SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2021 **Issue:** 10 **Volume:** 102

Published: 17.10.2021 **http://T-Science.org**

QR – Issue QR – Article

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STRESSED STATE OF SURFACES OF THE NACA 0012 AIRFOIL AT HIGH ANGLES OF ATTACK

***Abstract**: The analysis of distribution and magnitude of viscous and total stresses arising on the surfaces of the NACA 0012 airfoil when changing the angle of attack from 15 to 40 degrees was performed in the article. It is determined that with an increase in the angle of attack, total stress acts from the peak magnitude near the leading edge to the uniform distribution of the stress magnitude over the entire upper surface of the airfoil. A gradual increase in the magnitude of total stress near the leading edge occurs on the lower surface. The maximum magnitude of viscous stress was determined at the leading and trailing edges of the airfoil at the high angles of attack.*

***Key words**: the airfoil, the angle of attack, stress, the surface.*

***Language**: English*

***Citation**: Chemezov, D., et al. (2021). Stressed state of surfaces of the NACA 0012 airfoil at high angles of attack. *ISJ Theoretical & Applied Science, 10 (102),* 601-604.

***Soi**: http://s-o-i.org/1.1/TAS-10-102-62 ***Doi**: crossref https://dx.doi.org/10.15863/TAS.2021.10.102.62

***Scopus ASCC**: 1507.*

Introduction

The elements of the aircraft are exposed to dynamic pressure drops when moving [1]. The streamlined shape of the wing in cross section allows the aircraft to perform maneuvers [2]. The choice of the type of the wing airfoil depends on the different flight speeds of the aircraft: subsonic, transonic, supersonic and hypersonic. The modern biconvex symmetrical airfoils (for example, the NACA 0012 airfoil) are characterized by the formation of negative and positive pressure fronts on the upper and lower surfaces, resistances on the leading and trailing edges, the mirror magnitudes of the air flow velocity on the surfaces at the positive and negative angles of attack [3-10].

Stresses arise on the surfaces when air flows around the aircraft wing at the high speed. The following types of stresses are defined for aerodynamic studies: *total stress* is a combination of all stresses arising from the action of tensile, compression, bending, etc.; *viscous stress* occurs as a result of friction between liquid or gas and the body surface. Let us consider the change in these stresses on the surfaces of the aircraft wing in cross section under the unfavorable flight conditions (the high angle of attack of the airfoil).

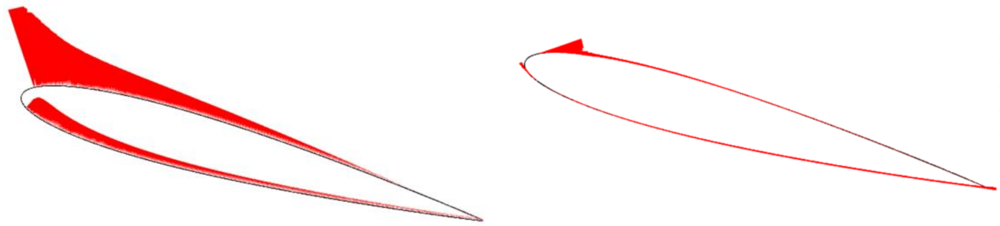
Materials and methods

The two-dimensional model of the NACA 0012 airfoil was built for the study. The computer calculation was carried out in the "*Turbulent Flow*" module of the "*Comsol Multiphysics*" program. The angle of attack of the airfoil of the aircraft wing varied in the range from 15 to 40 degrees. The step of changing the angle of attack was adopted by 5 degrees. The results of the computer calculation were obtained under the conditions of the aircraft movement in the atmosphere at a speed of 250 m/s. The weather conditions during the simulation were set to be normal.

Results and discussion

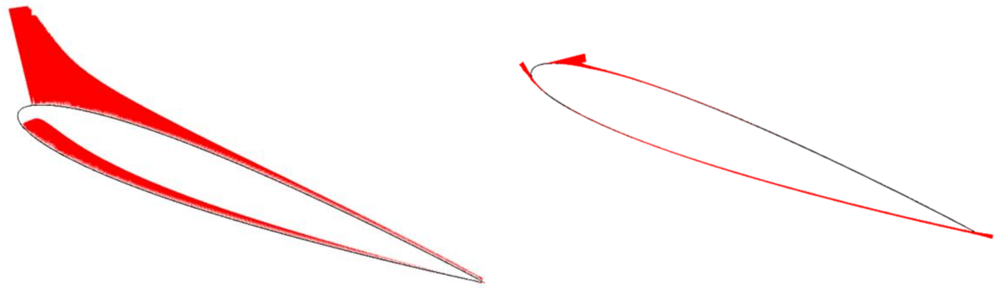
The vectors of viscous and total stresses were built on the leading and trailing edges and the upper and lower surfaces of the NACA 0012 airfoil after the calculation. The size of the vector corresponded to the magnitude of stress. Vector plots of the action of total and viscous stresses on the surfaces of the NACA 0012 airfoil at the different angles of attack are presented in the Figs. 1-6.

The peak magnitude of total stress was determined on the upper surface of the airfoil near the leading edge at the angle of attack of 20 degrees. A subsequent increase in the angle of attack leads to a decrease in drag on the leading edge of the airfoil and uniform distribution of stress over the entire upper surface. On the lower surface of the airfoil, there is a gradual increase in the magnitude of total stress from the side of the leading edge. A decrease in the magnitude of total stress was determined in the direction from the leading edge to the trailing edge on the lower surface of the airfoil. A slight increase in stress near the trailing edge of the airfoil at the angle of attack of 25 degrees or more is an exception.



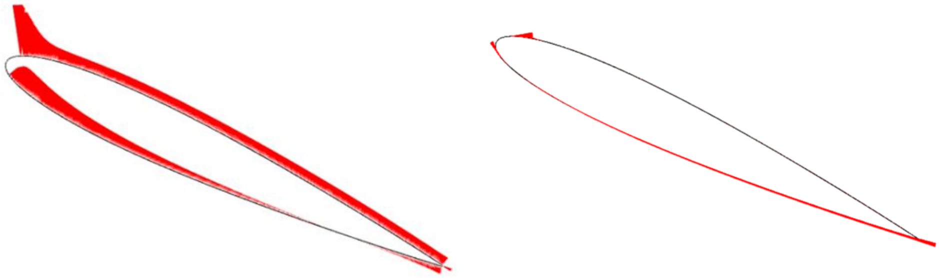
A *B*

Figure 1 – Vector plots of the action of total stress (*A*) and viscous stress (*B*) on the surfaces of the NACA 0012 airfoil at the angle of attack of 15 degrees.



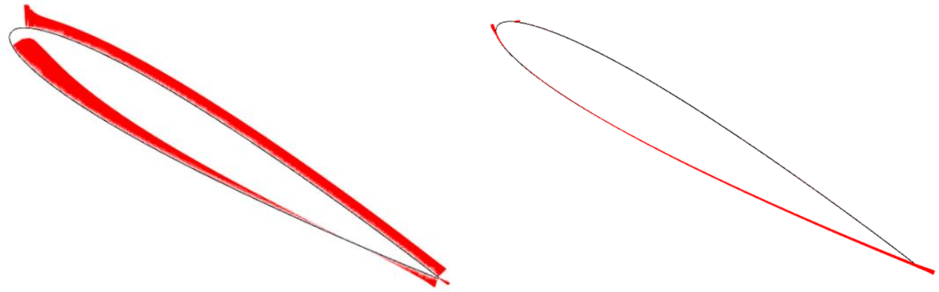
A *B*

Figure 2 – Vector plots of the action of total stress (*A*) and viscous stress (*B*) on the surfaces of the NACA 0012 airfoil at the angle of attack of 20 degrees.



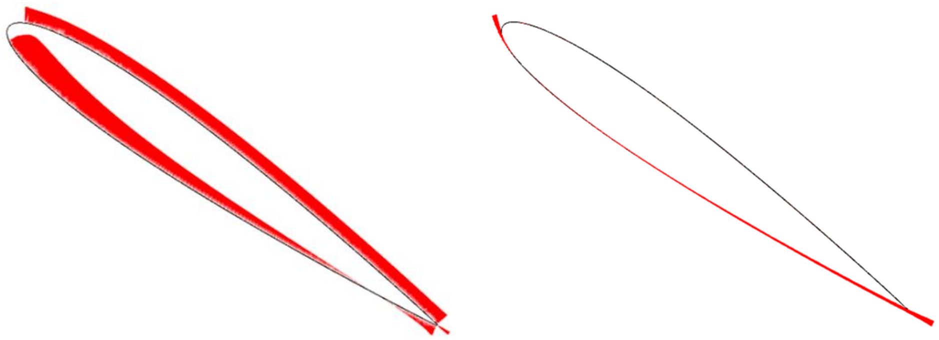
A ***B***

Figure 3 – Vector plots of the action of total stress (*A*) and viscous stress (*B*) on the surfaces of the NACA 0012 airfoil at the angle of attack of 25 degrees.



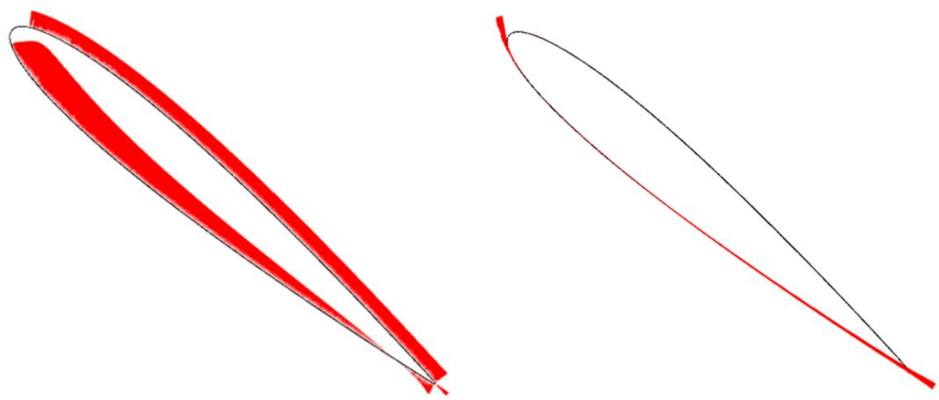
A ***B***

Figure 4 – Vector plots of the action of total stress (*A*) and viscous stress (*B*) on the surfaces of the NACA 0012 airfoil at the angle of attack of 30 degrees.



A ***B***

Figure 5 – Vector plots of the action of total stress (*A*) and viscous stress (*B*) on the surfaces of the NACA 0012 airfoil at the angle of attack of 35 degrees.



A ***B***

Figure 6 – Vector plots of the action of total stress (*A*) and viscous stress (*B*) on the surfaces of the NACA 0012 airfoil at the angle of attack of 40 degrees.

The maximum magnitude of total stress on the lower surface of the airfoil is less than the maximum magnitude of stress on the upper surface over the entire considered range of changing the angle of attack.

The calculated peak magnitude of viscous stress is concentrated on the upper surface of the airfoil near the leading edge at the angle of attack of 15 degrees. Changing the angle of attack by 35 degrees or more hides the upper surface of the airfoil of the aircraft wing from the direct action of air flows. Thus, there is no viscous stress at the high angles of attack on the given surface. It can also be noted that at the angle of attack of 20, 35 and 40 degrees, there is an increase in the magnitude of viscous stress on the leading edge of the airfoil from the side of the lower surface. A decrease in the magnitude of viscous stress is observed at the angle of attack of 15, 25 and 30 degrees. Viscous stress increases with an increase in the angle of attack near the trailing edge from the side of the lower surface of the airfoil.

Conclusion

The high angles of attack lead to the uniform distribution of total stress on the upper surface of the airfoil of the aircraft wing. The airfoil is subjected to the minimum drag force at the angle of attack of 30 degrees. Changing the angle of attack by 30 degrees or more leads to an increase in the drag force on the leading and trailing edges of the airfoil. Thus, the most optimal angle of attack of the wing airfoil to perform the maneuver of the aircraft is 30 degrees.

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