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Study of a water supply system in Matlab/Simulink environment using criterion equations to determine the losses in the head pipelines

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GOAL OF THE STUDY

The aim of the study is the development of a model in Matlab/Simulink environment for studying the existing water supply system for a specific populated area.

Mathematical model for studying the water supply system

The dynamic model of water supply system consists of active (pump units) and static (pipelines and reservoirs) elements. The head characteristic of a pump is described relatively accurately by a second-degree polynomial:

$H = a_1 + a_2 Q + a_3 Q^2,$

where a_1, a_2 and a_3 are depending on the form of the characteristic coefficients, where „a_1" coefficient express the head of the pump H_0 at flowrate $Q = 0$, meaning $a_1 = H_0$.

In the cases where the work of the pump units is examined at rotation frequency n, different from the nominal N_n, is good to know the head characteristic equation $H = f(Q, N)$. In this case can be used a polynomial from the type:

$H = A_1 N^2 + A_2 NQ + A_3 Q^2,$

To determine the operating mode of the pumping units, it is necessary to have the equation of the pipeline system - $H_S = f(Q)$, which has the form:

$H_S = H_{st} + h_V = H_{st} + kQ^2,$

where: H_{st} is the static head of the pumping system; $h_V = kQ^2$ – the loses of head in the system; k – the coefficient of the resistance characteristic of the pipeline network.

The differential equation describing the change in flowrate in a water pipeline of length $L_i$and section A_i at difference Δh_i in the heads in both its ends is:

$$\frac{dQ(t)}{dt} = \frac{g.A_i}{L_i}(\Delta h_i - h_{lossesi}),$$

where $h_{lossesi}$ are the total losses from friction in the pipeline,m

The differential equation, describing the reservoirs water volume change, is:

$$\frac{d(\rho.V_i(t))}{dt} = \rho.Q_i(t) - \rho.Q_{oi}(t),$$

where $Q_i(t)$ is the flowrate, entering the reservoir m^3/s; $Q_{oi}(t)$- the flowrate, flowing out of the reservoir; $V_i(t)$ - the water volume in the reservoir,m^3.

Virtual model for studying the water supply system in Matlab/Simulink environment

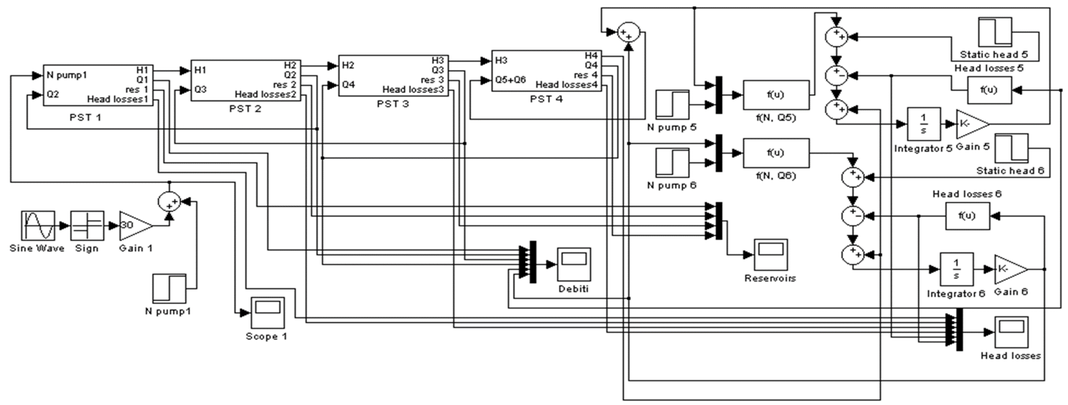

Fig. 1. Model of water supply system

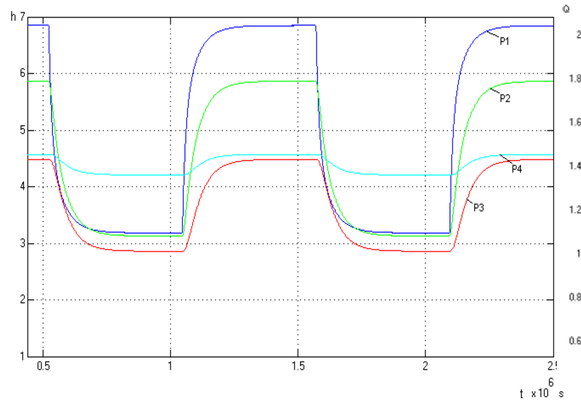

Fig. 2. Water level in the reservoirs

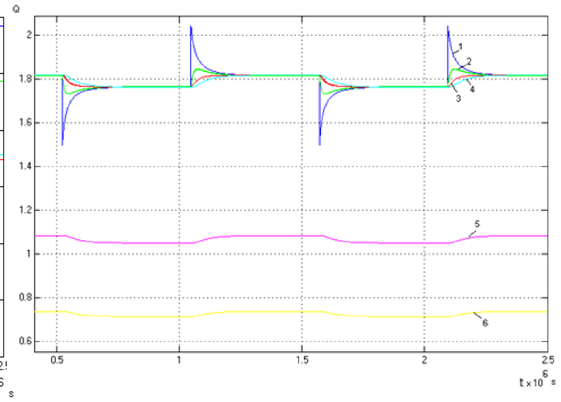

Fig. 3.Flowrate at different parts of water supply system

CONCLUSIONS

A mathematical model that describes the operation of the individual elements of a water supply system operating in a dynamic mode has been synthesized.

A virtual bench has been developed in the Matlab/Simulink environment to study the change in the volume of water in the tanks, their levels, as well as losses in the pipelines at a specific rotation frequency of the first pump in a real pumping system made up of five pumping stations.

The model can be used in the reconstruction or construction of new pumping stations, as well as in the investigation of the energy efficiency of water supply systems. The model can be used to analyze the processes in case of a change in the water consumption in different parts of the system and to define requirements for more efficient use of electrical energy.

ACKNOWLEDGMENT

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