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Simulation of Effect of Airfoil MH32 with Variation Taper Ratio and Angle of Attack Coefficient Lift and Drag Fixed wing Unmanned Aircraft

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Abstract

Nowadays, the aerospace sector is growing very rapidly. One of the newest technologies is unmanned aerial vehicle. This UAV has functions to monitor disaster, mapping, espionage and shooting target. Therefore it needs a plane that can fly fast and agile. To achieve these characteristics, one of the most important things is the design of the wings. Some of the important parameters contained in the wings are the type of airfoil, aspect ratio, wing area, taper ratio, and angle of attack. The article aims to analyze the type of airfoil MH32 as well as the effect of the parameter taper ratio with variations of 0.2, 0.4, 0.6 in variations of angle of attack 0 °, 3 °, 6 °, 12 ° and 15 ° to the value of coefficient of lift and coefficient of drag. The method used in this research is experimental with a computational approach using a computer, the advantage of this method is that it does not need a real plane shape. The type of simulation used is Computational Fluid Dynamic (CFD) found in Ansys Fluent. From the simulation, value of coefficient of lift, coefficient of drag, and image of pressure contour and streamline velocity were obtained. All the data was processed and analyzed, then the result is that the taper ratio 0.4 has the highest lift to drag ratio of 19,417. It means that it has the highest value of the coefficient of lift and has the lowest coefficient of drag. These simulated results are validated with experimental from UIUC (University of Illinois at Urbana-Champaign) 1996. The conclusion of this study is that the smaller the taper ratio, the greater the value of the lift coefficient. Then increase the angle of attack to make the value of the lift coefficient is also getting bigger.

Keywords: Simulation Effect Airfoil, Coefficient Lift, Coefficient Drag

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INTRODUCTION

Nowadays technology is developing very rapidly. The development of the field of technology is not only on land and at sea, but also in the air. An example of technological developments in the air is the UAV (Unmanned Aerial Vehicle) or commonly called an unmanned aircraft [1]. UAV is a technology that does not require a pilot to carry out a mission and can also be controlled remotely using a remote control or fly automatically.

The use of this UAV is very widely used, for example to search for victims of natural disasters, remote sensing, monitoring Perhutani areas and border areas, even for areas with uneven surfaces and with different elevation contours [2], UAVs can do this. In addition, UAVs are also used in the interests of civil society[3], such as fire fighting, traffic monitoring, remote area mapping, and natural disaster monitoring. In the military field, UAVs can also carry out dangerous missions such as infiltrating and lurking even inaccessible enemies [5].

The UAV aircraft consists of several main parts, including the fuselage , wings , empenage , and electrical components. In this study, we will focus on the discussion of the wings only, where the wings are the part that affects the characteristics of the aircraft's flying ability as well as producing lift. These influences include the type of airfoil used, swept, aspect ratio, taper ratio, winglet and also the type of tail [4][13]. For now, the NACA (National Advisory Committee for Aeronatics) airfoil is still widely used and applied to commercial aircraft and UAVs. For UAVs with delta models or regular models without tails, the MH type airfoil (Martin Hepperle) is often used. The type of airfoil greatly affects the flying quality of an aircraft because it has a different geometric shape for each type so that it will produce different lift and drag. Therefore, an analysis is needed to determine the value of lift and drag which aims to as a first step determine the flying character of the aircraft with the configuration selected before manufacturing in order to obtain an aircraft that can perform its mission well.

In this study, the method used is a computational approach using aerodynamic simulation on a computer. The advantage of this method is that it does not need the actual shape of the plane. And the type of analysis used is Computational Fluid Dynamic (CFD) contained in Ansys Fluent, where we can enter detailed environmental data. The results of the analysis using this software are also more accurate than the conventional method, in terms of the required cost is also cheaper [8][11][12]. Therefore, based on the description of the paragraph above, the author makes a study entitled "Simulation of the Effect of the MH32 Airfoil with variations of Taper Ratio and Angle Of Attack Coefficient Lift and Drag " Fixedwing Unmanned Aircraft.

a. Airfoil

Airfoil is a geometric shape which when placed in a fluid flow will produce a lift force greater than the drag force [6]. In the airfoil, the flow will be divided into two, namely the upstream and the downflow. Where the upper flow will pass a longer path, so it has a higher speed than the lower flow.principle Bernoulli which states that the higher the fluid velocity, the lower the pressure. Thus there will be a pressure difference between the lower and upper air. This is what causes thelift.

b. Lift and Drag

Lubis [7] said that the lift force or commonly called lift is the force exerted on the wings of an airplane. The lift coefficient is a function of a dimensionless parameter, the lift coefficient is strongly influenced by the shape of the object, the lift coefficient can be determined using the following equation:

$$C_L = \frac{F_L}{\frac{1}{2}\rho V^2 A}$$

Desription:

CL_{Lift} Coefficient

V = Fluid velocity (m/s)

A = Surface area of the object (m^2)

FL_{Lift} force (N)

= Density of fluid (kg/m^3)

Saputra, SF, & Agustian, S. (2018) say that drag is a force that hinders the movement of a solid object through a fluid or gas where The force has a direction parallel to the axis of the air flow velocity. The drag coefficient is a dimensionless number that indicates the size of the fluid resistance received by an object. The drag coefficient is defined as follows:

$$C_D = \frac{F_D}{\frac{1}{2}\rho V^2 A}$$

Where:

C_D = Drag Coefficient

V = Fluid flow velocity (m/s)

A = Surface area (m^2)

F_D = Drag Force (N)

Density of fluid (kg/m^3)

c. Taper Ratio

Taper ratio is the ratio of the tip chord length and root chord, the thinner the wing shape, the smaller the taper ratio . ratio to reduce the effect on wing weight, the smaller the value taper ratio, the wing weight can be minimized, and the selection taper ratio determines the efficiency of the wing due to the effects of induced drag.

$$\lambda = {Ct}/{Cr}$$

Where:

λ = Taper ratio

Ct = Tip chord (m)

Cr = Root chord (m)

d. Aspect Ratio

Aspect ratio is the ratio between the length of the span and the chord of the wing, so if the wings are longer and with the same width, the aspect ratio will be even greater. The application of aspect ratio is for aircraft that have low speeds and require long flight endurance, because the larger the aspect ratio, induced drag . Then for aspect ratio , it is used on aircraft with high speed, agility and does not require long endurance.

$$AR = \frac{s}{c}$$

Where :

AR = Aspect ratio

s = span length (m)

c = chord length (m)

e. Simulation CFDComputational Fluid Dynamic)

It is a method to solve problems related to fluid dynamics with a computer approach. Through this method, it is very easy to configure aircraft configurations and simulate without having to make a physical model first, which of course saves costs, time and minimizes risk. CFD can be used to calculate lift,dragandmoment along with their coefficients quantitatively and can even predict the occurrence of stall. In addition, CFD can also visualize pressure distribution, velocity distribution to streamlined so that it is very easy to observe and analyze air flow around the object under study.

METHOD

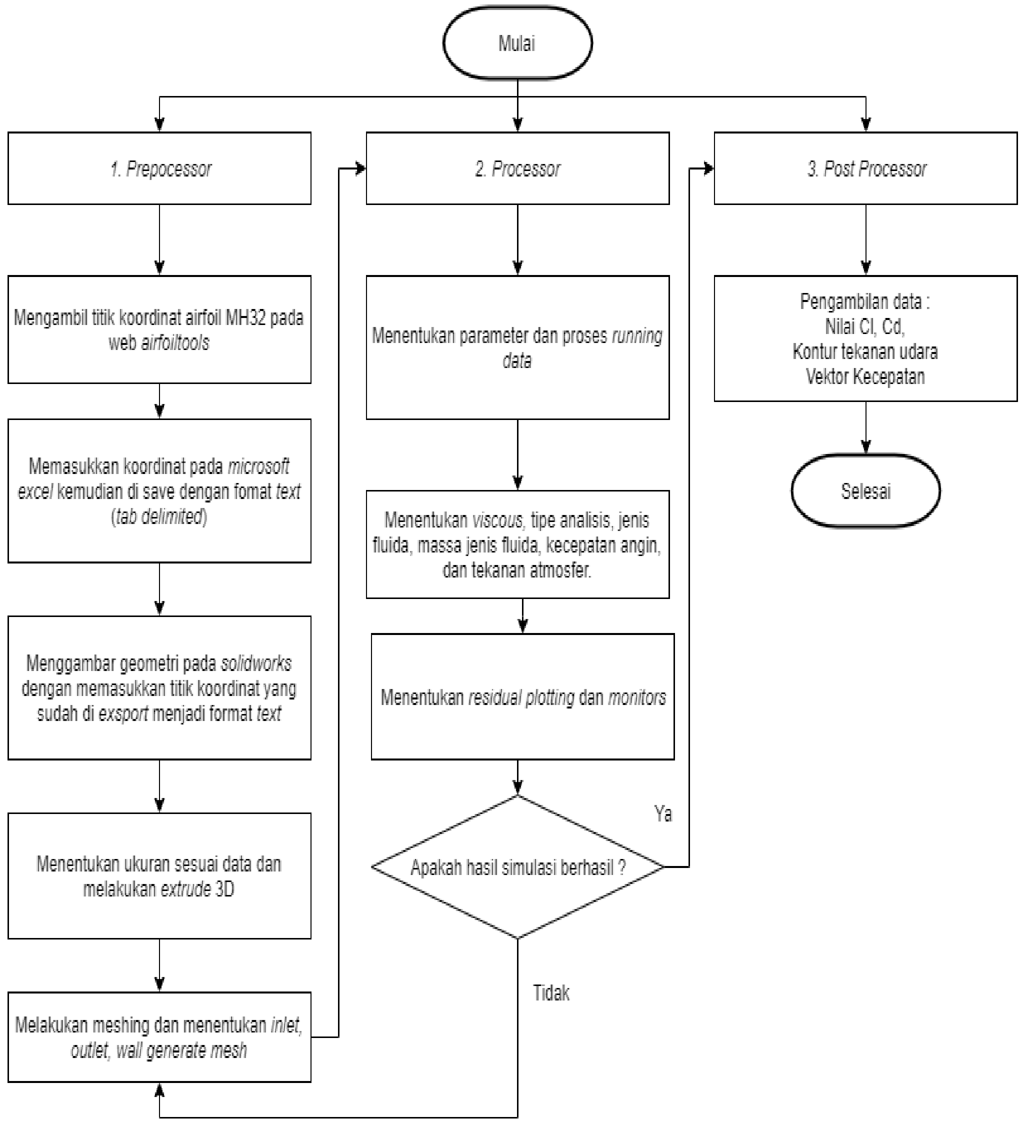
Type of Research

Type of research conducted simulation analysis using ANSYS 19.0 software related to aerodynamics, especially on unmanned aircraft wings and with the MH32 airfoil type. With the aim of finding the effect of the taper ratio and angle of attack on the lift and drag coefficients.

Simulation Flowchart

Tests and data retrieval using software simulations are carried out in the following steps:

Figure 1 Simulation flowchart



Preprocessor

Processor is a preparation stage before the simulation process is carried out. At this stage it is divided into two, namely making a wing object in 3D using Solidworks software and perform meshing with the cut cell and object definition.

Figure 2 The top view of the wing geometry design with variations in the taper ratio

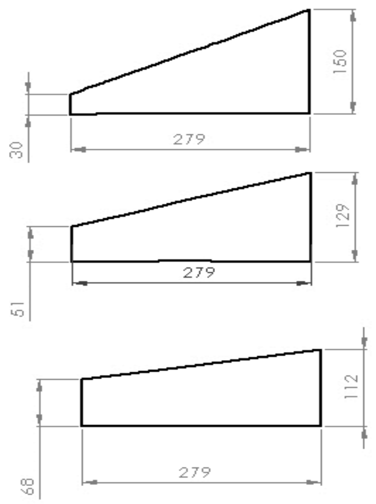
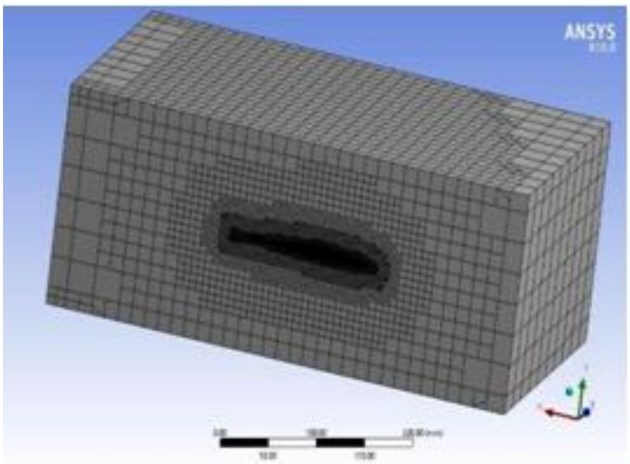


Figure 3 The meshing on the Ansys



1. Processor

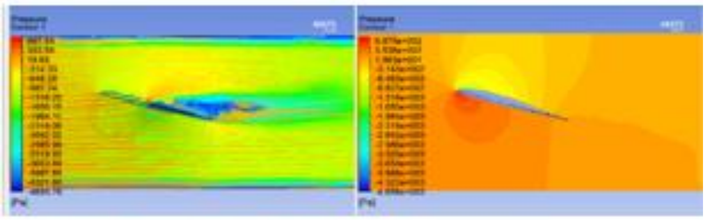
   Processor are the core stage of a simulation process, where at this stage the input parameters accordance with Table 1 and the determination boundary conditions. The parameters used must be in accordance with the actual conditions or conditions at the time of the experiment. So it is hoped that the results from the simulation are not much different from the experimental results, so that the simulation results can be declared valid.

Table 1 Parameters Simulations

General	Solver	Pressure-Based
	Time	Steady
Model	Viscous model	k-epsilon (2qn)
Material : Air	Densitas udara	1,225 kg/m^3
Boundary Conditions	Velocity – Inlet (constant)	33.3 m/s atau 120 km/jam
Solution Methods	Scheme	Coupled
	Pressure	Second Order
	Momentum	Second Order Upwind
	Turbulent Kinetic Energy	Second Order Upwind
Solution Initialization		Hybrid Initialization
Run Calculation	Number of Iterations	500

2. Postprocessor
   Postprocessor is the final stage of a simulation, where at this stage we get the results in the form of lift coefficient values, coefficients drag, streamline velocity, and pressure contours on the wing.

Figure 4 Simulation results in the form of lift coefficient, drag coefficient, velocity streamline and pressure contour



```
Calculation complete.

                              Cd                  ()
--------------------------------  ------------------
                       wing_wall         0.018179566

                            Drag                 (n)
--------------------------------  ------------------
                       wing_wall          0.31004447

                              Cl                  ()
--------------------------------  ------------------
                       wing_wall          0.16230595

                            Lift                 (n)
--------------------------------  ------------------
                       wing_wall           2.7680562
```

Research Variable

In carrying out this research, there are several variables that affect directly or indirectly. The following are related variables in this study.

1. Independent variables is a variable that is not influenced by other variables. The independent variables used in this study were:
   a. Taper ratio : 0.2, 0.4, 0.6
   b. Angle of attack : 0°, 3°, 6°, 12°, 15°
2. The control variable is a variable whose value is kept constant throughout the study. The controlled variables used in this study are:
   a. wind speed 33.3 m/s or 120 km/hour.
3. The dependent variable is the factors that are observed and measured to determine the influence of the independent variables. The dependent variable in this study is the value of the lift coefficient and the drag coefficient value.

RESULTS AND DISCUSSION

In this study, the object of the wing three to be tested. The aim is to determine the effect of angle of attack and variation of taper ratio on lift coefficient and drag coefficient.

Table 2 Value of lift coefficient and drag on taper ratio variation to five variations of angle of attack

Taper Ratio	Angle of Attack	Cl	Cd	Cl /Cd
0.2	0°	0.1484	0.018	8.244
	3°	0.4382	0.0236	18.568
	6°	0.705	0.0384	18.359
	12°	1.0541	0.1166	9.040
	15 °	1.0547	0.1926 5.476	0.4

	°	0.110 5	0.018 4 6.005	3
	°	0.406 2	0.022 6	17.97 3
0	6°	0.675 7	0.034 8	19.41 7
	12°	0.099 9	10.57 5	15
	°	1.068 6	0.173 3	6.166
	0°	0.159 4	0.018 5	8.616
	3°	0.080 36	0.704 85	0.02
0.6	°	0.02	326	1804 85
	1.0564	0.16	0.02	9.690
	15°	1.051 6	0.189 9 5.538	Figur e

Figure 5 Contour of simulated pressure at an angle of 0°

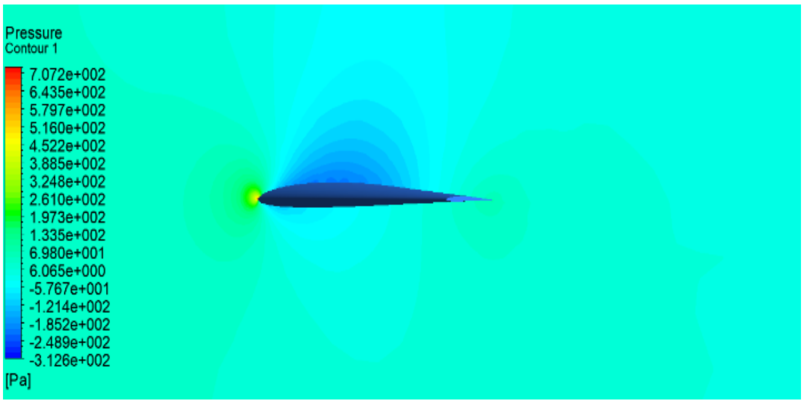


Figure 6 Contour of simulated pressure at an angle of 15°

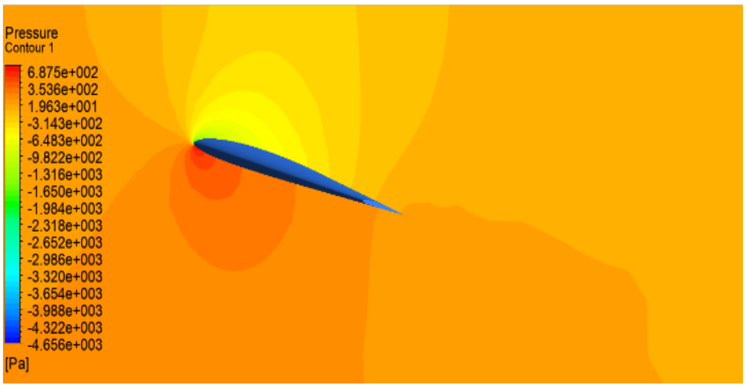


Figure 7 Streamline velocity at an angle of 0°

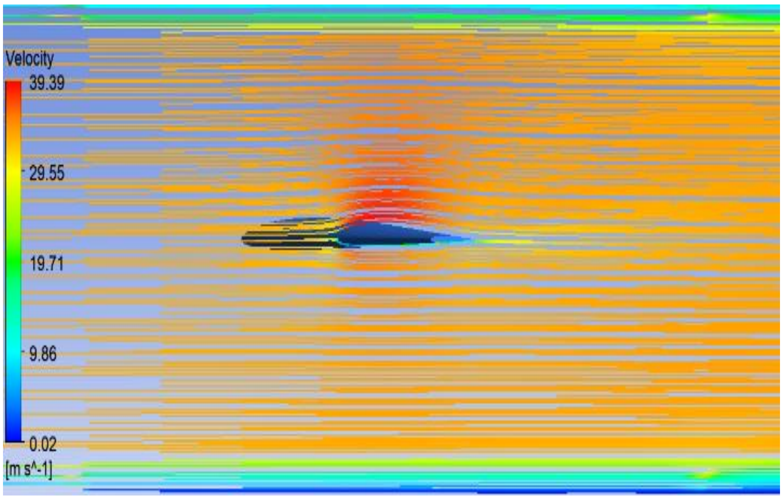


Figure 8 Streamline velocity at an angle of 15°

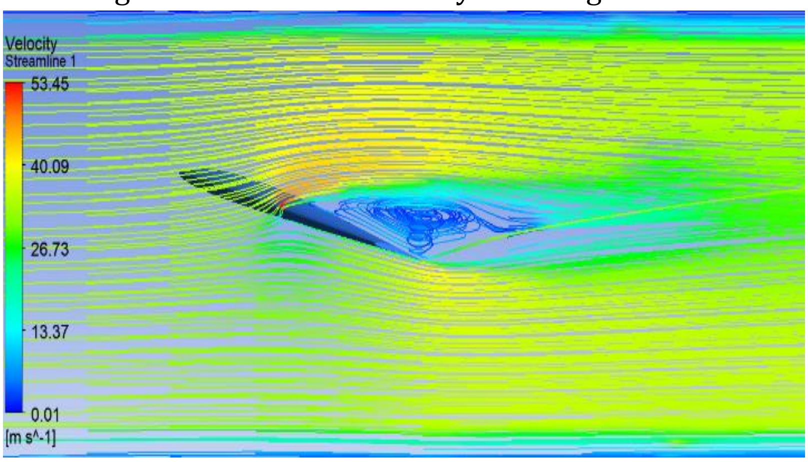


Figure 9 variation taper ratio at each the angle of attack on the lift

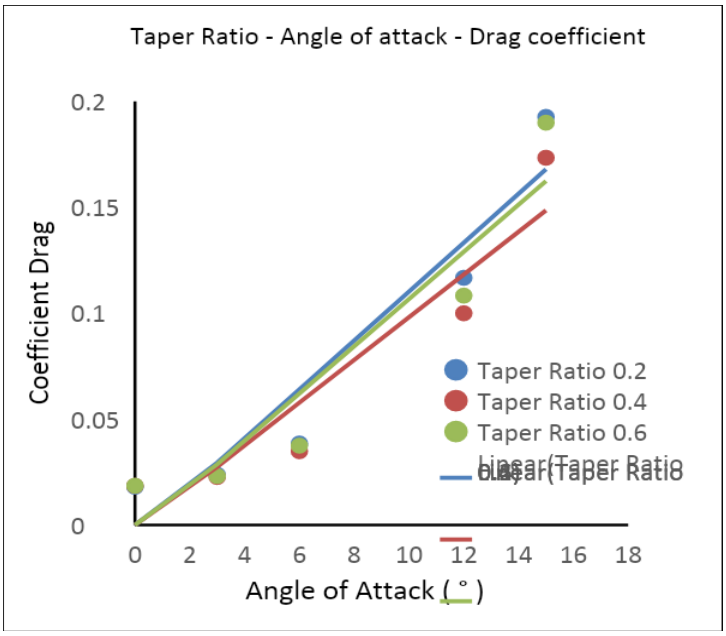
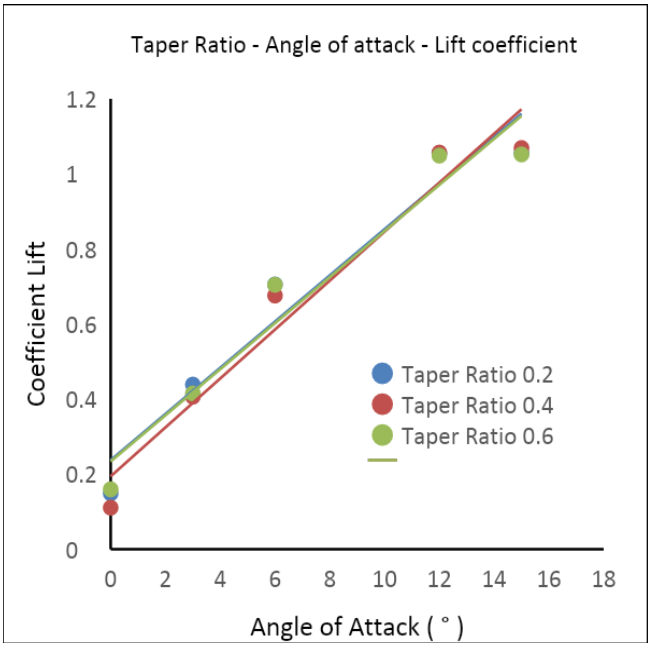
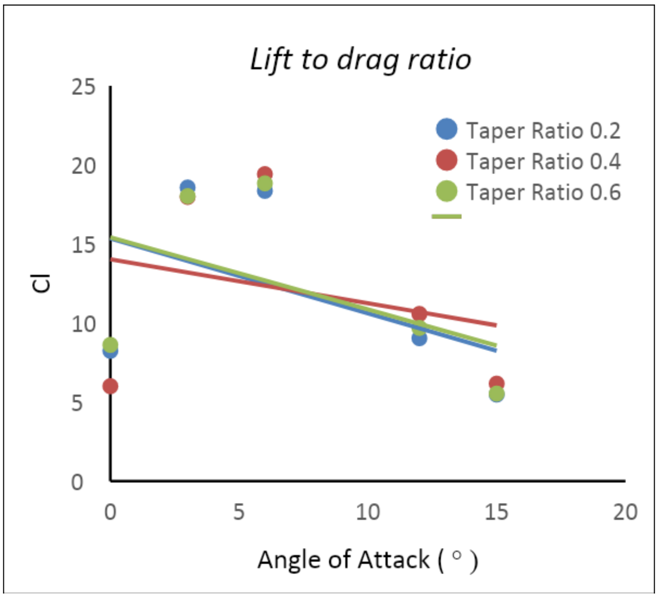


Figure 10 Graph of the variation taper ratio at each angle of attack to the value of the drag



The graph above shows that the greater the angle of attack , the higher the lift coefficient will be. Then from the results of the taper ratio , it can be seen that taper coefficient value lift compared taper ratios , but at an angle of 12° and 15° the highest value is found at taper 0.4. What causes the taper ratio to have a lift coefficient distribution lift along the span is the same. Because in this study the aspect ratio is made the same, the root chord will also be longer, so the lift will also be higher. For the graph of the drag, the reduction taper ratio causes the value of the drag to be greater.seen that taper coefficient value drag highestThis is due to the addition of induced drag and the presence of vortex on the wingtip effect of increasing the length of the root chord.

Figure 11 Graph lift to drag ratio



The value of the lift to drag ratio more or less determines aerodynamic performance and determines the flying efficiency of an aircraft. From the graph above, it can be seen that taper 0.4 has trendline coefficient of lift to drag ratio compared to other taper ratios. Which means it has the lift highest drag lowest

CONCLUSION

Based on the data above, it can be concluded as follows: The wing design with the best taper ratio is the design that has the best performance with a lift to drag ratio value. This is because the lift is large and the drag is small. Then the wing design chosen is a taper ratio of 0.4 because it has the lift to drag ratio value of 19.417 with the lift highest drag , namely 1.0686 and 0.1733. The greater the angle of attack coefficient lift , but after passing the stall , the lift tends to decrease. Increasing angle of attack is also followed by an increase in the value of the drag. The interaction of the two independent variables between taper ratio and angle of attack on the dependent variable in the form of lift coefficient and drag has a significant effect. Where based on the results of data processing using Minitab 19 software, the P value of angle of attack is smaller than the taper ratio. This means that the influence of the angle of attack is more significant and influential than the taper ratio.

The suggestions given so that the next experiment can be better and can complete the experiments that have been carried out in this study are : It is better to determine the angle of attack at a more varied angle such as a negative angle and a closer range so that the stall angle can be known specifically. It is hoped that further research will be able to make a prototype wing and conduct experimental testing using a wind tunnel. So that it can compare the simulation results with experimental results. The tools used will be better if you use a laptop or computer with higher specifications than those used in this study. So that the simulation running process will be faster and can complete more variations.

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