Turbulators

What are turbulators?

When I flew free flight A/2 F1a gliders there was a fashion for turbulators. These took a variety of forms. Some people used a wire or a thread, either elastic or fishing line, a few millimetres in front of the wing leading edge. Others used strips up to 1 mm thick glued on to the top surface of the wing. Some current RC models have protrusions from the wing and even full-size aircraft have them, especially gliders. Another option is to have holes in the upper and lower surfaces through which air can be pushed by the pressure difference above and below the wing. These are called pneumatic turbulators.They are also used in heat exchangers and golf balls.

http://www.mh-aerotools.de/airfoils/turbulat.htm

The reason for the turbulators is to avoid unpredictable laminar separation bubbles. These occur at the point on the wing where the transition to turbulent flow occurs, usually somewhere in the rear half of the wing chord. The turbulent region is made more predictable and controlled, reducing surges in drag and making stalls more gentle.

http://www.physicsdemos.juliantrubin.com/encyclopedia/aviation/boundary_layer.html

However there comes a point, the separation point, in which the boundary layer breaks away from the surface of the wing due to the magnitude of the negative pressure gradient. Beneath the separated layer, bubbles of stagnant air form, creating additional drag because of the lower pressure in the wake behind the separation point.

These bubbles can be reduced or even eliminated by shaping the airfoil to move the separation point downstream or by adding a device, a turbulator that trips the boundary layer into turbulence. The turbulent boundary layer contains more energy, so will delay separation until a greater magnitude of negative pressure gradient is reached, effectively moving the separation point further aft on the airfoil and possibly eliminating separation completely. A consequence of the turbulent boundary layer is increased skin friction relative to a laminar boundary layer, but this is very small compared to the increase in drag associated with separation.

In gliders the turbulator is often a thin zig-zag strip that is placed on the underside of the wing and sometimes on the fin. The DG 300 glider used small holes in the wing surface to blow air into the boundary layer, but there is a risk that these holes will become blocked by polish, dirt and moisture.

For the aircraft with low Reynolds numbers (i.e. where minimizing turbulence and drag is a major concern) such as gliders, the small increase in drag from the turbulator at higher speeds is minor compared with the larger improvements at best glide speed, at which the glider can fly the furthest for a given height.

Conference paper on turbulators

There is an excellent conference paper written by Julio Leo, Mariano Martinez, Federico Bacchi and Jorge Lerner about experiments they carried out on a single model aircraft-sized wing (0.8 m span and 0.42 m chord) with an Eppler 387 aerofoil.

To download the paper go to: https://www.researchgate.net/publication/269204821

Their conclusions were that :

1 The normal role of turbulators is to generate a turbulent flow on the wing extrados [on the exterior curve of the surface] in conditions close to stall, with the purpose of energizing the boundary layer to either delay the stall or reattach the flow. In this way higher lift can be achieved and sustained

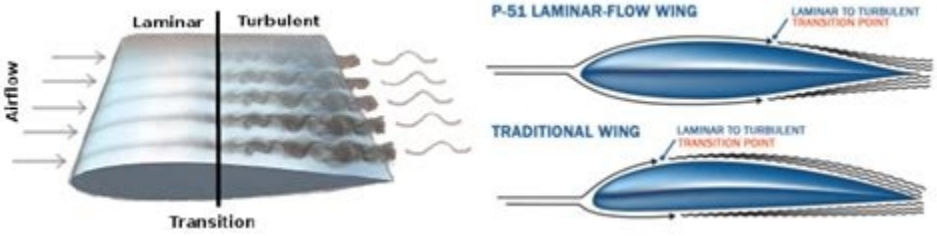
2 On the other hand, when the incident flow is already turbulent, the boundary layer for this range of Reynolds numbers is naturally turbulent, thus the effect of turbulators and their efficiency in the airfoils performance will be
different.

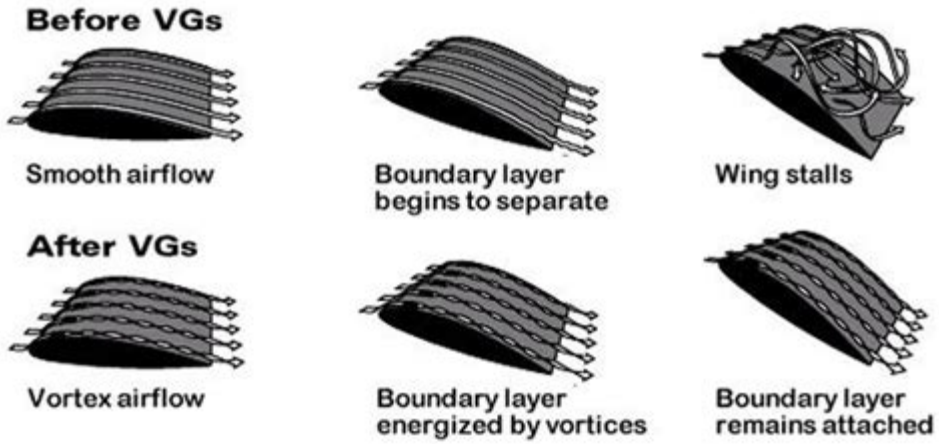
3 Finally, we found an increment in the efficiency using turbulators, due to the reduction in the drag at this Re numbers. The maximum efficiency, at the mean velocity incoming flow, change with the different turbulent intensities being higher for lower values of them.

We will perform new experiments changing the positions of turbulators and turbulent intensities of the incoming flow, at the same mean velocity flow, in order to achieve a better understanding of turbulators in turbulent flow.

B47 turbulators


U.S. AIR FORCE
2006 10 12


Laminar
Turbulent
Airflow
Transition
P-51 LAMINAR-FLOW WING
LAMINAR TO TURBULENT TRANSITION POINT
TRADITIONAL WING
LAMINAR TO TURBULENT TRANSITION POINT


Before VGs
Smooth airflow
Boundary layer begins to separate
Wing stalls
After VGs
Vortex airflow
Boundary layer energized by vortices
Boundary layer remains attached

Last edit 231 May 2021