Effect_of_Angle_of_Attack_on_Airfoil_NACA_0012_Performance.pdf

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Effect of Angle of Attack on Airfoil NACA 0012 Performance

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Abstract. *Airfoil is an aerodynamic form intended to produce a lift force with the smallest drag force. When an airfoil is passed through a fluid flow that causes interaction between the air flow and the surface, variations in velocity and pressure will occur along the top and bottom surfaces of the airfoil, as well as the front and back of the airfoil. The difference in pressure between the upper and lower surface of the airfoil is what causes the resultant force in the direction perpendicular to the direction of fluid flow, this force is called the lift force (lift). In this experiment NACA 0012 airfoil experiments have been carried out using simple wind tunnel. Experiments were conducted with the aim to determine the effect of the angle of attack on the performance of the NACA 0012 airfoil which then analyzed the lift force of the NACA 0012 airfoil. The variation of the angle of attack used was 0 °, 3 °, 6 °, 9 °, 12 °, and 15 ° and used wind speed of 21.5 m / s. The greatest lift force is obtained at an angle of attack of 9 ° with a value of 0.981 while the largest lifting coefficient with a value of 0.106. The greater the angle of attack the greater the airfoil lift force, but for symmetrical airfoil stall at an angle that is too large.*

Keywords- *Airfoil; Aerodinamic; Fluid Mechanics*

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INTRODUCTION

Airplanes are a type of transportation that can lift heavy loads in the air. This happens because of the lift that can be generated by the aircraft's wings [1, 2]. Efforts to research and develop airfoils or aircraft wings have been started since the 19th century. Although at that time it was known that a flat plate could generate lift at a certain angle of attack on the plate, it was thought that an airfoil shape that was curved and resembled a bird's wing could produce better lift [3, 4]. The patent shape of the airfoil itself was patented under the name Horatio F.Phillips in 1884 who was an Englishman who tested it in a wind tunnel. In addition, along with the idea of Otto Liliental who took a more accurate measurement of the shape of a bird's wing, he tested the airfoil shape with the curvature of a 7 meter diameter rotary engine. Because the key to successful flight is to use a chamber or curved airfoil [5, 6].

Lift occurs on the airfoil because the fluid flow pressure on the upper surface of the airfoil is lower than the fluid flow pressure on the lower surface [3, 7]. One of the geometric parameters that determines the result of airfoil lift is the location of its maximum thickness. The farther the location of the maximum thickness from the starting end, the later will result in an increase in the flow pressure passing through the airfoil surface, which will be one of the factors causing the average pressure along the surface to be lower. This is consistent with the occurrence of lift, where the upper surface pressure of the airfoil is lower than the bottom. But this is not only a factor of lift, there are other factors that influence lift, including the magnitude of the angle of attack and the size of the velocity of the air flow through the airfoil [8, 9].

In research conducted by H. Sogukpinar in 2017, entitled Numerical Simulation Of 4-Digit Inclined Naca 00xx Airfoils To Find Optimum Angle Of Attack For Airplane Wing, states that NACA 0012 has a greater lift coefficient than NACA 0008, 0009, 0010, 0015, 0018, 0021, 0024 with a lift coefficient value that is at α = 14 ° of 1.4 [10]. On the basis of previous research, the author's idea emerged to conduct further research on airfoil characteristics, this research was

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conducted on a symmetrical NACA 0012 airfoil with a variation of angle of attack (α) of 0°,3°,6°,9°,12° and 15° and aims to determine the effect of angle of attack on airfoil performance NACA 0012.

METODE

In this study, the method used is an experimental method where this method is used for the purpose of testing a new treatment or design of a process. In this study, changing a different treatment so that it becomes comparative data in order to obtain an interrelated event. With this method will be tested to the effect of angle of attack on lift.

Research Installation

The installation used in this study is described in a schematic as shown in Figure 1.

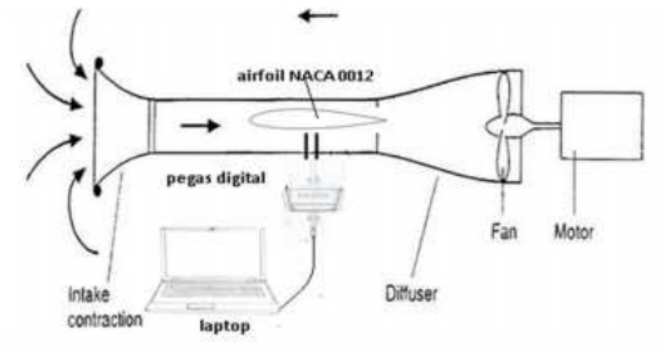

Figure 1. Research Installation

Airfoil used

The airfoil used in this study is the NACA 0012 model. The material used is a sterofoam and there is a shaft on the side of the airfoil which is the handle to adjust the angle of attack. The size used is a chord length of 20 cm and a span of 20 cm, and a maximum thickness of 2.4 cm is 12c (2.4 cm).

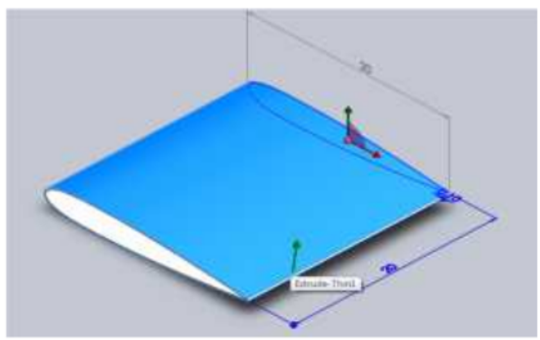

Figure 2. Airfoil NACA 0012

After the test object is finished and is given an angle of attack on the side of the arfoil, then the airfoil is weighed using digital scales and the result is that the weight of the airfoil to be tested is 0.140 kg.

The following is a table of specifications for the Airfoil NACA 0012 which will be tested.

Table 1. NACA 0012 airfoil specifications

Parameter	Length
Chord length	20 cm
Maximum airfoil thickness	2.4 cm
Airfoil span width	20 cm

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Testing Steps

In airfoil testing NACA 0012 uses a simple wind tunnel, which is used to determine the size of the airfoil lift with varying angles of attack. The test steps for obtaining airfoil lift data are as follows:

1. Record room temperature and pressure (before and after the experiment) because it uses a fan that does not vary in speed.
2. Install and place a digital sitting scale to measure lift on a stand for the scale.
3. Attaching the test object (airfoil) that has been given a seat for the shaft to the wind tunnel and wire it down to connect to the digital scale.
4. Set the airfoil seat to the Wind Tunnel, this is so that the airfoil does not move forward and backward.
5. Adjusting the angle of attack of the airfoil, starting from the angle of 0 °, 3 °, 6 °, 9 °, 12 ° and 15 °, shift the angle of attack by loosening the angle of fastening (adjust using a protractor).
6. Turn on the fan so that airfoil flows through the airfoil. With a flow rate of 21.5 m/s at 28.8 °C.
7. Observe the value of digital scales and record the results of the value of lift at each angle of attack. Each angle has a different lift.
8. Calculate and compare at the angle of attack how many degrees of optimal lift results occur and at the angle of attack what is the lowest degree of lift.

RESULT AND DISCUSSION

The research that has been carried out has resulted in changes in the extent of lift which are influenced by the size of the angle of attack that occurs on the NACA 0012 airfoil, where these results are presented in tabular form and will later be compared with previous studies that have been conducted.

From the results of experimental tests that have been carried out on airfoil NACA 0012. By conducting experiments 3 times and in different angles of attack, namely 0 °, 3 °, 6 °, 9 °, 12 °, and 15 °. The velocity of blowing flow v∞ = 21.5 m / s at 28.8 ° C, the results of the lift force value of the NACA 0012 airfoil (symmetrical airfoil) are as follows:

Table 2. The amount of lift against the angle of attack

Angle of attack	Experiment (kg)			Lift (N)			
	I	II	III	I	II	III	Average
0°	0.025	0.0035	0.035	0.245	0.034	0.343	0.208
3°	0.05	0.06	0.06	0.491	0.589	0.589	0.556
6°	0.06	0.075	0.065	0.589	0.736	0.638	0.654
9°	0.09	0.105	0.105	0.883	1.030	1.030	0.981
12°	0.08	0.09	0.1	0.785	0.883	0.981	0.883
15°	0.075	0.075	0.095	0.736	0.736	0.932	0.801

In table 2 it can be seen that the resulting lift force value is different at each given angle of attack, in general the lift force will increase as the angle of attack given before passing the stall angle increases.

At the angle of attack of 0°, 3°, 6°, and 9° with a speed of 21.5 m/s, it can be seen that the table of the airfoil tested has not shown signs of stalling and has an average lift value of 0.208 (α=0); 0,556 (α=3); 0,654 (α=6) and 0,981 (α=9). However at an angle of 12° there is a loss of lift on the NACA 0012 airfoil, meaning that the NACA 0012 airfoil is able to delay stall up to 9° with an average lift force value of 0.981 N.

From the airfoil tested, it has the ability to delay stall.This is due to the influence of the flow separation that is formed, for a thinner airfoil it has a tapered profile on the leadig edge so that the separation point is formed earlier and the separation results in the formation of a vortex. Unlike the airfoil which has a thicker max thickness, it can delay the occurrence of a stall up to an angle of 16 °, this is the effect of the profile shape on the leading edge so that it is able to shift the separation back from the leading edge.

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From the average lift force data in table 2, it can be presented in graphical form as in Figure 3.

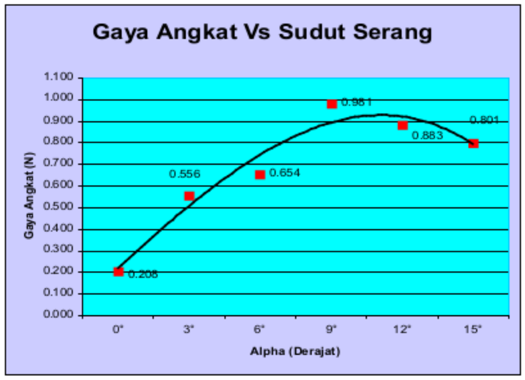

Figure 3.Graph of the amount of lift against the angle of attack.

In Figure 3, it can be seen that the value of the largest / maximum lift force is at the angle of attack of 9° before later stalling at the angle of attack of 12° with a maximum value of 0.981 N at (α = 9). It can be seen that the lift force value after stalling at an angle of 12° reaches 0.883 N. This is due to the effect of the flow separation formed, for a thinner airfoil it has a tapered profile on the leadig edge so that the separation point is formed earlier and the separation results in the formation of vortices. The alpha value (angle of attack) increases, the greater the value of upper side velocity on the airfoil compared to the lower side so that the pressure on the upper side is lower than the lower side, so that the lift is higher (high), but the NACA 0012 airfoil stall at the angle of attack 12°.

At the stall angle, the fluid flow on the upper side turns against the airfoil side as well as the fluid flow on the lower side turns against the upper side and creates a vortex or fluid vortex which causes the drag to increase. This is because at a large angle of attack the separation occurs far in front of the leading edge so that there is very low pressure on the upper side and the fluid moves quickly to fill the low pressure side [4, 7].

After knowing the value of lift from the Airfoil NACA 0012 test, it can be the basis for determining the lift coefficient on the airfoil being tested. Figure 4 shows a graph of the lift coefficient value.

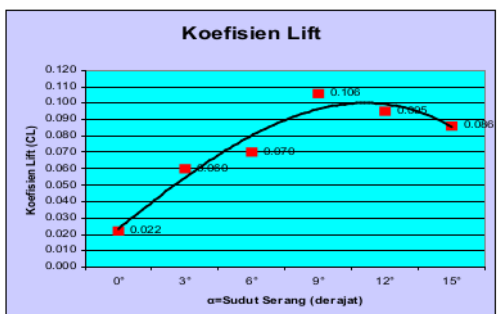

Figure 4. The graph of the lift coefficient on the angle of attack

At an angle of 0° to 9° with an air velocity of 21.5 m/s at 28.8 °C, it can be seen that the polynomial regression graph shows a significant increase before finally at an angle of 12° experiencing a stall. The lift coefficient value which was a maximum of 0.106 becomes 0.095. From the NACA 0012 airfoil tested, it has the ability to delay a stall at an angle of attack of 12°. This is due to the effect of the flow separation formed, for a thinner airfoil it has a tapered profile

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on the leadig edge so that the separation point is formed earlier and the separation results in the formation of eddies or vortices. Apart from the influence of the airfoil profile, the occurrence of stall values is also influenced by the large drag force, because the greater the angle of attack, the greater the drag generated by an airfoil.

The graph of the lift coefficient value as shown in Figure 4 can also be shown in Table 3 which is obtained from the equation:

$FL = CL \cdot ½ \rho \cdot V^2 \cdot Ap$

so that $CL = FL / (½ \rho \cdot V^2 \cdot Ap)$

Table 3. The value of the lift coefficient against the angle of attack

Angle of attack	LF Average (N)	ρ∞ (kg/m³)	Ap (m²)	v∞ (m/s)	v∞² (m/s)²	Cl Value
0°	0.208	1.005	0.04	21.5	462.25	0.022
3°	0.556	1.005	0.04	21.5	462.25	0.060
6°	0.654	1.005	0.04	21.5	462.25	0.070
9°	0.981	1.005	0.04	21.5	462.25	0.106
12°	0.883	1.005	0.04	21.5	462.25	0.095
15°	0.801	1.005	0.04	21.5	462.25	0.086

The results of velocity observations, especially in the flow velocity of Airfoil NACA 0012 emit more turbulence than NACA 2410 so that the value of the drag is greater, in NACA 2410 the drag is smaller because the turbulence on Airfoil is very small. Comparison of CL and CD between NACA 0012 and NACA 2410 the difference that occurs is that the CL NACA 0012 graph experiences a stall condition, NACA 2410 does not experience a stall condition, the peak value of NACA 0012 occurs at an angle of 150, while at NACA 2410 the peak condition is at an angle of 100. However, NACA0012 provides a greater lift effect compared to NACA 2410. In other words, a symmetrical airfoil is more ideal for getting a good lift effect so it is good and effective for use in aircraft [11].

CONCLUSION

Based on the results of experiments and data analysis that have been carried out, the conclusions that can be drawn from this study are as follows:

Air flow velocity and angle of attack have an influence on the lift and drag force of the airfoil. The greater the difference in airspeed, the greater the lift and drag forces experienced by the airfoil. Likewise for the angle of attack, the greater the angle of attack, the greater the lift and drag. However, if the angle of attack is too large, the airfoil will lose its lift or stall. So it can be concluded with different angles of attack can see the effect on the performance of Airfoil NACA 0012.

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Conflict of Interest Statement:

The author declares that the research was conducted in the absence of any commercial or financial relation- ships that could be construed as a potential conflict of interest.

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