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ROZPRAWA DOKTORSKA

METODY OPTYMALIZACJI EKSPLOATACJI STACJI UZDATNIANIA WODY Z NADMIAREM ZDOLNOŚCI PRODUKCYJNEJ

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Abstract

Optimization methods for the operation of drinking water treatment plant with exceeded redundant capacity

Over the past years in Poland, as well as in all EU countries, it can be observed that there has been a considerable decrease in water consumption. As a result less water has to be treated and delivered to the consumer, and consequently many water systems now have redundant capacity i.e. underutilized capacity.

Over the years, the results of reliability analysis of technical systems have been used in current operation and the optimization processes. The correlation between the proper exploitation and reliable operation of a particular system has already been used in a number of industries such as nuclear power, aerospace and electronics. The potential of the application of reliability analysis has been also noticed by researchers of municipal systems (including drinking water and sewage systems).

The definition of reliability for a water supply system takes into account the contemporary conditions of its operation, including cost factors. In this approach, the reliable system provides; continuous water delivery to the consumer, under certain operating conditions, in a given period of time, the necessary volume of water being of adequate quality and with the required pressure, at any time convenient for the consumer and at a unit price that is acceptable for the consumer. The problem however remains to ensure reliable operation of the system with the lowest possible generated cost. The development of modern science indicates that, for economic optimization of technical systems, Life Cycle Costing (LCC) is an effective tool. This method is based on the assumption, that each technical object passes through several phases of the life cycle, during which it generates specific costs, expenses and profits. The advantage of LCC is an easy adaptation to analysed variants and the prevalence of use in other economic areas such as communication or transport.

The key reason for undertaking the research on the optimization of operation of the water treatment plant was the lack in literature of a holistic methodology, joining both reliability and cost factors of water systems with underutilized capacity. Therefore, the main purpose of this dissertation was to develop optimization methods for the operation of drinking water treatment plants with exceeded redundant capacity. The proposed analytical method has been verified for the actual operating conditions of drinking water treatment plant - ZPW Goczalkowice. The presented research was based on computer-assisted analysis obtained through “Plusk” and “Statistica” programs and the achieved results allow one to describe the variants of operating systems with parameters values i.e. λ, T_p, T_o, f and K.

The proposed methodology has enabled the development of new parameters in assessing the quality of operation of water supply systems. The dissertation presents new analytical indicators of optimization of water treatment plants with exceeded redundant capacity, i.e .:

- economical operational readiness rate - R_e;
- indicator of consequences of operational decisions - I_c;
- unit indicator of efficiency safety - I_s;
- unit indicator of consequences of operational decisions - I_{uc}.

The obtained results were the basis for the development of a method which allows the assessment of variants of the operation of water treatment plants, taking into account the reduction of excess capacity. It also provides the new concept of technical working life, which defines the time horizon of the “use phase” of water supply systems and this a basis for the rate of depreciation calculations. This methodology can also be implemented to other areas where the LCC is applied. The paper also includes the presentation of a new interpretation of the indicator of failure frequency (f) of multiple structures, for which the reliability analysis is based on a partial revision method. The dissertation also presents Life Cycle Costing calculations carried out for all kinds of technical equipment and objects not only for the pumping stations.