Analysis of wings using Airfoil NACA 4412 at different angle of attack

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Abstract: *The purpose of this paper is to analysis the basic aerodynamic theory of wings and the provide an introduction to wind tunnel testing. This is followed by the result from the wind tunnel testing of a NACA4412 and the analysis of the data.*

Lift increase at the angle of attack increase at certain point and at this point it become maximum. After that if the angle of attack is increased by further, drag become the dominant factor and the wind enters the stall mode.

Keywords: *Air Foil, Angle of attack, Drag Force, Lift Force*

I. Introduction

The purpose of this report is to present an Introduction to structure and theory of wings. Also, it includes some background information on wind tunnels and wind tunnel testing. Lastly, this report describes the procedure for testing the NACA 4412 airfoil and presents a number of graphs and tables evaluating the data obtained through these tests. The objective is to find the angle of attack at which the lift is maximized in order to get the best performance of this wing when in flight.

This report is based on the research on basic aerodynamics of wings and fundamentals of wind tunnel testing. In addition, it will present the results from testing the NACA 4412. This data is then presented through tables and graphs using Microsoft Excel.

II. Aim Of Experiment

The present research describes the application of different turbulence models for flow around NACA 4412 aerofoil at angle of attack 15 degree, 20 degree, 22.5 degree. It is designed to investigate the change in the structure of the flow as a function of using different turbulence models, to investigate the performance of these turbulence models and to compare them with the available accurate experimental data. An improved understanding of the physical characteristics of separation on the aerofoil sections and in the region of the trailing edge is of direct value for the improvement of high life wings for aircraft. The configuration were planned with the knowledge that a small intermittent separated region will be formed at angle of attack □a = 15º, that corresponds to the position of maximum lift of a NACA 4412 aerofoil section

III. Wind Tunnel Testing Of The Airfoil

Wind tunnel testing is a crucial step in the design of an aircraft. It can give quite accurate information on the performance of an aircraft or a section of an aircraft by taking data on a scale model. This can save enormous amounts of money by testing models instead of prototypes. It is also much safer to test in a wind tunnel than out in the open. The following section covers the theory of the wind tunnels and procedures for testing the NACA 4412 airfoil.

IV. Theory Of Wind Tunnels

All wind tunnels can be divided into one of two types: open circuit (also called "straight through") or closed circuit (also called "return flow") 6. Open circuit wind tunnels pull the air from the environment into the tunnel and release the air back into the environment, whereas the closed circuit continually circulates the same air throughout the tunnel. The wind tunnel we used is a single return flow wind tunnel, shown in Figure.

Figure: The wind tunnel we used to test our airfoil.

Closed circuit wind tunnels are advantageous over open circuit wind tunnels for the following reasons: the quality of the flow can be easily controlled with screens and corner turning vanes; less energy is required to create an airflow of a given size and velocity; the wind tunnel runs more quietly. The disadvantages are the initial expense of building and need to change the air if it is significantly heated or polluted with smoke from smoke testing or engines7. Fortunately, neither of the disadvantages affected us.

V. TURBULENCE MODELS

The inlet boundary velocity U□was set to 18.4 m/sec for all turbulence models for direct comparison with the flying hot-wires measurements. The corresponding Reynolds number is 0.36 x 106 based on the chord *c* of the airfoil (250 mm). A computational grid of 150 ×150 was fixed for all models. Three different turbulence models were used, two equation models such as Realizable and RNG k-Reynolds and Reynolds Stress Model (RSM). These models selected because they are most widely used in aerodynamic industry, and they have well documented strength. Also these models proved to have a superior performance for flows involving strong streamline curvature. All computations have been performed on the same grid to ensure that the presented solution for each model will be compared with each other. Flow conditions around the airfoil were built up by finite element analysis using FLUENT 5 software by Fluent Inc.

VI. FIGURES AND TABLES

Figure 1 Pressure coefficient (for angle of attack 15)

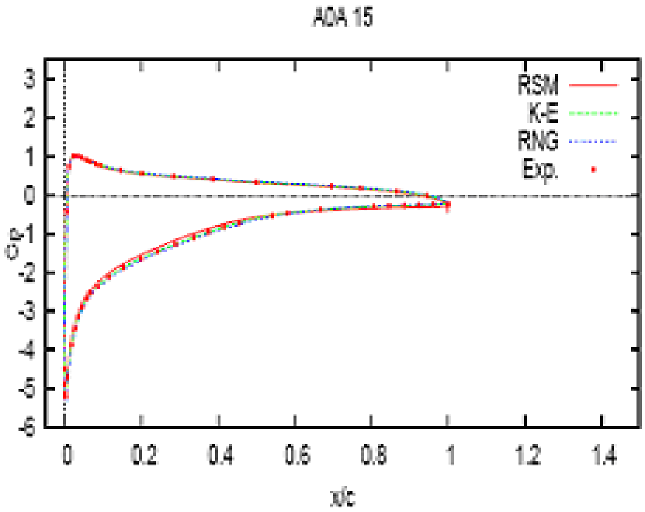
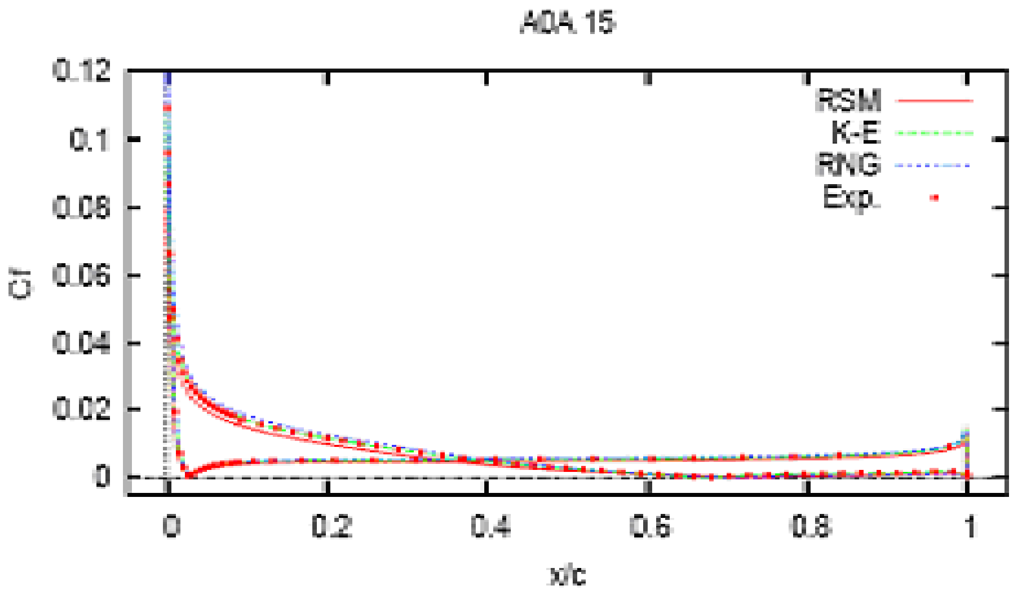


Figure 2 Friction coefficient (for angle of attack 15)



VII. Conclusion

One of the most important aspects of a turbulence model for aerodynamic applications is its ability to accurately predict adverse pressure gradient boundary-layer flows. It is especially important that a model be able to predict the location of flow separation and the wake behavior associated with it.

This study found that the turbulence models had captured the physics of unsteady separated flow. The resulting surface pressure coefficients, skin friction, velocity vectors, and Reynolds stresses are compared with flying hot wire experimental data, and the models produce very similar results. Also excellent agreements between computational and experimental surface pressures and skin friction were observed.

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