When the turbulent boundary layer (TBL) is exposed to an adverse pressure gradient (APG), a separation is expected to occur at a certain point which is difficult to predict. The boundary layer detachment from the bounding surface is accompanied with a rotational flow region just behind the separation point. When the turbulent separation takes place on the upper surface of an airplane wing, a rapid fall in the lift force is observed. This problem touches also other applied systems as diffusers or mobile vehicles where TBL detachment is responsible for substantial energy losses. In turn, this issue attracted a widespread attention and stimulated a considerable effort to search for techniques allowing to postpone the turbulent separation. Development of TBL in APG is accompanied with a decrease in wall shear stress in the streamwise direction and the separation usually takes place when this parameter reaches zero. Hence, an effective separation postponing method should allow either to increase wall shear stress locally (when the separation is expected to occur) or to reduce its decreasing rate within the entire APG region. Development of an effective approach to treat the problem may provide a number of benefits such as lower fuel consumption and consequently lower CO_2 emission (especially in civil aviation and in road and shipping transport), better maneuverability and so safer flights.

In general, available methods allowing for flow separation control can be classified as active or passive. The former one involve a number of different methods as gas injectors, uniform blowing and suction, heating and cooling processes, moving wall systems or exposing the flow to the action of the electromagnetic field. These methods although usually effective, require a considerable energy input which leads to a higher energy consumption and reduction in total efficiency. Not much attention has been paid to the passive methods which do not require an external energy source. This is manifested by the fact that the available approaches are usually not efficient enough as also the physics standing behind the postponement of the separation is usually not well understood.

This project is aimed at filling the gap. Our preliminary results showed that application of surface waviness with carefully chosen amplitude and period is able to notably increase the wall shear stress and consequently substantially postpone the flow separation. The effect was achieved under the flow conditions comparable to the ones occurring on the surface of the wing. Such a finding makes a new approach a serious candidate for practical implementation.

The new finding is very promising, however, it was tested only for one fixed value of the velocity and for a limited number of cases. Hence, there is still much research to be performed to examine the performance of the new approach under diversified flow conditions. We expect that our findings will allow to better understand the processes playing the key role in energy transport when applying the streamwise waviness and in turn substantially contribute to more efficient use of this solution in practice.

It is expected that the results obtained during the project will offer new guidelines for further flow control strategies. The project proposal has a pioneering nature is that such an attempt aimed at postponing separation at high Reynolds number using wall topology modification has not been undertaken in the past.