Labor Windkanal/Strömungsmesstechnik

OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG
MASCHINENBAU

Airfoil Measurements on Wing Sections Including Systematic Production Tolerances

Emanuele Del Peschio

Mechanical Engineering, Galgenbergstr. 30, D-93053 Regensburg, Head: Prof. Dr.-Ing. Stephan Lämmlein https://hps.hs-regensburg.de/las39261/

1. Outline

One amongst the most common problems about aerodynamics is the discrepancy that often occurs comparing experimental and numerical performances of a wing: the main reasons can be attributed to the simulation software, to the equipment of test section of the wind tunnel or to the geometrical imperfections caused by the production process. An investigation on the last one is the main topic of this paper.

Through experimental measurements, it is possible to study the influence of the manufacturing, testing several airfoils, where production imperfections have been deliberately added thickening the standard model. Therefore, it is possible to understand how the performances are affected. Additionally, the contribution of the material is examined testing the same wing, made out of both steel and plastic.

Moreover, the problem is faced also upstream with a geometrical check on the produced wings so as to ascertain the accuracy of the manufacturing process. The wings are 3D scanned and, successively, the point clouds are compared to the models.

Furthermore, a starting point for also an investigation on the simulation software is presented. Since the computational methods differ from laminar to turbulent regime, it is shown a comparison between a forced transition in both the numerical and experimental case so as to identify possible critical points.

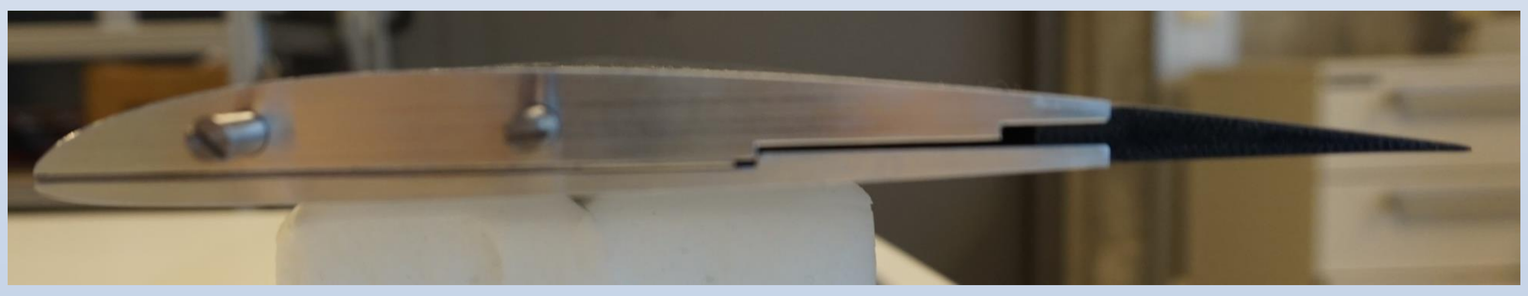

Fig. 1: Side view of the metal MM17-240 0.5mm airfoil. The trailing edge (in black) is made out of plastic and has been 3D printed, whereas the other parts have been milled.

2. Thickening and material influence

First of all, the influence of a thickening has been studied. The standard model of the MM17-240 has been produced also with two thickened versions (0.5mm and 1mm) in plastic, whereas the steel airfoil has the possibility to insert a metal plate in order to reach the wished thickening value.

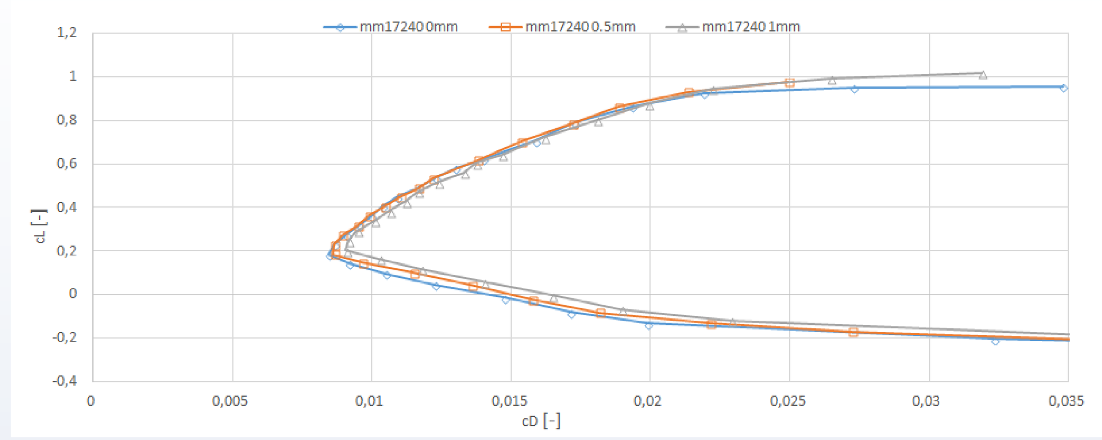

Fig. 2: Comparison amongst the MM17-240 airfoil class, plastic wings. The grey curve (1mm) shows different values with respect to the other two, demonstrating the limit of the thickening.

The performances of the plastic airfoils are similar each other, althought the MM17-240 1mm shows small differences that are a clear sign of a worsening of the coefficients. Therefore, it might be claimed that a thickening lower or equal than 0.5mm has no influence for this specific design. In addition, although small differences are visibile varying the material of the wing section, taking into account the arrangement necessary on the steel wing, they can be overlooked.

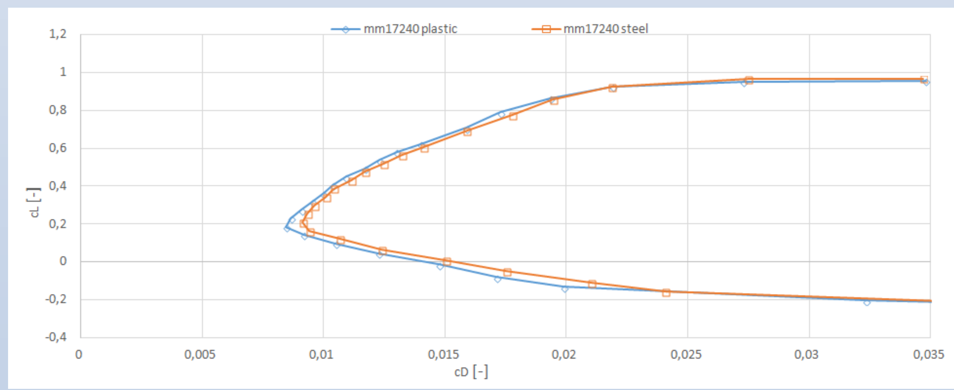

Fig. 3: The material comparison can be considered successful, although the discrepancies, because the metal wing's surface imperfection should be taken into account.

3. Forced transition on the MM17-240

Since the software Profili Pro 2.30c faces the transition with a no-space switch between a laminar boundary layer computation to a turbulent boundary layer computation, it has been thought necessary to investigate on the actual differences between the experimental case of a forced transition and the numerical one.

The production of the turbulators has been done with a laser engraving machine in the LWS. The design takes inspiration from the work of Prof. Selig, showing once again the superiority of the 3D turbulators over the two dimensional.

The final results show possible improvements in the performances of the airfoil, althought the gap between the two kind of investigations are still present.

Fig. 4: Laser engraving machine (KH-7050)

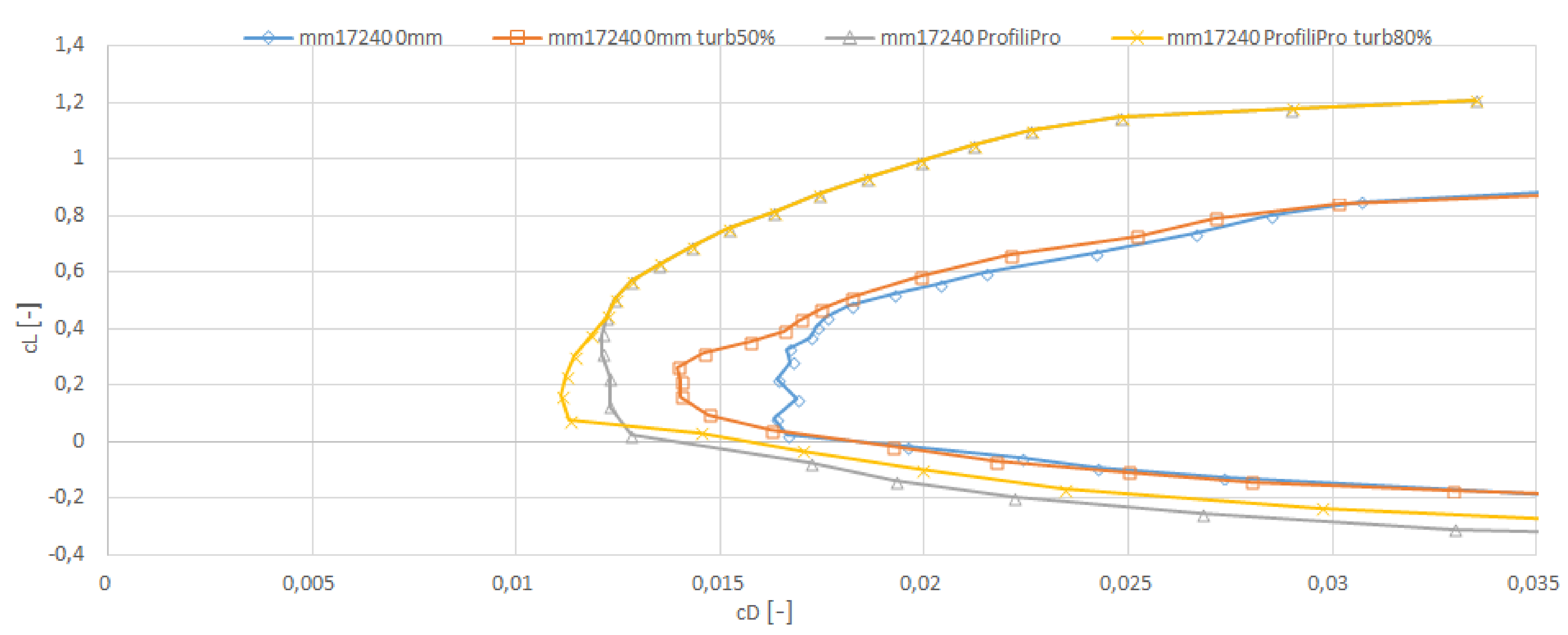

Fig. 5: Polar curves of the MM17-240, standard version. The orange curve shows a forced transition with a 3D turbulator at 50% of the chord. The difference with respect to the natural transition case (in blue) resembles the numerical case (respectively in yellow and grey)

4. Geometrical check

The geometrical check on the MM17-240 airfoil has been performed using the FARO Edge ScanArm. This 3D scanner allows to have a detailed point cloud. After that, a post-processing phase has been necessary. With the help of CloudCompare, the model (.stl file) has been overlapped to the point cloud and the distance between the two entities has been calculated. The final result shows the quality of the manufacturing process. The natural conclusion is that the discrepancies between the experimental and numerical performances cannot be attributed to geometrical imperfections.

Fig. 6: FARO Edge ScanArm, avaible at the LFW in the OTH Regensburg

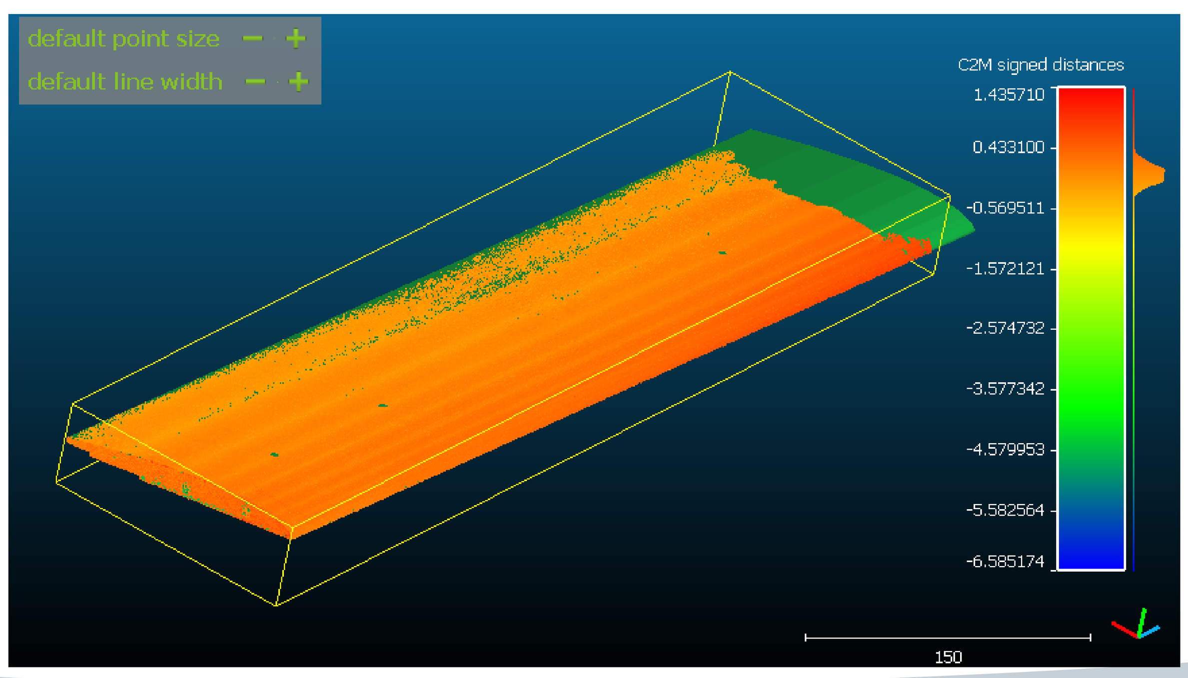

Fig. 7: Vectorial field distribution of the cloud-to-mesh distance. The green part is the original model (.stl file), whereas the orange part is the point cloud. On the right, a scale shows the average distribution of these distances.