Catalytic processes are still the most effective remedy for major air pollutions like automotive exhausts and harmful industrial emissions. For years, packed bed reactors, filled with catalyst grains, dominated in industry. The flow resistance was high for such reactors (thus large pumping energy consumption), diffusional resistances in large grains led to incomplete catalyst utilization, but the construction was simple and reliable. In 80. monolithic reactor (thus e.g. automotive catalyst) has initiated a revolution within catalytic reactors. The flow resistance was low in long, straight capillary channels. Reaction catalyst was deposited in thin layers at inner channel walls thus its exploitation was sufficient. However, a drawback was weak heat/mass transport to the channel walls hampering reaction rate especially for fast catalytic reactions. Frontal surfaces of the channel walls bring about important flow resistance, moreover, they induce vortices and stagnant zones significantly decreasing heat/mass transfer intensity, thus reactor yield.

Many of living organisms assume streamlined shapes to reduce flow resistance; birds and fishes are good examples. Engineering designs follow the way like airplanes or ships. Around streamlined objects, a fluid (e.g. air or water) flows smoothly, in laminar manner, without vortices, thus decreasing energy consumption. Nature has created such solutions during millions years of evolution, humanity has adapted them to numerous engineering products. Nonetheless, some areas of engineering, including chemical reactors engineering, remain conservative.

The main project objective is to design and study a new generation of structured reactor internals (catalyst carriers) that are based on a concept of an aircraft wing shape and are called “streamlined" or "aerofoil" structures. **The basic innovation is channel wall shaped as an aircraft wing.** These structures are similar to short monoliths of diverse cross-sectional shape, however, geometry of the channel wall will be fundamentally changed: from cubical to streamlined (aerofoil-like). As judged from initial computational fluid dynamics (CDF) simulations, such geometry can substantially improve the mutual relation between the heat/mass transfer and the flow resistance. Moreover, the heat/mass transport will be considerably enhanced compared with traditional monoliths. The structures invented enable easy adjustment of the transport intensity by simple channel length regulation, similarly to the short monoliths studied before; such an adjustment is not possible for classic monoliths, e.g. automotive ones.

At the beginning, the streamlined structures will be designed, then CFD modelled to determine their flow resistances and the heat/mass transfer coefficients. Next, the designed structures will be 3D printed from metal powder (e.g. by selective laser melting technology, SLM). A survey of the shape and dimensions of the 3D printing product will be performed, using the X-ray computing tomography, to compare final products with their designs. Then, rigorous experimental tests will be executed to validate the CFD methodology for such a structure type. The CFD and experimental studies will be performed for at least 3 geometries (channel cross-sectional shapes), each of 2-3 channel lengths. The flow resistance and heat transfer experiments will be carried out in the test reactor where metal structures will be heated by strong electric current flowing through them. Temperatures of the gas (air) and the structure surface will be measured by thermocouples, pressure drop by a micromanometer.

The streamlined reactor structure is a pioneering design. Similar structures have not been described in the literature so far. A novel concept of catalytic reactor structure can exert a large impact on further reactor design and modelling. Former important innovation - monolithic reactor – has given rise to violent development of catalytic reactors; concept of streamlined reactor structure can be another turning point. According to the CFD simulations performed, the aerofoil-shaped reactor structure is hoped to improve the mutual relation between the heat/mass transfer and the flow resistance. The structure flow/transfer properties can be adjusted to the reaction kinetics not to limit the reaction rate. The 3D printing manufacturing technology opens door to catalytic reactor internals tailor-made for a process considered. These lead to reactor yield increase and significant savings in pumping power, catalyst amount, reactor mass and dimensions, important e.g. for car exhaust treating.

Innovative reactor concept proposed with the optimisation procedure should bring about serious savings in catalytic environmental processes thus giving both economic and social effects. The savings may result in important air quality improvement (thus public health), and better economic competition (thus faster development of economy).

At the current, initial stage of researches they undoubtedly belong to the basic researches. However, future perspectives of application are promising, mainly in automotive and chemical industry. Therefore, we plan to patent the invention, firstly in Poland, finally in EU, USA and Japan.