real conditions. Pressure measurements were the basic part of these tests. The obtained data allowed for the calibration of the models made.

Keywords: calibration, computer simulation, distribution systems, water supply network, water works.

1. Introduction

Managing the water distribution system is an extremely complicated and complex task. A number of highly specialized industry companies are appointed to handle the tasks related to this project. Keeping up with the constantly changing standards results in considerable expenditure on development, and the consequences of wrong decisions force the network managers to search for tools for quick and effective planning. A good development strategy for a company means optimally used inputs[2]. The ability to model and predict the operation of the network is a valuable facility which, until recently, required a lot of resources and human resources. The possibility of immediate observation of the results makes it easier to visualize the situation without having to be guided by intuition [5]. The benefits of using mathematical modeling are invaluable, and taking into account the dynamics of the model through the time factor is irreplaceable.

2. Results and Discussion

The model of water supply networks was made using the Epanet program [3]. In the first phase of model construction, a raster map was used. After processing the map of the water supply network, a file was created that served as the basis for the computer model. It contains the basic elements of the water supply - the main sections with marked diameters. The ordinates of these elements in the field were also introduced into the model [4]. In the process of creating the model, the results of field tests were used, which allowed to adjust the values and their parameters to real conditions. Pressure measurements were the basic part of these tests.

The obtained data allowed for the calibration of the models made [1]. The water distribution model mapped in the computer program consists of nodes and connections). Connections are represented by

pipes (Rys.1). The nodes are joints and reservoirs. The losses in the water flowing in the pipe due to friction against the walls were calculated using the Darcy-Weisbach formula [5]. In order to calculate the water consumption in individual nodes, a database of readings from water meters in the format of a spreadsheet was used, in which data on the average daily water consumption was compiled. Average daily consumption for individual water meters was calculated, and then - as a result of grouping by address - determination of the average daily consumption in a given network node [6].

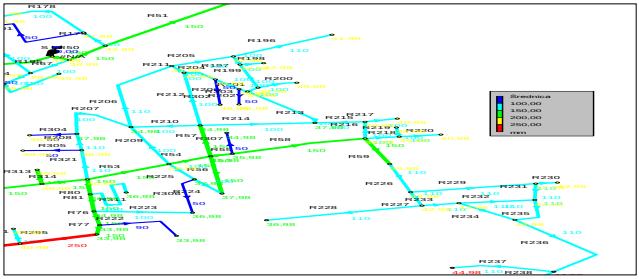

Fig. 1. Model of the water network of the city of Juchnowiec commune taking into account the ordinates

3. Concluding Remarks

As a result of the model tests carried out in the field of the dynamics of the water supply network, the results were obtained which influenced the quality of the better functioning of the system. Building a model that reflects real conditions, through correct mapping, has brought invaluable benefits in the form of reliable results. Tests have shown that the water flow velocity in the water pipes is lower than the recommended 0,5 m/s. Places where water stagnation were found due to low water consumption were identified. The simulations of the adopted concepts became an indication to improve the working conditions of the tested water distribution system.

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