Further Turbulator Investigations on the Wing Section SL13-000

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1. Goals

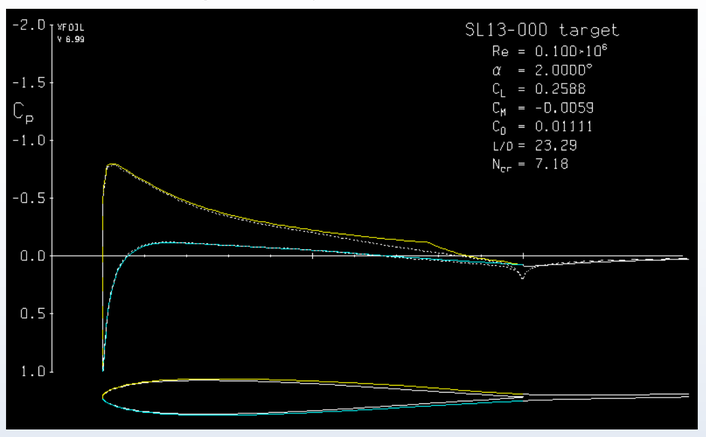
In the closed test section of the Regensburg Windtunnel (RWT), polars can be investigated due to the effects of airfoil modifications. Therefore the lift is measured by pressure difference between the upper and lower wall. The drag is measured by a wake rake.

At low Reynolds numbers especially from Re= 50000 to Re= 100000 a so-called dead band occurs in the lift slope of the SL13-000 profile. This wing section is used at sailplanes of UAVs. This results in a reduced handling and stability characteristics of the aircraft. Therefore, turbulators are picked up on the airfoil in order to linearize the lift slope and eliminate the laminar separation bubble. For this purpose, an optimum arrangement with regard to position and turbulator geometry has been surveyed.

Fig. 1: Closed test section in the Regensburg Wind Tunnel (RWT) at the OTH Regensburg.

2. XFoil simulations

In order to estimate the extent of the dead band as well as the size of the laminar separation bubbles, simulations were carried out with XFoil. Thus, the measurement effort can be significantly reduced and time can be saved.



At first, simulations to identify the position of the laminar separation bubble were carried out. With these results, the next step was to determine the optimal turbulator position to force transition.

Fig. 3: Simulation in Xfoil with the SL13-000.

However, the XFoil simulations, make a rough estimate only, since in reality 3D phenomena as well as environmental influences are occurring, that are not adressed in the numerics. Therefore, simulations can not replace real measurements in the wind tunnel.

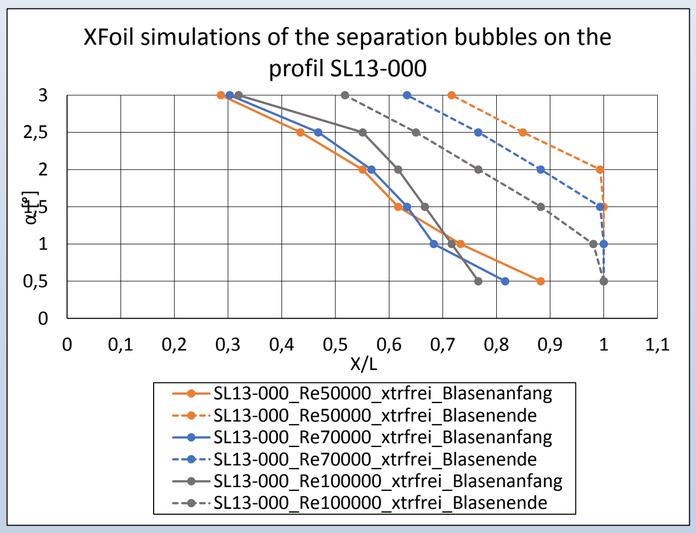


Fig. 4: Diagram showing size and position of the laminar separation bubbles.

3. Turbulator production by laser processing

As the manufacturing process for the turbulator stripes, laser processing was chosen. Due to this it is possible to produce any geometries and shapes of turbulators.

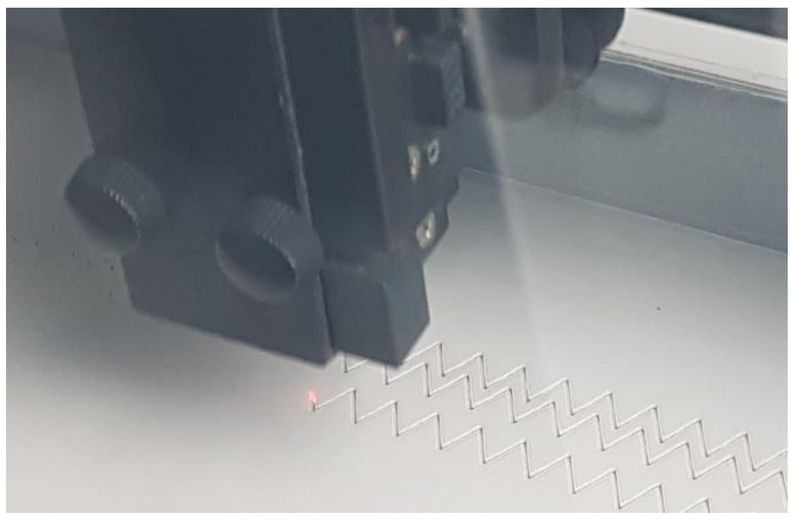


Fig. 5: Laser processing of a 3D-zigzag Turbulator.

The turbulator geometries for the laser cutter can be constructed in cad programs and saved as dxf- files. In order to achieve the required cutting quality, the process parameters like beam power and focus must be set correctly.

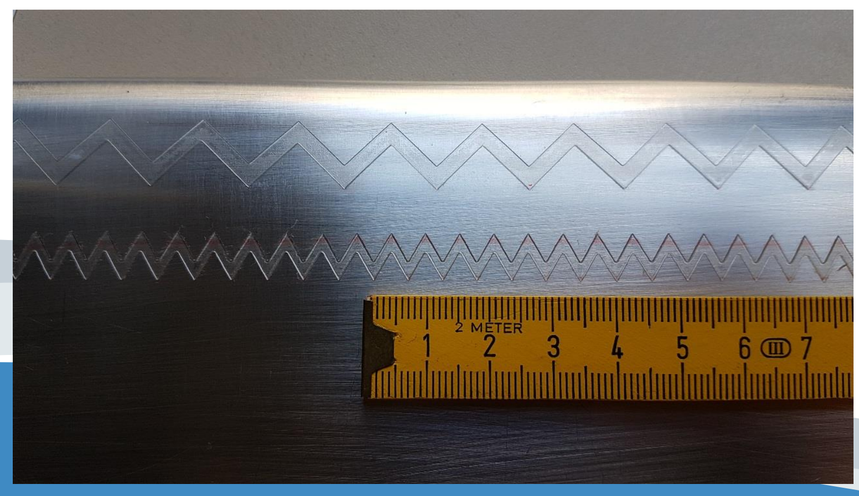


Fig. 6: Airfoil SL13-000 with the turbulators zigzag90° (above) and zigzag60° (below).

4. Measured results

2D-turbulators (straight tape, width 3mm) were measured in thickness between 0.15mm and 0.25mm, as well as 3D-turbulators (zigzag pattern) with the angle of inclination 60° and 90° and a thickness of 0.2mm. In order to define the optimal arrangement, both, the lift slope as well as the drag curves of the different turbulator configurations were compared with each other. It turned out that the optimal configuration is the zigzag90° at a position of 25% based on the leading edge.
As it can be seen in the diagrams, the lift slope shows a clear linearization over the basic configuration. Furthermore the polar plot shows a drag reduction compared to the basic configuration.

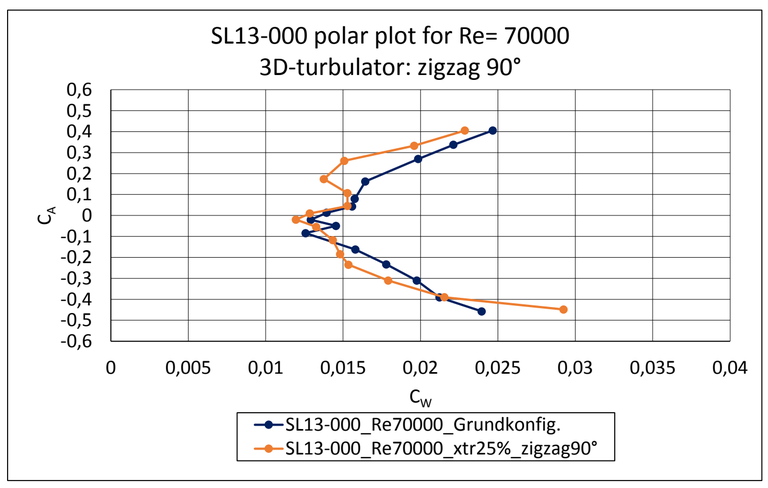


Fig. 7: Comparison between basic configuration and optimized configuration (zigzag90°) in the polar plot.

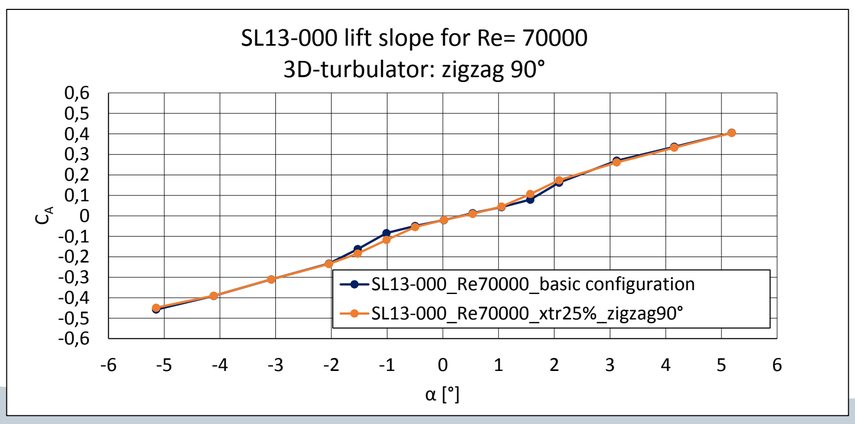


Fig. 8: Comparison between basic configuration and optimized configuration (zigzag90°) concerning the lift slope around zero lift. The dead band effect is reduced.

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