Airfoil Lift and Drag Depending on Angle of Attack

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1. Abstract

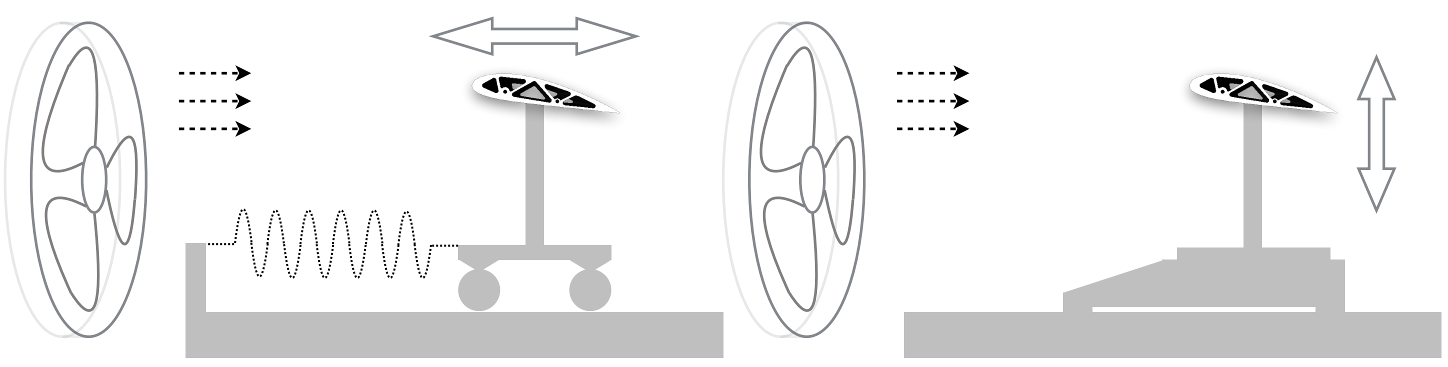
A model of the NACA 4418 airfoil is tested on lift and drag with different angles of attack. The comparison with data from NASA shows similar graphs and striking points. Deviations are caused by an inhomogeneous airflow and inaccuracies while collecting the values.

2. Introduction

Without aviation the modern lifestyle would not be possible and to keep the aeroplanes in the air, the shape of the wings is essential. It helps saving fuel and costs, while making it possible to reach climate protection goals.
Nowadays the airfoils are optimized with the help of formulas and computer simulations, while still being tested in the wind tunnel. To do so, models of the airfoils are built to be tested on lift and drag.
In this seminar paper one airfoil was tested on these parameters and the results were put in relation with recent aerodynamic findings.

3. Material and Methodes

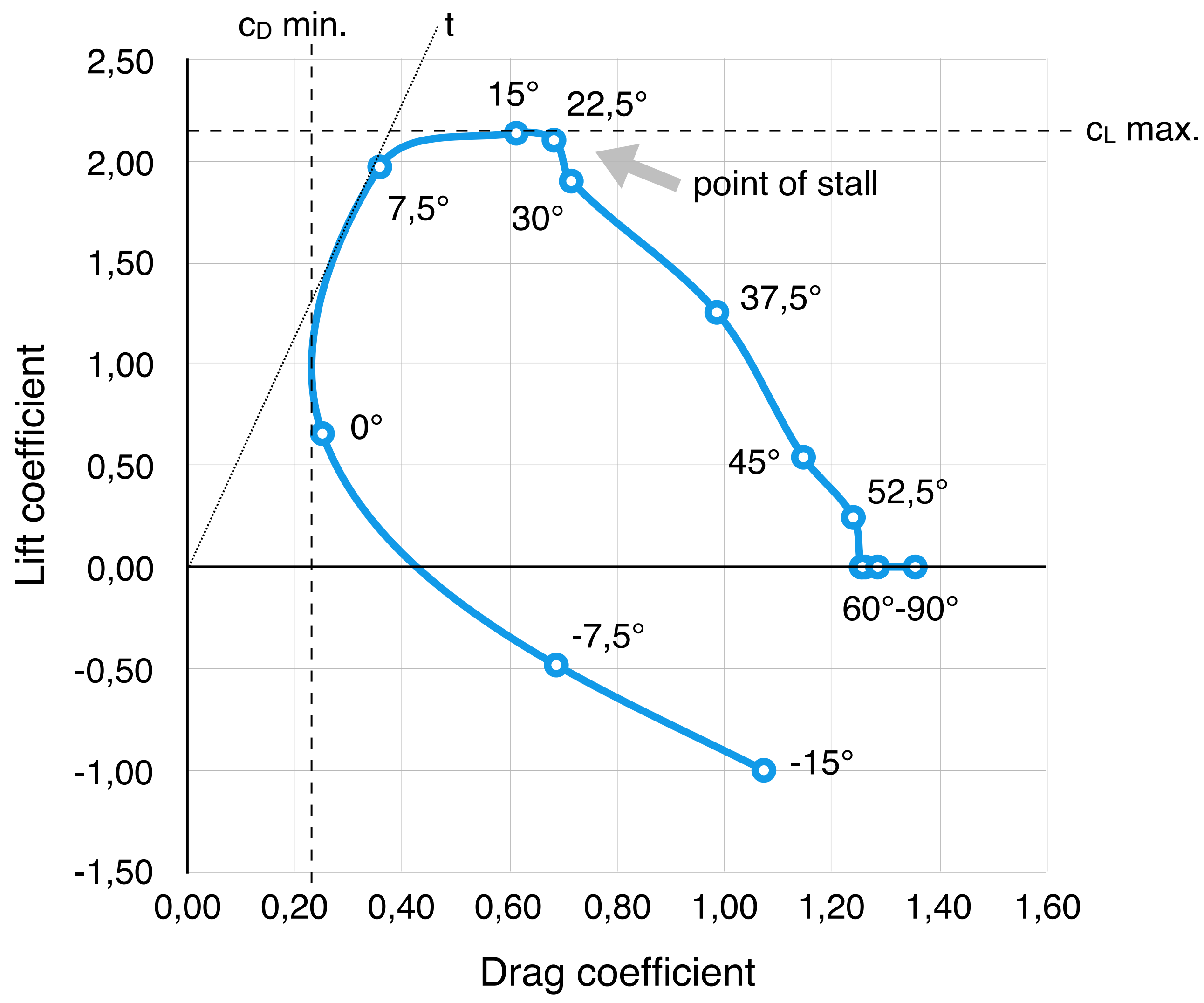
A model of the NACA 4418 airfoil (100x90x18.3mm; 53.6g), 3D-printed out of the thermoplastic PA12, was used in the bisected experiment.
The following constructions were used to measure the drag (left) and lift (right):



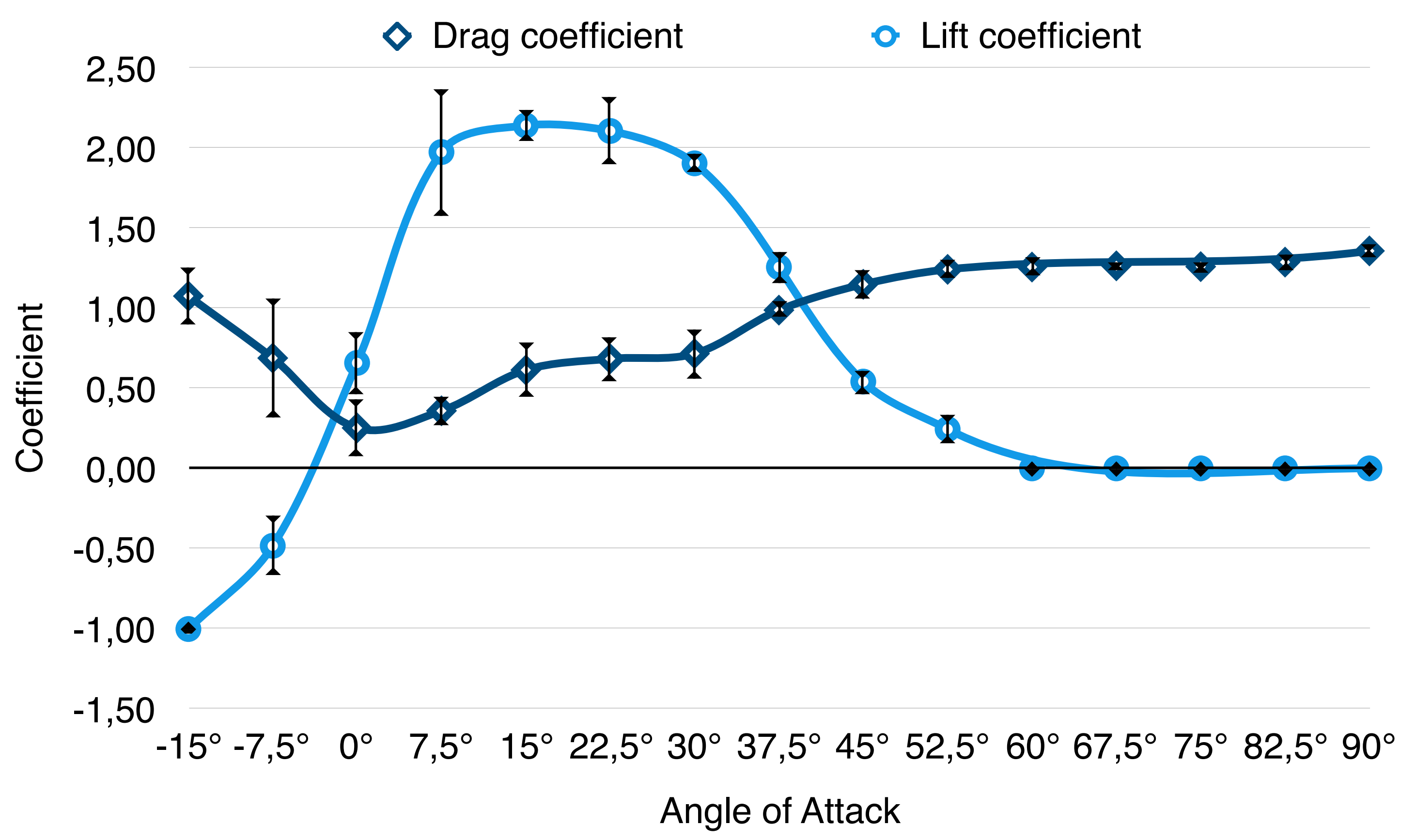
In both experiments, the airflow is simulated by a commercial fan. The drag is measured by the deflection of a spring, which is connected to the airfoil mounted on a movable platform. The spring constant has to be measured too. To measure the lift the airfoil simply stands on a scale.
Angle of attack varies between -15° and 90° in steps of 7.5°.
There are two additional values to be measured: the reference area (area hit by the airflow) and the speed of the airflow. To get the first, the airfoil is illuminated to cast a shadow on a wall, which can be measured. An anemometer is used to get the speed of the airflow.

4. Results

The gained values were calculated into dimensionless coefficients for lift and drag and visualized in two different polar curves. This makes it possible to detect striking points: i. e. maximum lift and drag or the point of stall, where the lift suddenly decreases. The first type is a polar curve, where lift coefficient is shown depending on the drag coefficients under the parameter of the angle of attack:



As seen above, the maximum lift is reached at an angle of attack of about 15°, minimum drag at slightly over 0° and the point of stall is located at 22,5°. The intersection with the tangent *t*, which intersects the origin, marks the point with the biggest ratio of the two coefficients at about 7,5°. It is possible to choose the right angle of attack for a specific purpose by looking at these points: maximum lift for a long time in air, highest c_L/c_D ratio for maximum speed and minimum drag for the highest distance to pass.
The second polar curve shows the data differently. Drag and lift coefficients are shown depending on the angle of attack. Additionally the standard deviation can be read out of the following diagram.



5. Discussion

In comparison with data from NASA there are many similarities, but also some differences. The striking points are similar and up to an angle of attack of about 30° the lift coefficients are similar too. Then the graphs differ because NASA does different measurement for pre- and post-stall angles of attack. The same applies to the graphs of the drag coefficients, these match best between 30° and 50°. Different Reynolds-Numbers, a real wind tunnel used by NASA and friction are further reasons for those differences.

6. Literature

1. Oertel, H. jr., (13th Edition, 2012). „Prantl - Führer durch die Strömungslehre", Karlsruhe, Springer Vieweg-Verlag
2. Schlichtig, H., Truckenbrodt, E. (1962). „Aerodynamik des Flugzeuges (Teil 1)", Göttingen, Springer-Verlag