Considering economic and ecological criteria, the improvement in the efficiency of heat engines, especially modern aircraft engines and power engineering gas turbines, is the priority of engineering efforts nowadays. Such engines are composed of a compressor, a combustion chamber where compressed air is mixed with fuel and fired, and a turbine where expansion of hot gases occurs. In this case, one of the basic methods of improving efficiency is to raise the temperature at the turbine inlet. At present, the temperature may even exceed 1200^0C. Consequently, sophisticated cooling techniques and special materials are required to cool the turbine blades appropriately. The turbine blades are cooled by the compressor air. The structure of the blades ensures an air flow through internal cooling passages and through the orifices that blow the air onto the external blade surface to cool it as well. The cooling passages design should ensure appropriate cooling of the blade entire surface at a possibly small volume of the cooling stream. Therefore, efforts are made to intensify the heat exchange between the blade material and the coolant. In order to achieve this, additional ribs are used in the cooling passages and the shape of the passages is optimized. However, there are still places where traditional cooling is extremely difficult, e.g. the blade tip.

The presented project concerns research aiming to develop and verify a new cooling technique based on the use of high-frequency non-stationary phenomena. One of them is noise generation and propagation. Current computational and experimental research on sound, and on noise in particular, is being pursued actively due to ever-stricter standards concerning protection against noise, e.g. in aviation. However, the efforts focus primarily on modelling noise generation and propagation and finding methods of noise reduction.

The research proposed in this project goes in a different direction and concerns the use of the mechanism of the acoustic wave generation for the purpose of the heat transfer intensification. The potential space for the solution application is the turbine blade cooling system. However, the proposed works are meant to have the nature of basic research and from the inter-disciplinary perspective they are focused on determining the relationship between the acoustic wave generation and the heat transfer process.

One source of the acoustic wave generation may be the flow of air through an appropriately shaped channel with a vertical cavity. In this case, sound is generated by high-amplitude pressure pulsations that arise in the cavity, but the pulsations occur only for a certain velocity range that depends on its assumed geometry. This is related to resonance – the phenomenon that arises due to the interaction between the pressure waves generated in the cavity and the vortices being the effect of the flow above it. This type of the acoustic resonator can be relatively easily incorporated into a flow system, e.g. in the turbine blade cooling system, because it has no moving elements. Nonetheless, developing the resonator appropriate geometry and determining its impact on the heat exchange process present a complex task. This is mainly due to the fact that in this case two processes with a completely different frequency are involved which have to be analysed in parallel. This problem concerns both numerical and experimental investigations. However, correct numerical modelling of such phenomena is currently possible. Naturally, the obtained results should always be verified based on experimental testing.

Therefore, research on the heat transfer intensification due to the acoustic wave effect is planned in three basic stages comprising the numerical part, the experimental component and the optimization process with the acoustic wave generator implementation in the turbine blade cooling system. The numerical calculations will be performed using the Computational Fluid Dynamics commercial code Ansys-CFX. Non-stationary computations are anticipated to capture the acoustic wave generation process for a two- and three-dimensional model of the acoustic generator under different flow conditions.

The design of the test stand intended for experimental testing will make it possible to investigate the impact of the acoustic wave generation on the heat transfer process in the cavity for a wide range of thermal and flow conditions and selected geometries of the cavity. It is also planned that a heating element will be used on the cavity selected surfaces and that measurements of the temperature field, velocity and pressure oscillation will be performed for a wide range of flow parameters.

The final stage of the works will be optimization of the acoustic generator shape using a Computational Fluid Dynamics commercial software package and an in-house optimization algorithm. The aim of the optimization process will be maximum intensification of the heat transfer in the region of the acoustic resonator application for selected flow conditions. The results obtained at this stage will be verified based on the final experimental testing.

The proposed research constitutes a new approach and aims to use strongly non-stationary phenomena to substantially improve the heat transfer conditions. This is the innovative element of the project. The results obtained during the project completion may contribute to an improvement in current cooling techniques. They may be used in a wide range of applications, but within the project they are mainly intended for implementation in the gas turbine blade cooling system. This especially concerns the cooling of the blade tip and intensification of the heat transfer by using a new geometry of the ribs in the turbine blade cooling passages.