

DOCTORAL DISSERTATION ABSTRACT

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Title: An influence of the design parameters of the impeller with gap blades on the low specific speed centrifugal pump operation

Field of science: Engineering and Technology

Discipline of science: Environmental, Engineering, Mining and Energy

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The doctoral dissertation concerns the influence of the design parameters of an impeller with a gap blade on the performance characteristics of a centrifugal pump with a low specific speed. The topic undertaken arises from the fact that, in low-specific-speed pumps, achieving high efficiency is particularly difficult due to the large contribution of rotating disc friction losses, volumetric losses, hydraulic losses, and mechanical losses. The literature review showed that, despite the growing interest in impellers with gap blades, there is still a lack of systematic experimental studies that would allow the influence of gap geometry on head, efficiency, and the effective operating range of the pump to be determined unambiguously.

The aim of the dissertation was to determine the influence of the geometric form of the gap blade on the performance characteristics of a centrifugal pump with a low specific speed and to formulate design recommendations concerning the application of this solution. The dissertation adopted the thesis that there exists such a geometric form of the gap blade that its application in the impeller of a rotodynamic pump with a low specific speed leads to an increase in head and/or efficiency. Verification of the thesis was carried out on the basis of experimental investigations, statistical analyses, and CFD numerical calculations.

The investigations were carried out in two stages. In the first stage, preliminary investigations were performed, the purpose of which was to assess the validity of using a gap blade and to select the direction of further analyses. In the main stage, the gap geometry was described by three parameters: width E_{gap} , position radius R_{1gap} , and length L_{gap} . The experimental program was designed using a *Central Composite Design* (CCD), and regression models were subsequently developed to describe the dependence of head and efficiency on gap geometry and flow rate. The interpretation of the experimental results was supplemented by qualitative analysis in the form of validated numerical flow calculations.

Within the main investigations, two sets of impellers were analyzed, characterized by identical gap blade geometry and differing only in impeller width b_2 . In set Z1, $b_2 = 2$ mm was adopted, whereas in set Z2, $b_2 = 1$ mm. The obtained results confirmed that an appropriately selected gap geometry may have a beneficial effect on the operating parameters of a centrifugal pump with a low specific speed. For the investigated impeller sets with $n_q = 12.46$ and $n_q = 9.90$, an increase in head and efficiency relative to the reference impeller was observed in most cases, with a slightly changed shaft power. The maximum increase in efficiency amounted to 2.78 percentage points for set Z1 and 4.91 percentage points for set Z2. A shift of the region of highest efficiency towards higher flow rates and a flattening of the $\eta(Q)$ characteristic were also observed, which indicates a widening of the operating range. At the same time, it was shown that not every gap configuration is beneficial; in particular, variants with an excessively small radius of gap location proved to be unfavorable.

An important outcome of the dissertation was also the determination of the applicability limit of the analyzed solution. In the limiting case corresponding to $n_q = 15.63$, no improvement in energy performance was observed; therefore, based on the obtained results and taking into account the limitations of the test rig, it was assumed that the applicability limit of slotted blades lies within the range of the specific speed coefficient $n_q \approx 13\text{--}15$. CFD calculations further showed that favorable slot variants promote a more uniform velocity distribution and a more even pressure rise in the interblade channel, thereby reducing local loss zones and improving flow organization.

The investigations carried out made it possible to confirm the thesis of the dissertation and to formulate conclusions of both scientific and practical significance. It was demonstrated that a gap blade may constitute an effective design modification of the impeller of a centrifugal pump with a low specific speed, provided that its geometric parameters are properly selected. The obtained results constitute a basis for further design and application work in the field of increasing the efficiency of low-specific-speed pumps.



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