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## **UMERJANJE HIDRAVLIČNEGA MODELA CEVOVODNEGA OMREŽJA Z UPORABO GENETSKIH ALGORITMOV**

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### **Povzetek**

Diplomska naloga obravnava hidravlično modeliranje vodovodnih sistemov, optimizacijo njihovega umerjanja in izbor merilnih mest. Umerjanje in izbor merilnih mest sta tesno povezana v postopku hidravličnega modeliranja. Glavni cilji naloge so poznavanje področja modeliranja in razvoj lastnih optimizacijskih orodij, tj. računalniških modelov za optimizacijsko umerjanje in izbor merilnih mest z uporabo genetskih algoritmov. Optimizacijski problem umerjanja je sestavljen iz ciljne funkcije, ki minimizira odstopanja med napovedmi hidravličnega modela in meritvami, zbranimi na vodovodnem sistemu. Optimizacijski problem izbora merilnih mest pa je sestavljen iz dveh normaliziranih ciljnih funkcij. S prvo ciljno funkcijo se povečuje natančnost umerjanja parametrov hidravličnega modela, z drugo pa zmanjšuje število merilnih mest. V nalogi optimizacijski problem rešujemo z uporabo genetskih algoritmov. Primerjava rezultatov obeh optimizacijskih modelov in njihova verifikacija je bila opravljena na hidravličnem modelu teoretičnega vodovodnega sistema »Anytown«, na katerem so bili preverjeni primerljivi modeli drugih avtorjev. Uporaba genetskih algoritmov v optimizacijskih modelih se je izkazala za zelo učinkovito, saj je bil optimizacijski proces zelo robusten in pridobljene rešitve so hitro konvergirale k končnim vrednostim. Primerjava modelov z rezultati drugih avtorjev kaže, da oba optimizacijska modela za umerjanje in izbor merilnih mest dosegajo enako učinkovitost.

**Ključne besede:** vodovodni sistem, hidravlika, modeliranje, umerjanje, načrtovanje merilnih mest, optimizacija, genetski algoritmi

### **Abstract**

The diploma thesis is addressing the issue of hydraulic modelling, calibration and sampling design for water distribution model with optimization tools. The calibration and sampling design process are closely related in the process of water distribution modelling. The aim of the diploma was to get to know the modelling process and the development of optimization tools, i.e. computer models for optimal calibration and sampling design using genetic algorithms. The calibration optimisation problem is formulated as an objective function, which minimizes the differences between model predictions and field measurements from water distribution systems. The sampling design optimisation problem is formulated as a normalized joint objective consisting of a calibration accuracy objective function and a sampling design cost objective function. The first objective function is maximizing the calibration accuracy of model parameters, while the second is minimizing the number of monitoring points. In the diploma genetic algorithms were used for solving the optimization problem. A comparison of both optimization models and their verification was done on the theoretical water distribution model of "Anytown", where comparable models of other authors were applied. The use of genetic algorithms in the optimization models has shown great efficiency because the optimization process was robust and the results showed fast convergence to their final values. Comparing the models with results of other authors shows that both optimization models of calibration and sampling design achieve the same efficiency.

**Key words:** water distribution system, hydraulics, modelling, calibration, sampling design, optimization, genetic algorithms