Nanomaterial, a New Pathway to Change Boundary Conditions of Airfoil.

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The aim of this work is the development of a new boundary layer control method, which would influence not only the buffet onset and but change also the laminar-turbulent transition and the boundary layer separation, allowing an improvement in economical efficiency and safety of aeroplanes. The new approach proposed is associated with the unsteady surface heating regime using the electrical properties of nanomaterials embedded in the wing skin. Many investigations in unsteady flow control are based on slot suction and injection. However, the implementation of nano-strips on/in the wing skin is a new design concept and it could be carried out at a low manufacturing cost without weakening the structure integrity of the wing and with a reduced maintenance cost.

The most important factor due to energy release (surface heating) is the density change in the region influenced by the heating. This region's structure is controlled by the convection and thermal conductivity properties. At the same time a density change (reducing due to the temperature rise) will change the boundary layer thickness. The situation is similar to the local flow near a local surface distortion, but in our case, an effective surface distortion was created due to temperature (density) change. The difference is that the distortion shape is not known beforehand but it is formed due to the energy release in the boundary layer and due to the region with smaller density formation.

An analysis of local processes associated with the heating element were then carried out because any heating element has a so-called thermal inertia limiting possible unsteady regimes from the point of view of attainable frequency. This frequency strongly depends on the heating element size and shape.

In this study, a set of nano-strips located parallel to the leading edge for boundary layer control was proposed for the first time and implemented on a flat plate. Two strip shapes were considered: straight and wavy. The computations were carried out using Fluent at Mach 0.1 and Mach 0.3. A constant temperature was applied on the strips from 15°C till 65°C. The feasibility of the use of nanomaterial to control the boundary layer by a local unsteady heating was demonstrated through a series of computations. The results indicate that the nano-strips could be a very promising candidate requiring a small fraction of energy to improve the stability of the boundary layer in order to reduce the friction drag, and as a result to reduce the fuel consomption. .