The aim of the project is a detailed analysis of the phenomena occurring in the micro-channels between two co-rotating discs and the determination of the conditions of the effectivity increase of the momentum transfer between the fluid and the discs by means of the selection of the disc wall parameters. This topic is of significant importance in many fields of science and industry, but particularly in viscous machines. The principle of operation of these machines is not based on the fluid reaction on the elements of the rotor, but rather on the phenomenon of the momentum diffusion due to viscosity and adhesive force. It is possible to increase the control over the phenomena in the gap between the rotating discs by means of the modification of the disc surface (e.g. directional roughness or shaping of the micro-channels).

The investigation will be carried out with the use of analytical, numerical and experimental methods. Analytical methods will depend on the solution of the simplified, two-dimensional differential equations of the flow field with taking into account the adjustments introducing the influence of the surface parameters. The methods enabling the imposition of the velocity profile shape and the angles of the velocity vectors with the unambiguous determination of the tangential stresses will be implemented.

The numerical simulation of the computational fluid dynamics (CFD) will be carried out with the use of the Ansys CFX commercial software, which makes use of the finite volume method. A full and a partial numerical model to investigate the flow phenomena will be elaborated. The analysis will be carried out with the use of unsteady Reynolds Averaged Navier Stokes (uRANS) and Large Eddy Simulation (LES) methods. The optimization techniques will be used to determine the geometry of the reference turbine with maximal efficiency. The optimized parameters will be the geometries of the inlet nozzles and the gap between the discs. The numerical analysis will be the basis for elaborating the methods of the description and selection of the surface parameters. The research will be carried out for air as an ideal gas and for organic fluids treated as real gases.

The experimental investigations will be performed with the use of the air installation working in the negative gauge pressure and supplied by the Roots blower, which can produce pressure ratio up to 1.88. The installation will be modified so to make it possible to work in the positive gauge pressure allowing the achievement of the critical flow parameters in the inlet nozzles. The turbine model, which was already manufactured, has a rotor consisting of the 5 discs, each 160 mm in diameter. Its flexible construction makes it possible to change the number of the discs, the size of the inter-discs gaps and the configuration of the inlet apparatus. The important part of the test rig is the measurement system. All fast-changing signals will be transferred with the use of National Instruments system and processed in the LabView software. The experiment will be used for the validation of the results obtained from the numerical and analytical methods and the method of the surface parameter selection as well.

The detailed aims of the study are:

1. To set-up the semi-analytical and numerical models to identify how the flow structure inside the gap between rotating discs and tangential stresses distribution on the discs depend on various geometrical configurations of the supply nozzles, gaps, working zone of the discs, outflow configuration and operating parameters. Determination of the reference geometry of the friction turbine by the optimization using Design of Experiment Method for the experiment.
2. To perform an extended 3-D CFD simulation of the unsteady flows (uRANS and LES) between the co-rotating discs. The evaluation of the influence of the unsteady character of the jets inside the inter-disc gap on the effectiveness of momentum transfer.
3. To perform experiments for validation of the semi-analytical and numerical models with air as the working medium.
4. To extend the models that describe the flow in the inter-disc gap with the roughness parameters.
5. To determine the optimal method of selection of the surface parameters in order to increase the angular momentum transfer
6. To consider the features like designed roughness in microchannels, anisotropic roughness, microstructures on a disc surface.
7. To evaluate numerically the new findings regarding momentum transfer improvement obtained for air (ideal gas) in relation to the organic fluids with the low Global Warming Potential (GWP) proposed for application in the Organic Rankine Cycles (ORC).