ANALYSIS PERFOMANCE ADDING V-GROOVE RIBLETS ON FLAP WITH NACA 43018 AIRFOIL

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ABSTRACT
Research on airfoils is a technological development in the world of aerodynamics. In this study, the analysis of aerodynamic characteristics of airfoils was carried out by simulating air on a test object in the form of NACA 43018 airfoil geometry which was given an extension in the form of riblets with variations in the shape of v-groove and plain wing. The existence of v-groove riblets, can delay the occurrence of separation. In this study, the analysis of aerodynamic characteristics of airfoils was carried out by simulating the air on the test object in the form of NACA 43018 airfoil geometry which was given an extension in the form of riblets with variations in the shape of v-groove and plain wing. The software used is ANSYS R22. Data processing using the Computational Fluid Dynamic (CFD) method. The simulation shows that the highest lift coefficient increase occurs at $\alpha = 12^\circ$ with an increase of 2.9% lift coefficient and can reduce drag by 2.4% at $\alpha = 10^\circ$ so it can be concluded by adding riblets to the airfoil can improve the performance of the Airfoil.

Keywords: *Airfoil, Riblets, Aerodynamics*

1. INTRODUCTION

Airplanes are one of the most amazing technological achievements in human history and have had a significant impact on global connectivity, transportation and the economy. Advances in aviation and aircraft design do not just happen, but through continuous research, development and innovation by scientists, engineers and the aviation industry. The study of wings involves in-depth aerodynamic analysis, where mathematical calculations and computer simulations are used to understand how airflow interacts with the wing shape. This allows engineers to design wings that produce the desired lift while reducing drag, which can reduce aircraft efficiency and performance. In this research, a study of the airflow on the aircraft wing after the addition of v-groove riblets on the flap with NACA 43018 airfoil was conducted using ANSYS software. Riblets are roughness contours on the surface of the flow path, namely the wing. Riblets are regular grooves that have thickness and width. The use of riblets can increase and decrease the drag force, it depends on the configuration of the thickness and width of a riblets. So the use of riblets is still rarely used. The NACA 43018 airfoil is used on the ATR 72 wing both in the 500 and 600 series. This type of aircraft in Indonesia is operated by Garuda Indonesia and Lion Air for short routes such as Surabaya-Jogjakarta and Surabaya-Banyuwangi. The ATR 72 is part of the ATR family which uses twin turboprop engines with high winged wings and is equipped with 2 Pratt & Whitney 127F engines made by the French-Italian aircraft company, ATR. In this research, a solution was chosen, studying the problem of aerodynamic characteristics around the airfoil using ANSYS software with NACA 43018 airfoil test objects by adding V-groove riblets with a chord line of 200 mm and a wing span of 600 mm. NACA 43018 airfoil is used on the wing of ATR 72 aircraft both 500 and 600 series. The performance of a riblets will produce bound vortex or also called lifting vortex. Bound vortex occurs due to changes in velocity that are sudden on the airfoil and due to the pressure difference. As a result of this bound vortex, the flow above the surface will get additional velocity, and the flow below the surface will get a reduction in velocity. Because of the difference in velocity, in accordance with Bernoulli's law, a force is generated in the upward direction and is called lift.

2. METHODS

Data collection in this final project research is computationally using CFD (Computational Fluid Dynamics) method, in the form of airflow simulation on the test object in the form of airfoil. The data taken are the value of the lift force, the value of the drag force, and the contour of the velocity distribution on the test object after the simulation running process. After the data analysis process and discussion based on the simulation data, the simulation data obtained will be in the form of velocity contours, lift values and drag values. From this data, it is processed to see how the effect of adding riblets extensions and variations in the shape applied to the pressure and velocity distribution that can be seen from the contours. And for more advanced how the overall effect on the effectiveness of airfoil work in the form of a comparison table of 2 variations of test objects applied in research simulations. Every data that has been obtained from the results of numerical simulations using the CFD program must be validated. There are three main parameters in the data validation stage, namely:

1. Convergence, defined as the determination of the number of iterations before CFD calculation is performed. This step is carried out at the flow solver stage, which is the stage of determining the various boundary conditions that must be applied before the simulation process is carried out. The number of iterations used affects the amount of time required for the simulation process. The more number of iterations applied, the more time is needed for the simulation process. The number of iterations required is directly proportional to the total number of elements used in the modeling process. The more the total number of elements/grids used, the more iterations are needed.
2. Grid Independence, needed to determine the best and most efficient grid level and structure so that the modeling results are close to the truth. Grid independence is done to get the amount of meshing that tends to be constant so that it is obtained In this grid independence, the number of meshing is divided into several types, then from this type of meshing, the smallest difference in value will be sought. The smallest value difference of each meshing will be sought by comparing the numerical Cd graph.
3. Verification with experimental data. Results Experiments meet the elements if grid independence gets the best and most efficient structure so that the modeling results are close to the truth. In the process of working on this final project, the results obtained are not always good. Results that are far from the test results are still possible. So, what is done is to improve the meshing size and also re-correct the geometry shape. Common errors that occur in the process of this final project are in the meshing process, data input, and boundary conditions. These three determine the final result of the simulation process. The test objects used for simulation can be seen in Figure 2.1 and Figure 2.1 and Figure 2.2

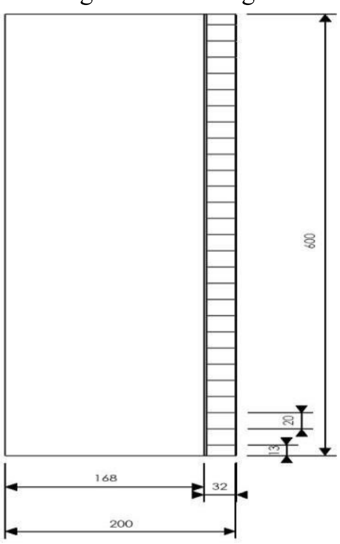

Fig 2.1 Flap with Riblets

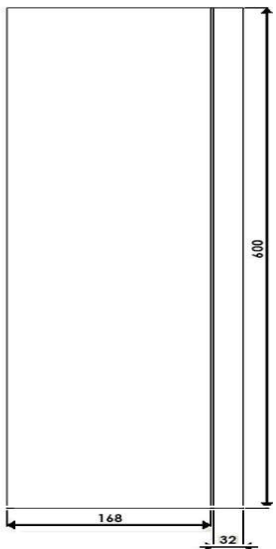

Fig 2.2 Plain Wing

3. RESULT AND DISCUSSION

The effect of adding v-groove riblets on the flap can produce greater lift than plain wing. The effect of adding v-groove riblets has drag which is lower than plain wing. Can seen in table 3.1 and table 3.2 shows the highest increase in lift coefficient occurs at $\alpha = 12^{\circ}$ with an increase of 2.9% coefficient of lift and can reduce drag by 2.4% at $\alpha = 10^{\circ}$. so it can be concluded by adding riblets on the airfoil can improve the performance of the NACA 43018 airfoil. Riblets help reduce turbulence of the airflow at the aerodynamic surface, which in turn reducing the drag generated by turbulence. This can improve the fuel efficiency and flight range of the aircraft. By reducing drag, riblets can improve the performance of the aircraft.

Table 4.1 Comparison of Lift Coefficient of Plain Wing and Riblets NACA 43018 Airfoil .

Angle Of Attack	CL		
	Plain	Riblets	Δ
0°	380.2439	382.8129	0.7%
2°	700.3968	712.3942	1.7%
4°	1025.18	1048.247	2.2%
6°	1319.562	1340.262	1.6%
8°	1617.437	1632.039	0.9%
10°	1997.183	2043.772	2.3%
12°	2254.51	2319.458	2.9%
15°	2673.422	2720.559	1.8%
16°	2100.254	2140.759	1.9%
17°	1760.808	1779.741	1.1%
19°	1690.53	1710.855	1.2%
20°	1400.419	1412.115	0.8%

Table 4.1 Comparison of Drag Coefficient of Plain Wing and Riblets NACA 43018 Airfoil .

Angle Of Attack	CD		
	Plain	Riblets	Δ
0°	32.0213	31.60439	-1.3%
2°	39.9534	39.70648	-0.6%
4°	53.0254	52.58778	-0.8%
6°	69.5376	68.27648	-1.8%
8°	90.8317	89.61076	-1.3%
10°	120.862	117.9951	-2.4%
12°	150.784	147.822	-2.0%
15°	207.277	202.7128	-2.2%
16°	225.784	223.1561	-1.2%
17°	247.077	242.03	-2.0%
19°	291.63	287.146	-1.5%
20°	314.079	309.2378	-1.5%

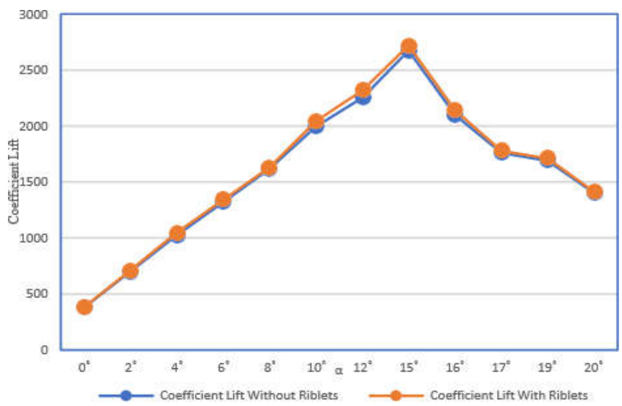

Fig. 3.1 Comparison of Lift Coefficient of Plain Wing and Riblets NACA 43018 Airfoil .

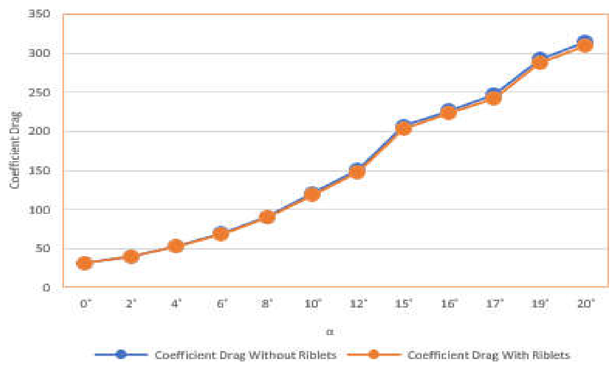

Fig. 3.2 Comparison of Lift Coefficient of Plain Wing and Riblets NACA 43018 Airfoil .

Figures 3 and 4 explain the visualization of velocity contour α = 12° there is a separation that can be seen between using riblets and the visible difference between using riblets and plain, velocity contour with riblets looks more laminar than plain wing. air flow is more laminar than plain wing. So that the use of riblets can delay the occurrence of separation.

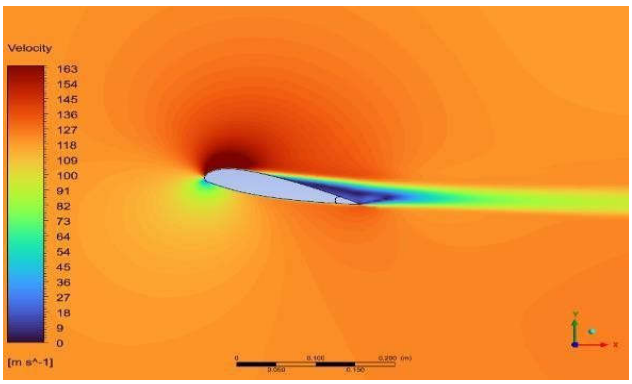

Fig 3.3 Visualization of Velocity Contour Plain Wing α = 12° on y-x axis

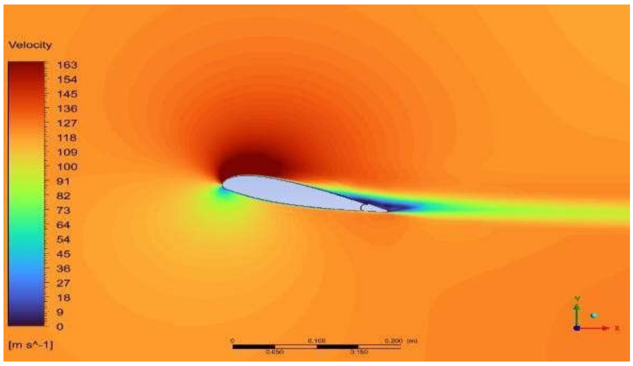

Fig 3.4 Visualization of Velocity Contour Riblets α = 12° on y-x axis

Figures 5 and 6 explain the visualization of velocity contour α = 15° there is a separation that can be seen between using riblets and the visible difference between using riblets and plain, Contour air flow that uses riblets better can be seen from the separation point, while on the plain wing the air flow is more irregular From this study, it can be seen that the the difference in contour velocity that occurs when using riblets or on plain wing.

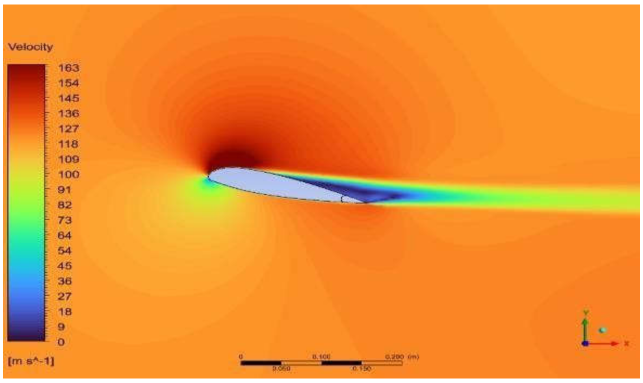

Fig 3.5 Visualization of Velocity Contour Plain Wing α = 15° on y-x axis

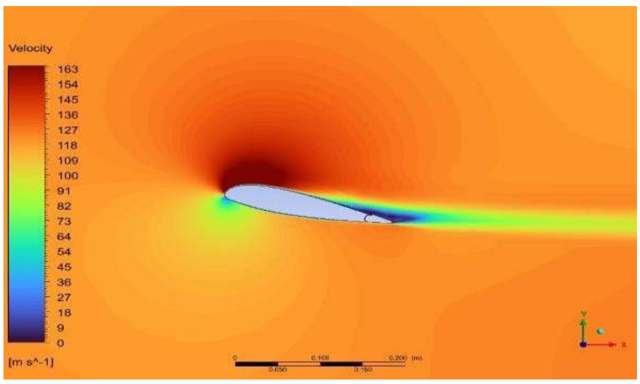

Fig 3.6 Visualization of Velocity Contour Riblets α = 15° on y-x axis

4. CONCLUSION

Here are some conclusions that can be drawn from research on each test object based on simulations that have been carried out:

1. From the simulation results, it can be seen that the coefficient of lift is highest at $\alpha = 12^\circ$ with an increase of 2.9%. Coefficient of lift and can reduce drag by 2.4% at $\alpha = 10^\circ$. So it can be concluded by adding riblets on the airfoil can improve the performance of the NACA 43018 airfoil.

2. From the simulation results that have been tested, it can be seen that the use of v-groove riblets on the flap can increase the lift coefficient and can reduce the coefficient drag produced by the airfoil test specimen NACA 43018.

3. From the simulations performed, the lift value reaches the highest value on the NACA 43018 airfoil type test specimen with v-groove riblets and the highest drag value on the plain wing specimen. Therefore, it can be concluded that the use of v-groove riblets can increase the performance of the NACA 43018 airfoil to increase coefficient.NACA 43018 airfoil to increase the coefficient of lift and able to reduce drag on the NACA 43018 airfoil.

5. SUGGESTION

1. Simulation of airfoil test specimens using software to be developed because this is an interesting topic and can still be developed so that the results become perfect.

2. It is hoped that people who are involved in the world of aeromodeling to pay more attention to studies like this research, so that in the future in terms of making model aircraft can be more efficient and economical.

3. It is hoped that further research can be more extensive in the test object and look for references that are references in the world of aerodynamics.

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