AERODYNAMIC ANALYSIS OF A RC AIRPLANE

İbrahim GÖV
Gaziantep University
igov@gantep.edu.tr

Abstract: In this study, lift force and drag force of a RC airplane was calculated using computational fluid dynamic (CFD) analysis. NACA 2412 airfoil was used for wing design. When the aircraft is moving into the air, it subjects to aerodynamic forces. These aerodynamic forces are the drag, lift, and thrust forces. Drag force produces a resistant to relative motion. Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. Thrust is generated by the engines of the aircraft through some kind of propulsion system. Drag and lift forces were investigated at maximum speed to represent the aerodynamic performance of a RC airplane.

Key words: RC airplane, Aerodynamic analysis, Drag force, Lift force.

INTRODUCTION

In the design stage of airplanes, aerodynamic analysis is very important step of the design. After performing the aerodynamic analysis, lift force and drag force values are determined. Lift force must be maximized and drag force must be minimized to increase fuel efficiency. In the literature, many different studies are existing due to the aircrafts. Some of them are related to structural parts, hydraulic systems and brake systems analysis. Some of them are associated with fatigue, aerodynamic and dynamic behavior.

Hedges et. al. (2002) studied on the flow around a generic airliner landing gear truck using the methods of Detached-Eddy Simulation, and of Unsteady Reynolds-Averaged Navier-Stokes Equations, with the Spalart-Allmaras one-equation model. Comparison of experimental and calculated results is performed. It is seen that simulation can give the pressure of wheels correctly.

A general aviation airplane was designed and analyzed. A three-dimensional layout of the airplane was created using RDS software based on conic lofting. Static stress analysis was performed for wing design purposes. Using the finite element software package COMSOL, the calculated aerodynamic loads were applied to the wing to check the wing reliability (Atmeh et al., 2010).

A wing is a surface used to produce an aerodynamic force normal to the direction of motion by traveling in air or another gaseous medium. A wing is an extremely efficient device for generating lift. Its aerodynamic quality, expressed as a Lift-to-drag ratio, can be up to 60 on some gliders and even more. This means that a significantly smaller thrust force can be applied to propel the wing through the air in order to obtain a specified lift (Chitte et al., 2013). So, in the literature many different study is exist about the aerodynamic force analysis.

Doğru and Güzelbey (2014) studied on static thrust calculation of ducted fan in various speeds. They used two experimental method to obtain static thrust. In the first method, the duct fan was placed in the pipe regarding to drill some static tapping holes on the pipe. Static pressure was measured and the thrust of the duct fan has been obtained from this measurement. In the second method, a spring system was established for getting duct fan thrust force.

A landing gear is designed by using CAD software and structural safety for static and spectrum loads is analyzed using ANSYS by Imrana et. al. (2015). The maximum possible loads applied through RBE3 connection at the axle end spreading to wheel base. The composite material is used to check the strength of the landing gear for self-weight, static loads, modal conditions and shock spectrum loads as per mil standards. The results show lesser stresses and deflections with composite material.

Doğru et. al. (2016) investigated the static thrust analysis by experimentally. The static thrust value was obtained experimentally under the effect of the ducted fan, which is located inside the ground effect region. The thrust of the ducted fan was measured using two different experimental methods. In the first method, the static pressure measurement system was used to calculate the thrust. The spring method was used in the second method to calculate the thrust. They obtained that the lift force decreased, as expected.

Velocity distribution and turbulence energy were investigated for the projectiles on different tip shapes by using SolidWorks Flow Simulation CFD analysis. Three different projectile nose shapes were examined in the study. Initial velocity was accepted to be 500 m/s for all situations. At the end of the study, velocity and pressure distribution on the penetrators in different tip geometries were obtained. The maximum velocity decrease at the tip of penetrator was found to be as 57.5% for the rounded type projectile (Doğru, 2017).

At the end of the literature survey, it is seen that many studies exist related with airplanes. Such as analysis of the hydraulic systems, brake systems and structural parts were performed. Lift force and drag force values are very critic specification for fuel efficiency of an airplane. So, this study concentrated on aerodynamic analysis of a RC airplane to calculate lift force and drag force.

ANALYSES

All analyses are performed using SolidWorks Flow Simulation program. Drag force and lift force on a RC airplane (in figure 1) are obtained by using aerodynamic analyses. NACA 2412 airfoil (in figure 2) is used for wing design. Cruse speed is taken as 30 m/s and angle of attack is taken as 0^0, 5^0, 10^0, 15^0, and 20^0.

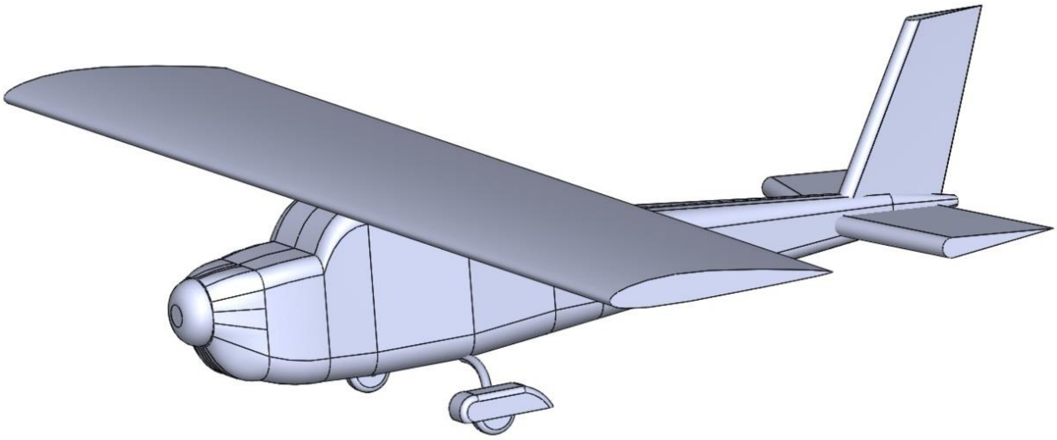

Figure 1. Solid Model of Airplane (Adiwibowo B., 2013)

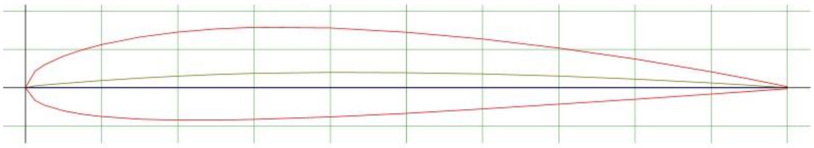

Figure 2. NACA 2412 Airfoil (AirfoilTools, 2017)

RESULTS

Flow trajectories of velocity and pressure at 0^0 AoA on airplane are given in figure 3 and figure 4 respectively.

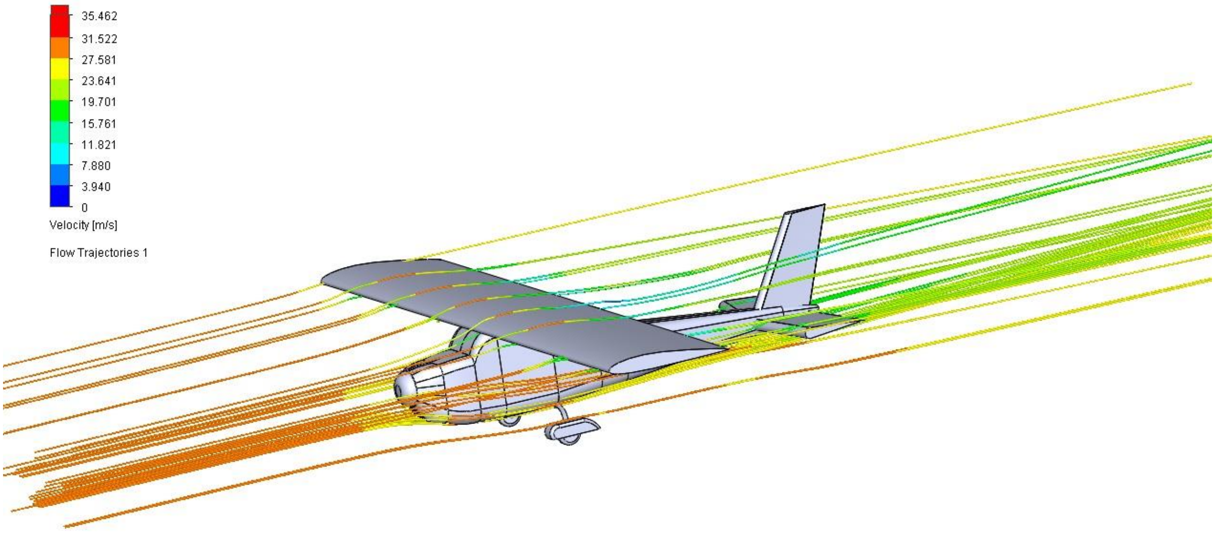

Figure 3. Flow Trajectories of Velocity on Airplane at 0^0 AoA

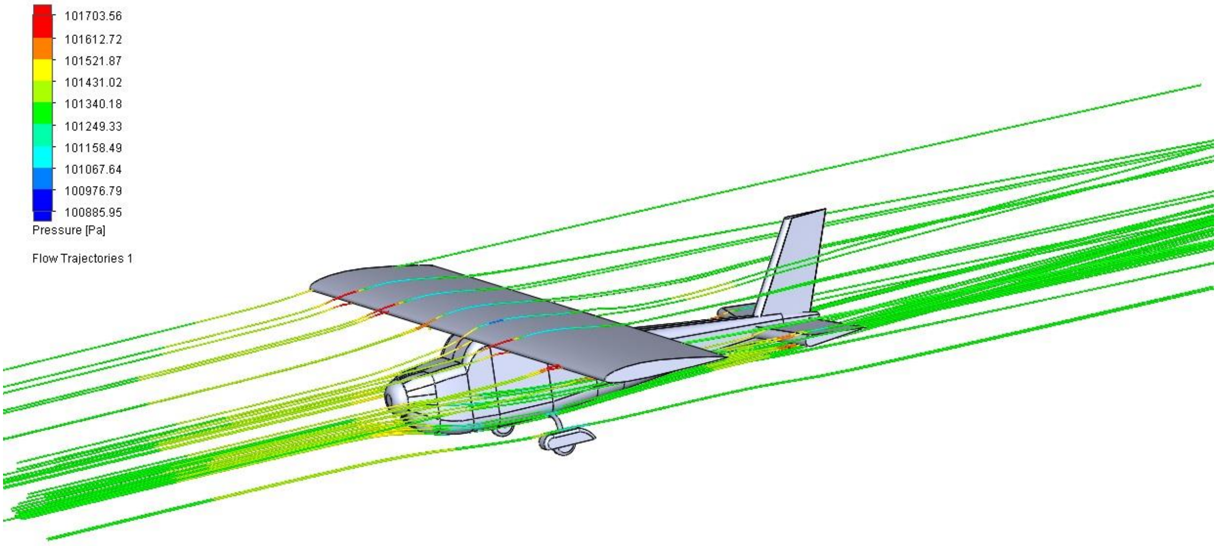

Figure 4. Flow Trajectories of Pressure on Airplane at 0^0 AoA

Flow trajectories of velocity and pressure at 5^0 AoA on airplane are given in figure 5 and figure 6 respectively.

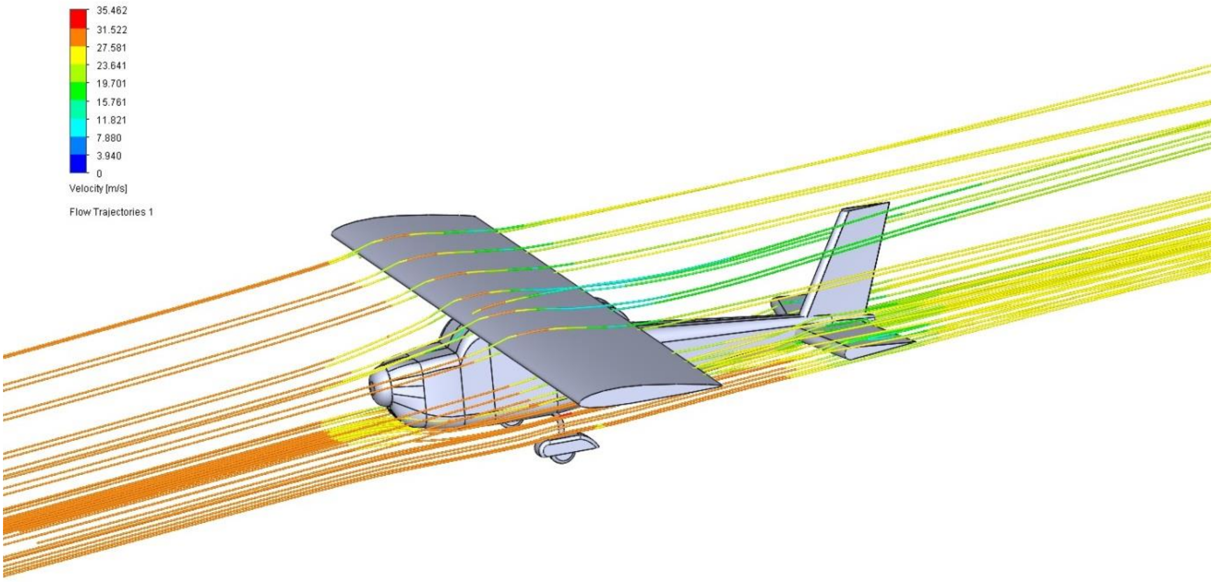

Figure 5. Flow Trajectories of Velocity on Airplane at 5^0 AoA

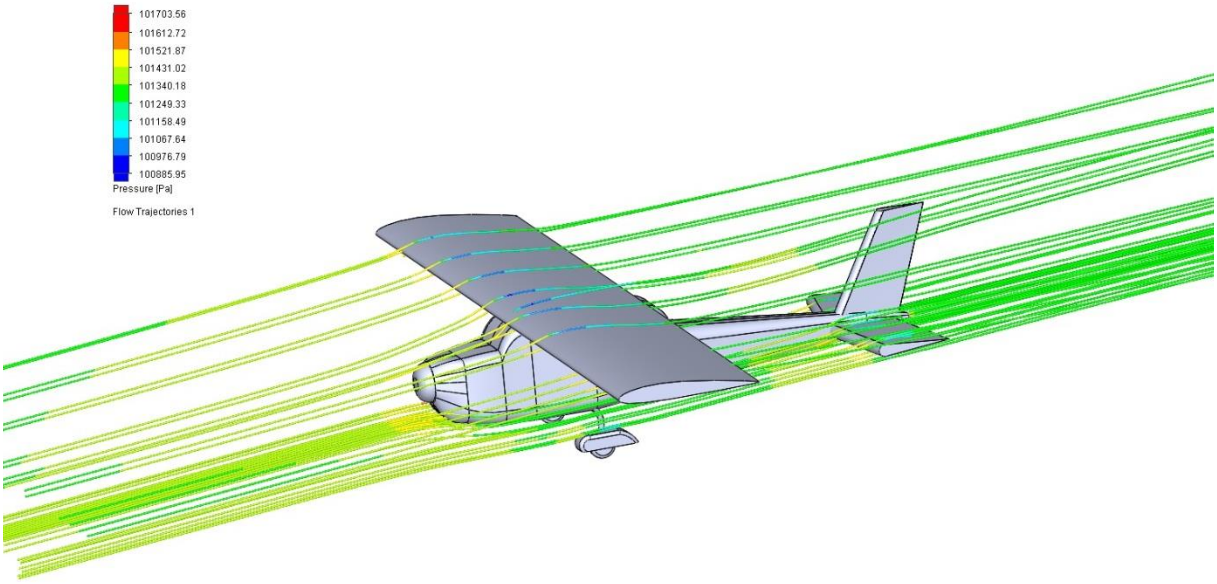

Figure 6. Flow Trajectories of Pressure on Airplane at 5^0 AoA

Flow trajectories of velocity and pressure at 10^0 AoA on airplane are given in figure 7 and figure 8 respectively.

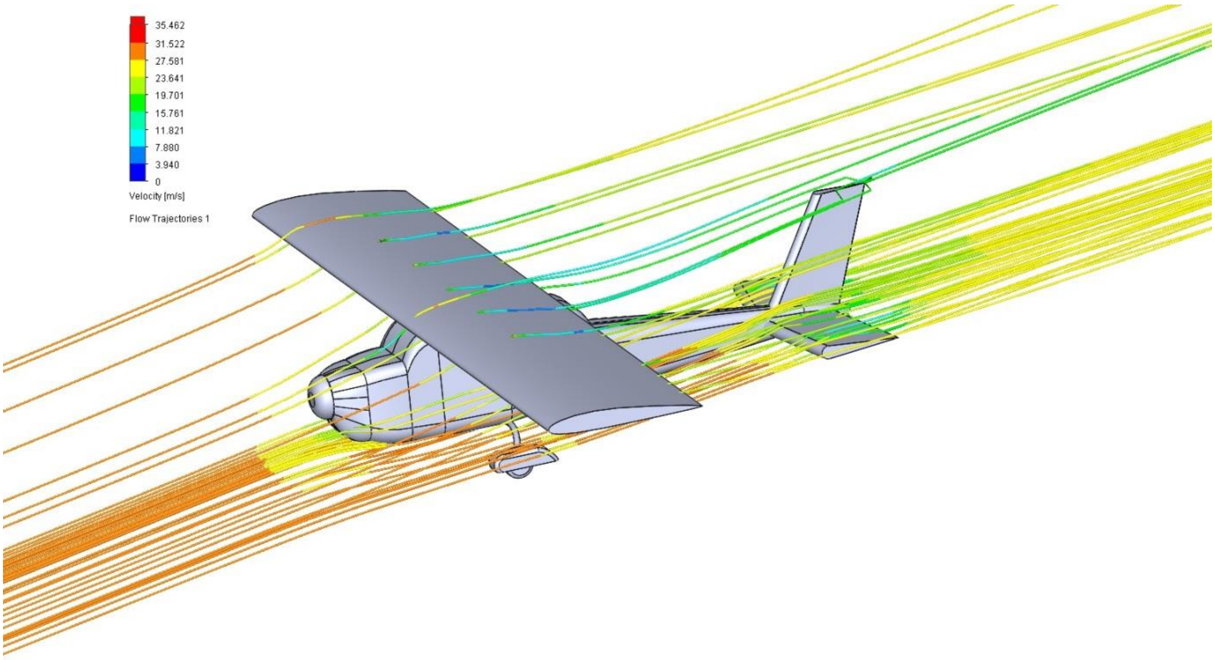

Figure 7. Flow Trajectories of Velocity on Airplane at 10^0 AoA

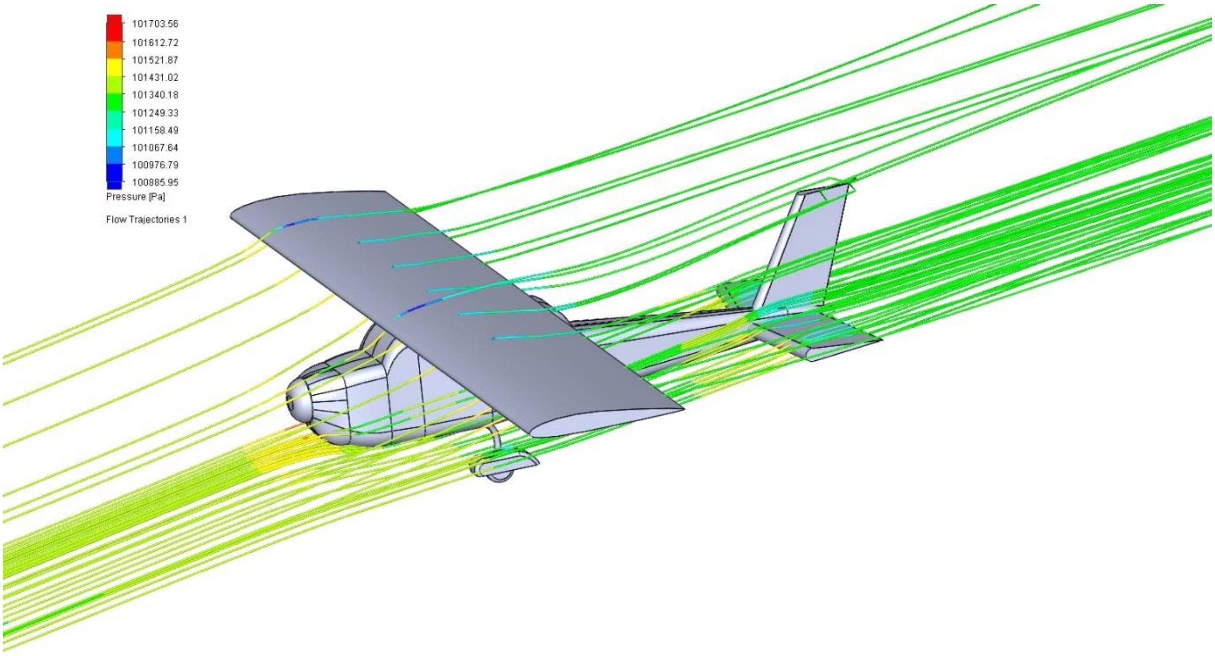

Figure 8. Flow Trajectories of Pressure on Airplane at 10^0 AoA

Flow trajectories of velocity and pressure at 15^0 AoA on airplane are given in figure 9 and figure 10 respectively.

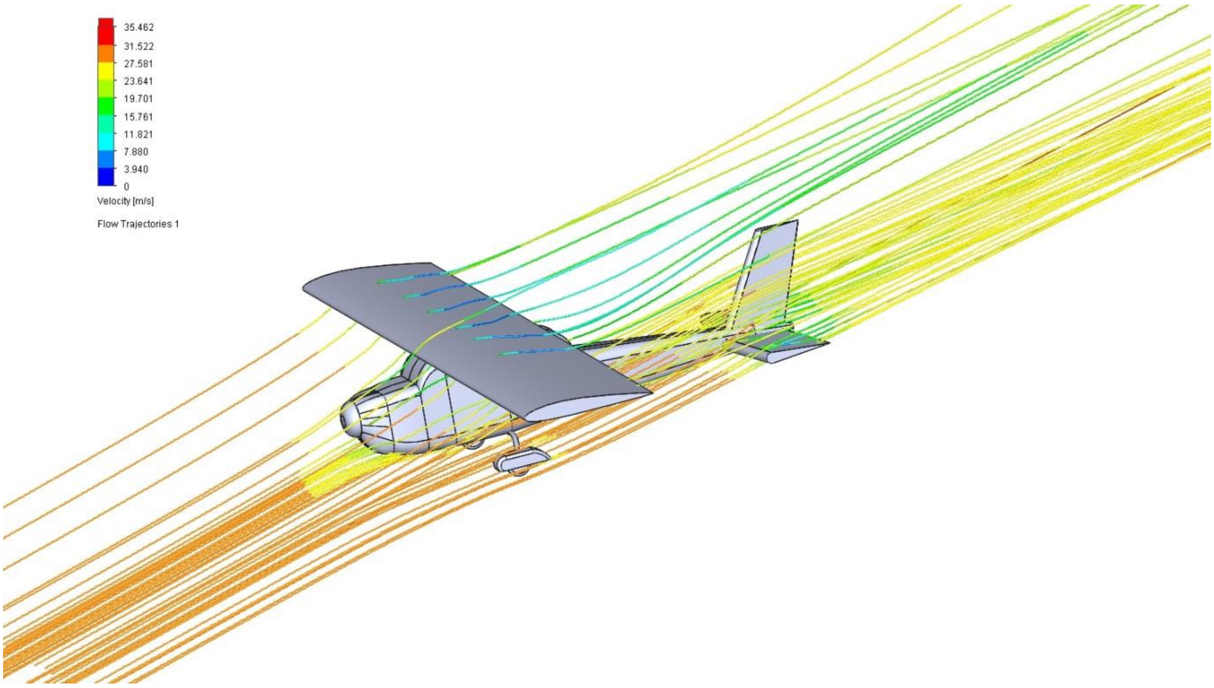

Figure 9. Flow Trajectories of Velocity on Airplane at 15^0 AoA

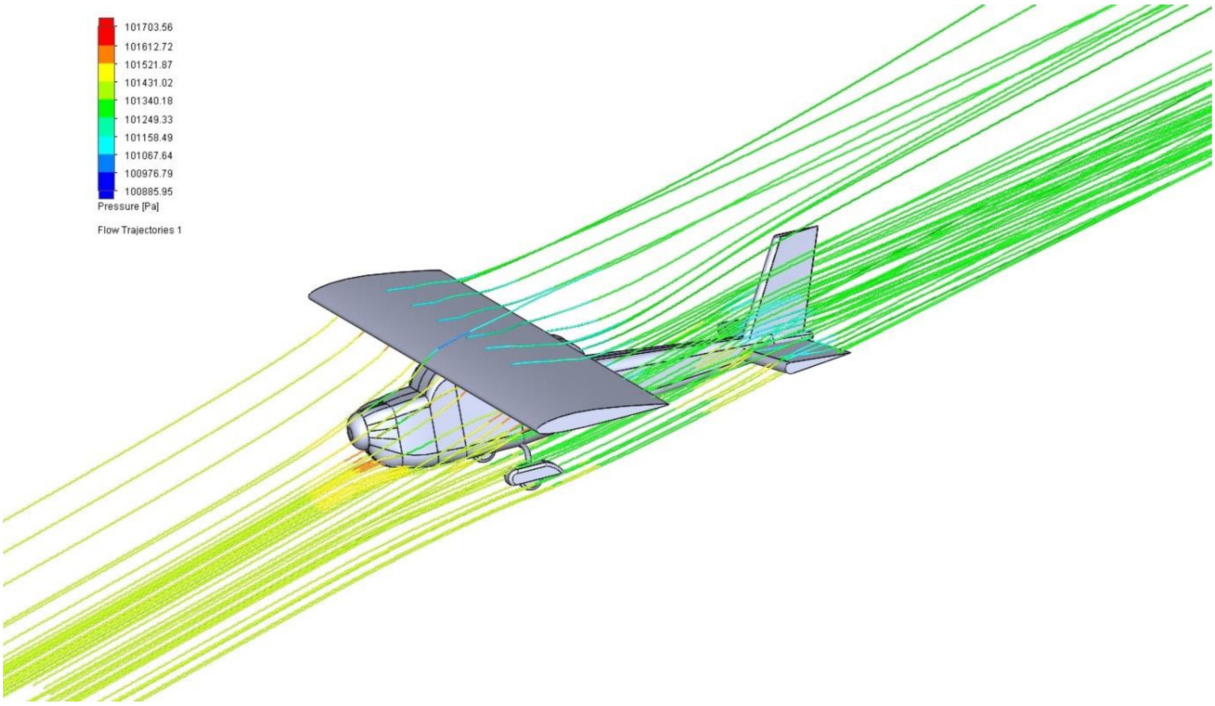

Figure 10. Flow Trajectories of Pressure on Airplane at 15^0 AoA

Flow trajectories of velocity and pressure at 20^0 AoA on airplane are given in figure 11 and figure 12 respectively.

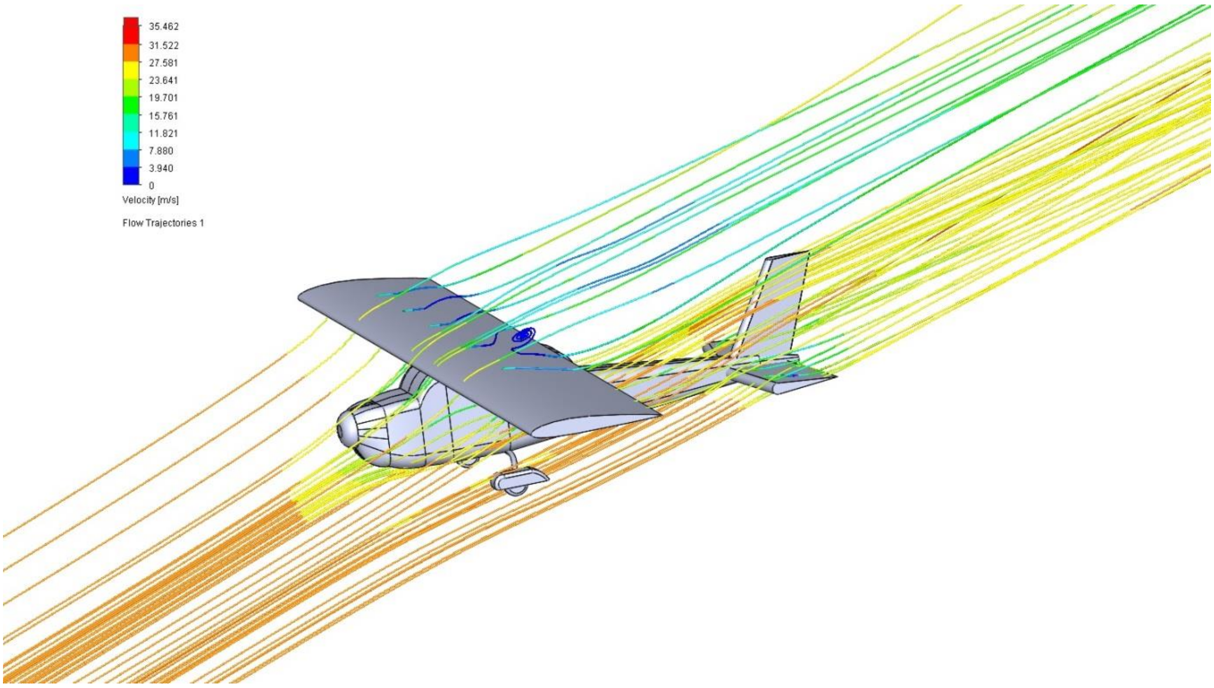

Figure 11. Flow Trajectories of Velocity on Airplane at 20^0 AoA

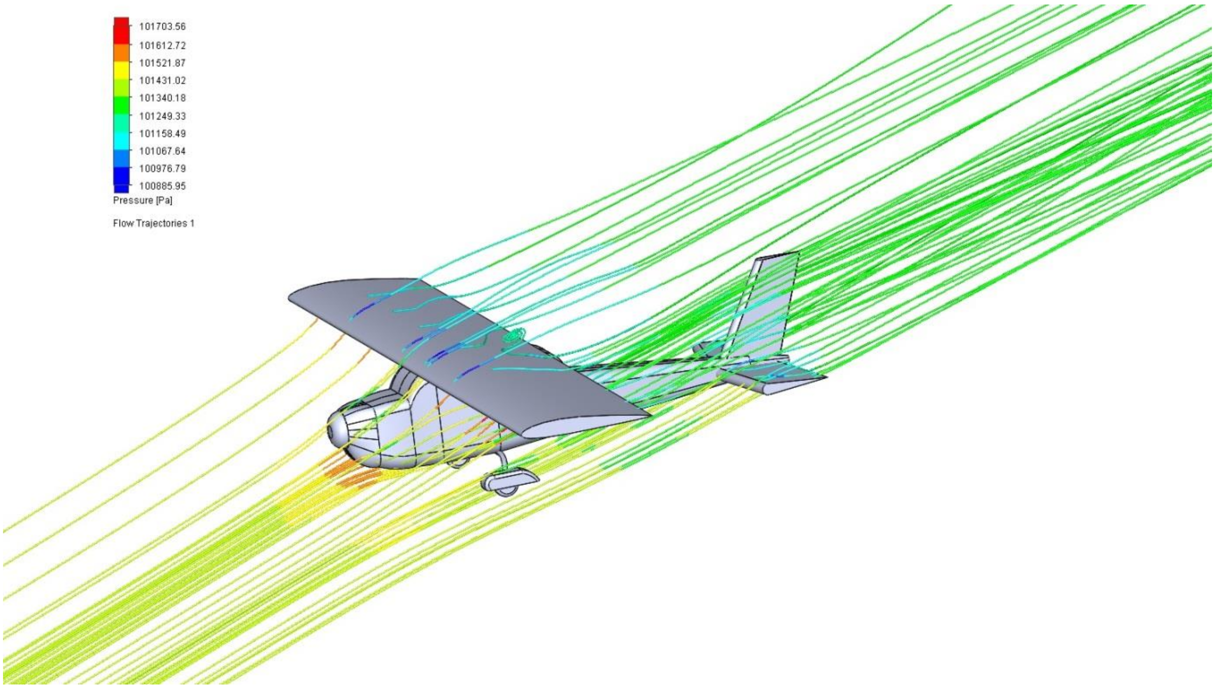

Figure 12. Flow Trajectories of Pressure on Airplane at 20^0 AoA

Lift force and drag force results at different angle of attack values are listed in table 1.

Table 1 Lift and Drag Force Results

	Lift Force (N)	**Drag Force (N)**
0^0 AoA	20	11,8
5^0 AoA	47,7	12,7
10^0 AoA	76,6	13,2
15^0 AoA	97,4	13,8
20^0 AoA	114,8	13,9

When the result which are given in table 1 are compared, drag force and lift force values are increased due to AoA increment.

CONCLUSION

Lift force and drag force of a RC airplane is calculated using computational fluid dynamic (CFD) analysis. NACA 2412 airfoil is used for wing design. Flow trajectories of velocity and pressure on airplane are given at different AoA values (0^0, 5^0, 10^0, 15^0, and 20^0). After this study, it is shown that both drag force and lift force values are increased due to AoA increment.

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