Abstract of a doctoral dissertation

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„Influence of volute casing geometry on the energy characteristics of a double-entry centrifugal pump operating in pump and turbine modes"

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The volute is one of the key structural elements of a centrifugal pump. It is responsible for collecting the liquid from the impeller and directing it to the hydraulic system. Its geometry affects the flow conditions, the position of the best efficiency point, efficiency, hydraulic loads, and the stability of the pump.

Pumps operating as turbines are increasingly used to recover energy from flowing liquid, for example in water supply networks and industrial systems. Their advantages include lower investment costs and a simpler design compared with classical water turbines. However, it should be emphasized that pumps are mainly designed for pump operation. Therefore, their flow components, including the volute, do not always provide favourable operating conditions in turbine mode. For this reason, it is important to define volute design rules that allow favourable operating parameters to be obtained in both modes.

The aim of the dissertation was to determine the influence of the geometrical parameters of the volute and its design method on the energy characteristics of a pump operating in pump and turbine modes. The research was carried out using a hybrid approach that included numerical flow modelling and experimental tests. The numerical model was validated on a test rig that enabled the analysis of pump operation in both modes.

The study analysed the influence of selected geometrical features of the volute, such as the method of designing the cross-sectional areas, the inlet width and inlet diameter of the volute, the cross-sectional shape, and the wall opening angle. Their influence on head, mechanical power, efficiency, and hydraulic losses in the volute for a pumps with a specific speed of 23 and 66 was assessed.

The degree and nature of the influence of the volute geometrical parameters was determined using the analysis of operating parameters, flow structure, and statistical analysis. The obtained results confirmed that the geometry of the volute has a greater influence on pump operation in turbine mode than in pump mode. This means that, when designing pumps intended for reverse operation, the requirements resulting from turbine mode should be considered first.

Based on a multi-criteria analysis, the volute geometry of two pumps that provides a favourable compromise between pump and turbine operation was determined. Original recommendations for selecting the geometrical parameters of the volute were presented. The results of the dissertation may provide a basis for designing volutes of centrifugal pumps (specific speed of 23 and 66) intended to operate both in pump mode and in turbine mode.

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