

Methods for balancing axial thrust in a centrifugal pump by structuring the front side of the pump casing.

The flow of liquid through a pump's flow channels generates **axial thrust**, resulting from the imbalance of forces acting on the outer surfaces of the impeller's front and rear shrouds. This force can reach significant values, which necessitates its reduction to levels that can be safely transferred by the bearings. Although there are many widely used methods for balancing axial thrust, each has certain limitations, justifying the need for new solutions or improvements to existing ones.

One promising approach involves axial thrust reduction through **surface structuring** (grooves or ribs) applied to the pump casing on the side of the impeller's front shroud. This surface modification reduces fluid swirl in the working domain, increases pressure on the front shroud and thus lowers the pressure differential between the front and rear sides – resulting in reduced axial force. The proposed solution is simple to implement, reliable and functional even in worn systems. It is suitable for both single-stage and multistage pumps.

The current state of the art **confirms the justification for applying this method** and outlines the basic guidelines for its implementation. However, further work is needed to evaluate how variations in structuring parameters influence thrust balancing and to develop analytical formulas linking these parameters with axial force, swirl coefficient, dimensionless Reynolds number and the pump's energy performance. An appropriate selection of geometric parameters of the structuring is expected to enable axial thrust reduction exceeding 70% compared to an unstructured configuration. Structuring parameters include the number, length, depth, width, inclination angle and shape of the grooves and ribs. Inclination angle is a new variable for the method – not examined yet to the date. **Addressing aforementioned knowledge gaps is the main objective of the proposed project**, which also aims to deepen the understanding of flow phenomena in the relevant working domain through dedicated flow visualization.

The research will be carried out using two complementary methods: experimental (covering both preliminary and main testing phases) and numerical (flow visualization using selected combinations of structuring parameters). Structured covers (casing elements with surface structuring) will be produced using additive manufacturing (commonly known as 3D printing) and numerical simulations will be performed in the CFD environment ANSYS Fluent.

Experimental tests will be carried out using a specially designed and constructed test rig developed specifically for this purpose. Care has been taken to ensure that, as far as possible, parameters are measured directly using dedicated sensors and instrumentation. The experimental plan includes modifications to selected components of the tested pump: the bearing assembly will be adapted to allow direct measurement of axial force using strain gauges and the pump casing will be modified to enable the installation of interchangeable covers.

The expected outcome of the project is the development of equations that describe the studied phenomena, the examination of the impact of the new proposed variable on the tested parameters, and an improved understanding of flow mechanics. The theoretical knowledge gained through this research may serve in the future as a foundation for the development of practical engineering solutions, competitive with existing market technologies in terms of axial thrust balancing efficiency, hydraulic performance, reliability (MTBF – Mean Time Between Failures) and manufacturing cost of the pumping system.

The personal **motivation behind the desire to pursue this research** stems from the conviction that working on design improvements aimed at increasing the efficiency of machines and energy systems directly contributes to environmental protection. Current axial thrust compensation methods often result, through various mechanisms, in increased energy consumption by the pump – and higher energy use means a larger carbon footprint. It is estimated that pumps account for 20–30% of global electricity consumption annually. Considering that axial thrust is a particularly critical issue in large pumping units, which represent the highest energy demand within the pumping industry sector, the problem is of significant importance – and the topic, well worth pursuing.