



# Experimental Study of the Effect of Using a Gothic Vortex Generator Counter Rotating Arrangement on Wing Airfoil Eppler 562 with a Smoke Generator

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**Abstract.** The development of science and technology affects all sectors of life, one of them is technological progress in the aviation world. The wing is the most important part of an aircraft because the wing produces an elevator When moving against the airflow because of its airfoil shape. The airfoils found on the aircraft have a pressure difference between the upper surface and the lower surface which causes the aircraft to get lifted. To improve the performance of the airfoil, the wing is added to the wing of the generator vortex. The method used in this study used a wind tunnel. By using smoke in the wind tunnel and fan acceleration against smoke. As well as changing some angles and distances of the gothic vortex generator (VG). Using Eppler 562 with a freestream velocity has a speed of 5 m/s and an angle of attack  $\alpha = 0^\circ, 4^\circ, 10^\circ, 16^\circ, 20^\circ$ , and variations in the spacing between gothic vortex generators (VG). The result obtained from this study is the appearance of airflow performance around the airfoil. This is because there is a difference between airfoils that use a gothic vortex generator and do not use a gothic vortex generator. Airfoils that use gothic vortex generators have simpler partition points than airfoils that do not use gothic vortex generators.

**Keywords:** airfoil · vortex generator · Eppler 562 · smoke generator · wind tunnel · lift

## 1 Introduction

In the years 1900–1902, the Wright brothers conducted experiments using non-motorized aircraft commonly referred to as gliders. The aircraft was able to fly due to the slightly curved shape of its wings, which were later referred to as airplanes. To be able to fly and stay in the air.

Aircraft manufacturing requires a pre-flight analysis of the aerodynamic performance of the aircraft. The method of testing wind tunnels on aircraft models is still considered a fairly effective method for predicting the aerodynamic load and stability of the aircraft to be built. The stability characteristics of aircraft models can be obtained from several

methods of aerodynamic analysis, which are useful for estimating the possible maneuvers of the aircraft.

How to conduct aerodynamic testing, especially using a wind tunnel in the hangar of the Surabaya Aviation Polytechnic. The Eppler 562 airfoil serves as a test object in the room that resembles a venturi tube where the wind tunnel operates using an air-sucking mechanism by changing the smoke in the wind tunnel and accelerating the fan against the smoke. And changing some angles on the airfoil. To be able to compare or analyze the airfoil on Eppler 562. Research using the Eppler 562 airfoil has previously been carried out by many experts, including Hariyadi [1–7]. While research using smoke generators has previously been carried out by Trinder [8], Manovski [9], Gurjot [10], etc.

Based on the above background, in this research and discussion, the desired objectives are as follows analyze the effect of the gothic vortex generator on the separation point compared to without using a gothic vortex generator and analyze fluid flow that occurs after passing through the gothic vortex generator and without the use of a gothic vortex generator.

## 2 Methods

The research method that will be used is the wind tunnel simulation method with the type of open circuit subsonic wind tunnel. The test object to be used is the Eppler 562 airfoil. In the course of wind history, the test object will be positioned in a wind tunnel. To validate the results, an airfoil and wind geometry with a length of  $1 \times 10.5$  m was created (Fig. 1).

The airfoil design that will be used in this experiment is an airfoil with profile airfoil Eppler 562 without being given additionally to determine the influence of the flow passing through the top of the airfoil on the angle of attack as well as the lifting force and inhibitory force.

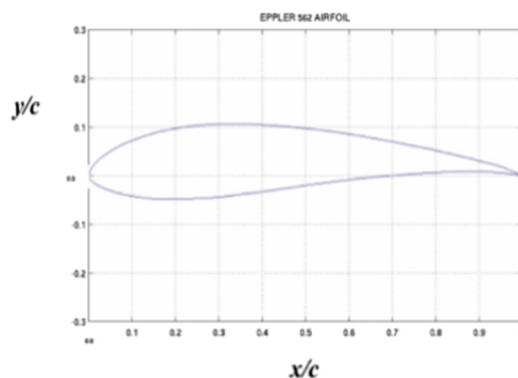


Fig. 1. Airfoil Eppler 562

Dimensional analysis is necessary to determine whether a parameter affects a study or not. The flow parameters studied in this study are:

- 1. Density of fluid,  $\rho$  (kg/m<sup>3</sup>j)
- 2. Fluid velocity,  $U \propto$  (m/s)
- 3. Thickness of boundary layer,  $\delta$ , (om)
- 4. Airfoil thickness,  $\times$  (m)
- 5. Distance between flat plate wall and Airfoil, G(m)
- 6. Length of Airfoil Chord, c(m)
- 7. Height Vortex Generator, h(m)
- 8. Vortex Generator Length, l(m)
- 9. The distance between the leading edge to the Vortex Generator, t (m).

The following parameters will be used in this study (Fig. 2 and Table 1).

Wind tunnels are used as a research tool. This research method uses an open wind tunnel at a velocity of 5 m/s to test the object on the model scale, with the air flowing into it released directly into the free air after passing through the test section. This is because the actual measurement is difficult and expensive. As a result, the wind (wind tunnel) is made in conditions as close as possible to reality, ensuring that the result obtained is quite accurate (Fig. 3).

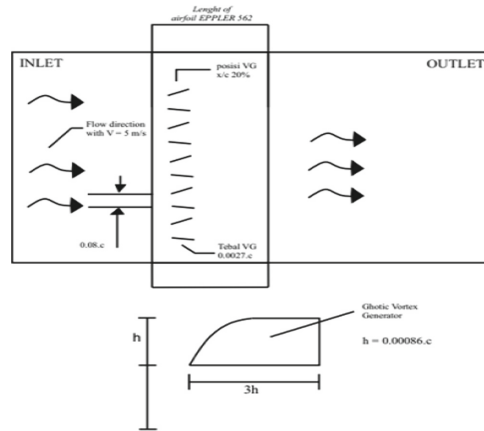
The flow is incompressible on the inlet and wind tunnel. Incompressible flow is a flow in which the volume does not change due to changes in pressure, e.g. air.

Test section shape: Rectangular cross section.

- a. Length: 1800 mm
- b. Height: 660 mm
- c. Width: 660 mm.

Table 1. Parameters of Vortex Generator

PARAMETER	EXPERIMENT
Shape	Gothic
h	0.00086.c
l/h	3
AoA	0°,4°,10°,16°, and 20°
x/c	20%
C	70 mm
d	0.05.C and 0.08.C
Position	Counter Rotating
V	5 m/s



**Fig. 2.** Parameters of the Vortex Generator with variations in the distance to be used [11, 12]



**Fig. 3.** Subsonic, open circuit wind tunnel

### 3 Results and Discussion

From this study, it can be concluded that airfoils without VG have a longer separation point, and when used gothic vortex, the separation point in the airfoil is shorter. It can be concluded that for each variation in the angle of attack, the greater the angle of attack, the greater the separation point obtained from the end of the airfoil. At the same time, the smaller the angle, the shorter the separation point obtained.

The experimental study used the smoke generator method to determine the visualization of laminar flow with unequal separation points in each angular change from the laminar flow to the turbulent boundary layer, to examine changes in the separation point and the influence of gothic VG addition. In the Eppler 562 airfoil, there is a straight line extending vertically from the left side to the right side of the airfoil, whose function is to determine the stagnation point ( $X_p$ ) with a purple point, a transition point ( $X_l$ ) with a blue dot, it can be separated ( $X_s$ ) with a red dot, and a green point with a variation in the angle of attack. Counting 1 full section of an airfoil from the leading edge to the trailing edge results in numbering on the airfoil. Divide 10% on each part to get ten parts. The gothic vortex generator is placed at 20% of the leading edge, that is, on line 0.2 (Table 2 and 3).

**Table 2.** Research Results of Eppler 562 Airfoil Without VG

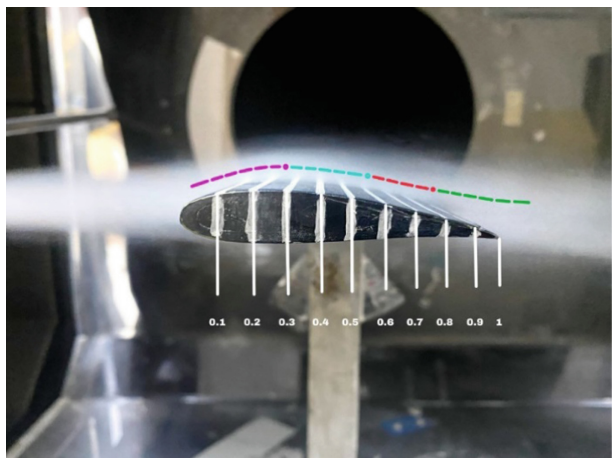
$\alpha$	$X_l$	$X_s$	$X_t$
0°	0.25	0.6	0.8
4°	0.2	0.55	0.75
10°	0.15	0.5	0.7
16°	0.1	0.2	0.25
20°	-	-	0.1

**Table 3.** Research Results airfoil Eppler 562 Spacing 0.05c Gothic VG

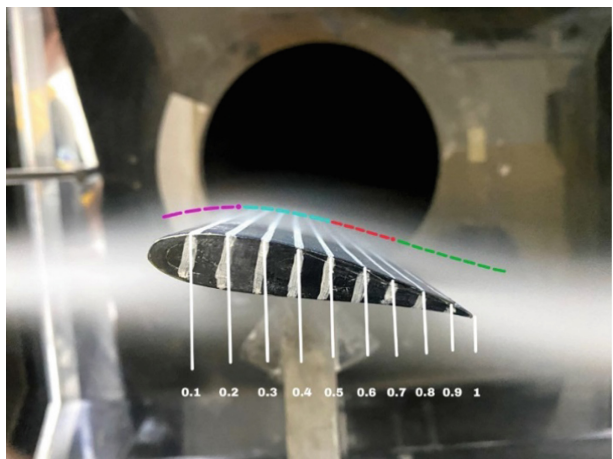
$\alpha$	$X_l$	$X_s$	$X_t$
0°	0.2	0.75	0.9
4°	0.2	0.69	0.84
10°	0.18	0.64	0.74
16°	0.1	0.24	0.29
20°	—	0.14	0.2

The stagnation point is purple (Xp), the transition point is blue (Xl), the separation point is red (Xs), the vorticity point is green (Xt) (Fig. 4).

In Fig. 5, it is shown that smoke flow is seen on the upper surfaces of the airfoil, the transition point is indicated by the point 0.2–0.5, the separation point is indicated by the point 0.55, the vorticity point is indicated by the point 0.75 which causes the flow to be disturbed and the vortices formation leads to the trailing edge.



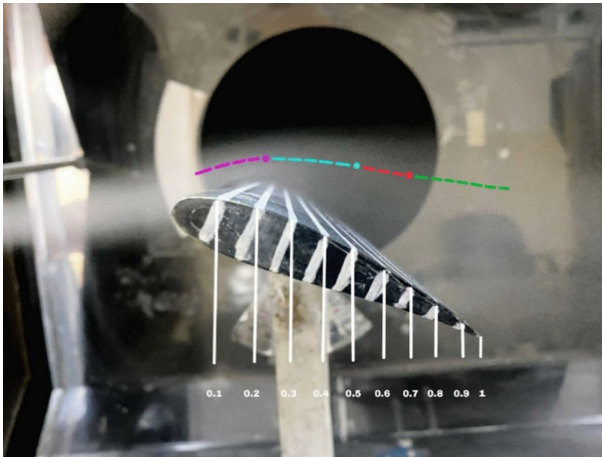
**Fig. 4.** Airfoil without Vortex Generator  $\alpha = 0^\circ$



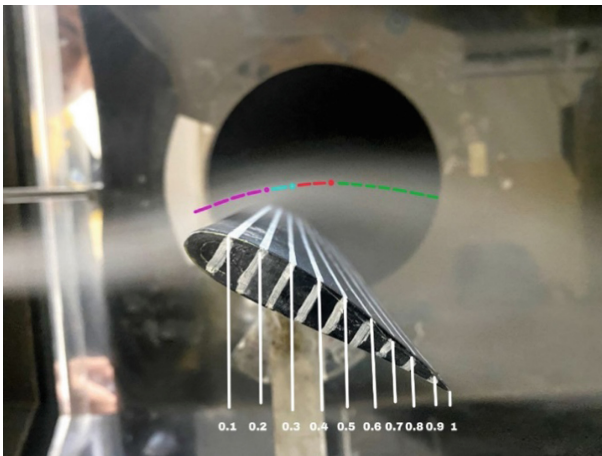
**Fig. 5.** Airfoil without Vortex Generator  $\alpha = 4^\circ$

In Fig. 6 smoke flow is seen on the upper surfaces of the airfoil, the transition point is indicated by the point 0.15–0.45, the separation point is indicated by the point 0.55, and the vorticity point is indicated by the point 0.75 which causes the flow to be disturbed and the vorticity formation leads to the trailing edge.

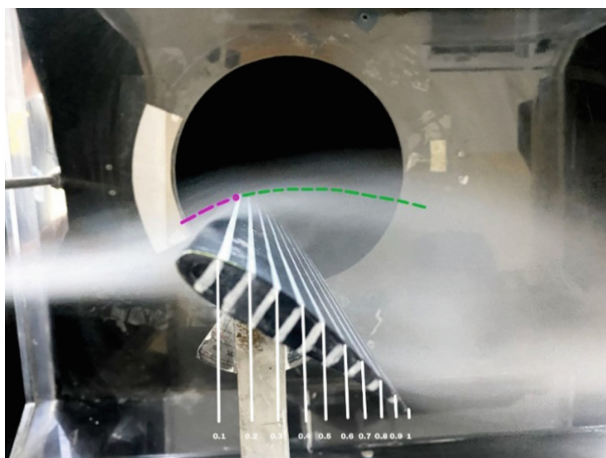
In Fig. 7, it can be seen that the airfoil that does not use the vortex generator when the smoke flows on the upper surface still has a slight lift where the indication is seen at the transition point at point 0.1. In Fig. 8, airfoils do not use a vortex generator after smoke flows at the leading edge or stagnation point, namely the flow is turbulent and there is no meaningful transition point indicating stall. In Fig. 9, with the gothic vortex generator installed in the Eppler 562, airfoil with a spacing distance of  $d = 0.05c$  the separation point is indicated by point 0.75, the transition point is indicated by point 0.2–0.7, and the



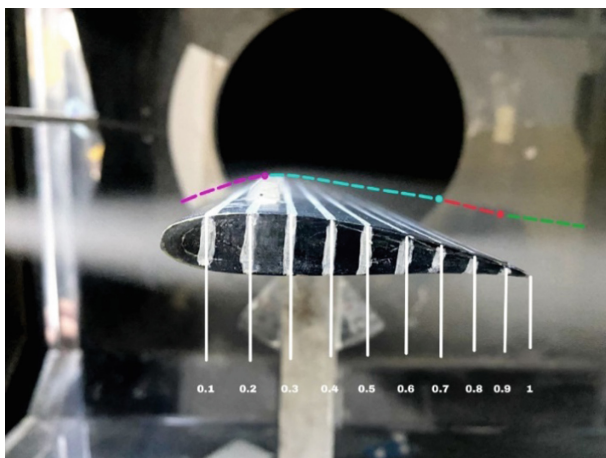
**Fig. 6.** Airfoil without Vortex Generator  $\alpha = 10^\circ$



**Fig. 7.** Airfoil without Vortex Generator  $\alpha = 16^\circ$



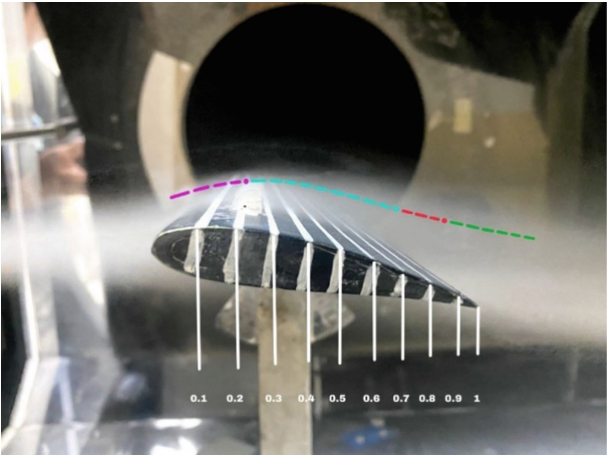
**Fig. 8.** Airfoil without Vortex Generator  $\alpha = 20^\circ$



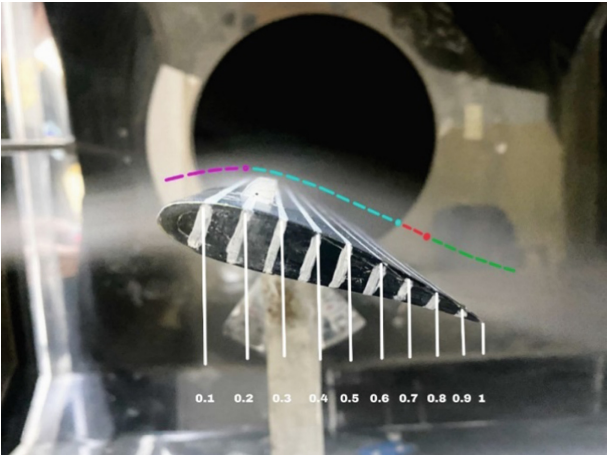
**Fig. 9.** Airfoil with Gothic Vortex Generator  $\alpha = 0^\circ$   $d = 0.05c$

vorticity point is indicated by point 0.9 and continues to point backward. In Fig. 10, with the gothic vortex generator installed in the Eppler 562, airfoil with a spacing distance of  $d = 0.05c$  the separation point is indicated by point 0.69, the transition point is indicated by point 0.2–0.6, and the vorticity point is indicated by point 0.84 and continues to point backward. There is Fig. 11 with the gothic vortex generator installed in the Eppler 562 airfoil with a spacing distance of  $d = 0.05c$  the separation point is indicated by point 0.64, the transition point is indicated by point 0.18–0.54, and the vorticity point is indicated by point 0.74 and continues to point backward. But in Fig. 12, with the gothic vortex generator that the indication is still a visible transition point on the upper surface occurring at point 0.1.

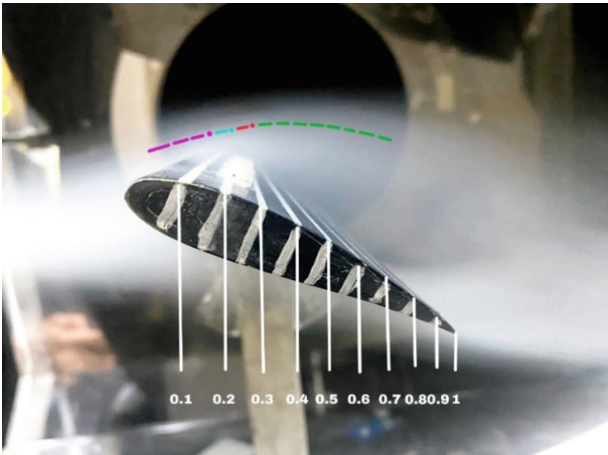




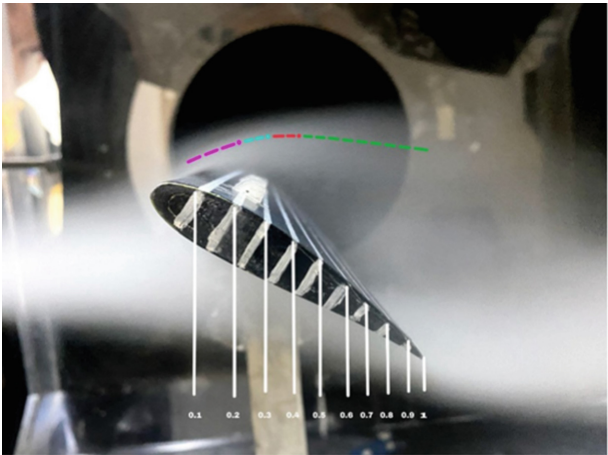
**Fig. 10.** Airfoil with Gothic Vortex Generator  $\alpha = 4^\circ$   $d = 0.05c$



**Fig. 11.** Airfoil with Gothic Vortex Generator  $\alpha = 10^\circ$   $d = 0.05c$



**Fig. 12.** Airfoil with Gothic Vortex Generator  $\alpha = 16^\circ$   $d = 0.05c$

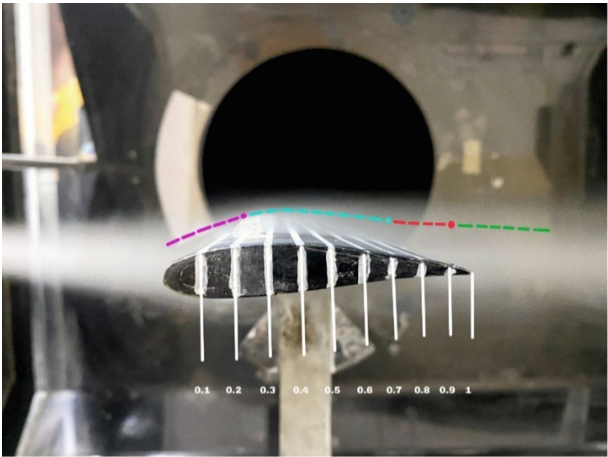


**Fig. 13.** Airfoil with Gothic Vortex Generator  $\alpha = 20^\circ$   $d = 0.05c$

However, in Fig. 13 due to the addition of the gothic vortex generator, the indication is still a visible transition point on the upper surface (Table 4).

**Table 4.** Research Results Airfoil Eppler 562 Spacing Distance 0.08c Gothic VG

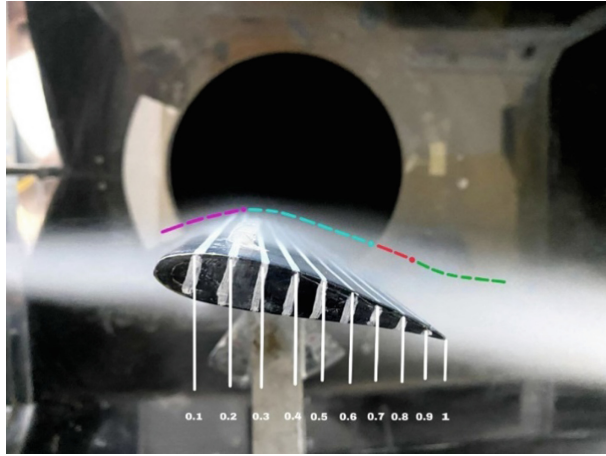
$\alpha$	Xl	Xs	Xt
0°	0.2	0.75	0.9
4°	0.2	0.7	0.85
10°	0.18	0.65	0.75
16°	0.12	0.25	0.3
20°	–	0.15	0.2



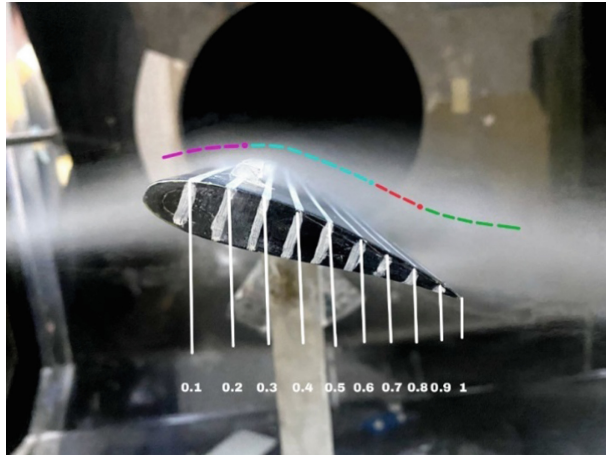
**Fig. 14.** Airfoil with Gothic Vortex Generator  $\alpha = 0^\circ$   $d = 0.08c$

In Fig. 14 with a gothic vortex generator installed in the Eppler 562 airfoil with a spacing of  $d = 0.08c$  the separation point is indicated by point 0.75, the transition point is indicated by point 0.2–0.7, and the vorticity point is indicated by point 0.9 and continues to move backward. In Fig. 15, with the addition of a gothic vortex generator on the Eppler 562 airfoil with a spacing distance of  $d = 0.08c$ , the separation point is indicated by point 0.7, the transition point is indicated by point 0.2–0.6, and the vorticity point is indicated by point 0.85 and continues to point backward.

In Fig. 16 with a gothic vortex generator installed in the Eppler 562 airfoil with a spacing distance of  $d = 0.08c$  the separation point is indicated by point 0.65, the transition point is indicated by point 0.18–0.55, and the vorticity point is indicated by point 0.85 and continues to point backward. In Fig. 17 with the addition of a gothic vortex generator, the indication is still visible that the transition point on the upper surface occurs at point 0.12. In Fig. 18 with the addition of the gothic vortex generator the indication is still a visible transition point on the upper surface.

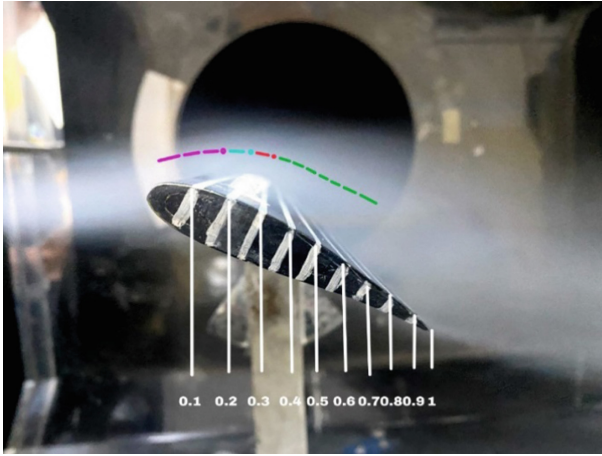


**Fig. 15.** Airfoil with Gothic Vortex Generator  $\alpha = 4^\circ$   $d = 0.08c$

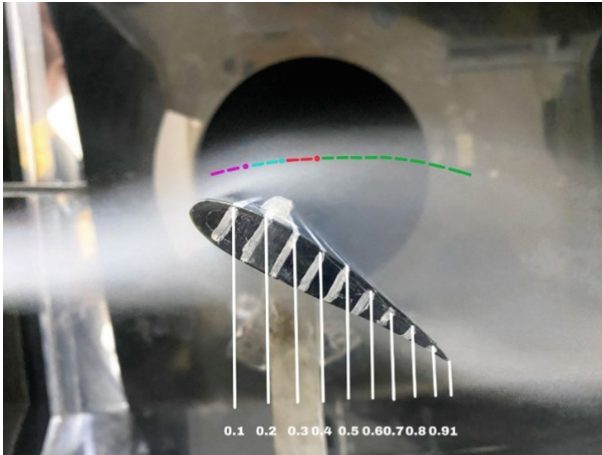


**Fig. 16.** Airfoil with Gothic Vortex Generator  $\alpha = 10^\circ$   $d = 0.08c$

The most significant addition of the gothic vortex generator occurs at an angle of attack  $\alpha = 16^\circ$  with the separation point located at point 0.5 of the leading edge and an angle of attack  $\alpha = 20^\circ$  at point 0.15 of the leading edge. From these two angles, it can be used as a comparison reference between the airfoil and the gothic vortex generator versus the airfoil without a gothic vortex generator that  $\alpha = 16^\circ$  still has a slight lifting force (lift) and the  $\alpha = 20^\circ$  has no lifting force (lift) seen on the upper surface in the form of a turbulent boundary layer.

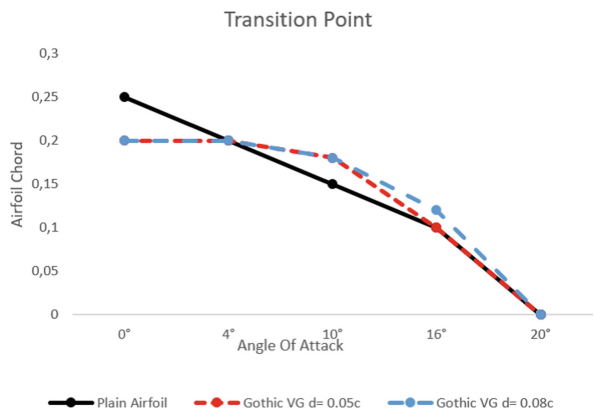


**Fig. 17.** Airfoil with Gothic Vortex Generator  $\alpha = 16^\circ$   $d = 0.08c$

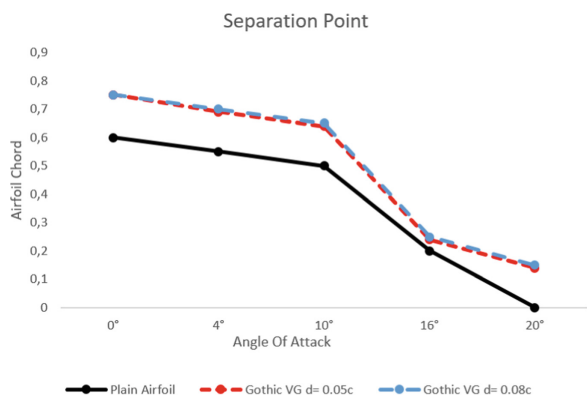


**Fig. 18.** Airfoil with Gothic Vortex Generator  $\alpha = 20^\circ$   $d = 0.08c$

The phenomenon of comparison of space spacing in the generator vortex and that without the use of the generator vortex can be seen from the separation point on the airfoil shorter when using the generator vortex and the variation in the placement distance on the generator vortex. The use of a gothic vortex generator shape on the upper surface makes the separation point longer and lower than without using a vortex generator. Counter-rotating type vortex generators can delay flow separation effectively compared to other forms (Figs. 19, 20 and 21).

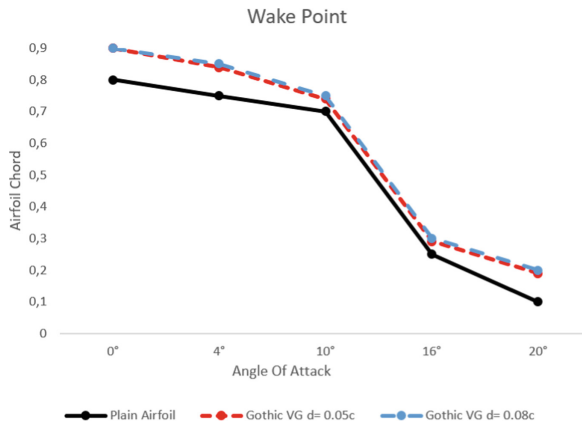


**Fig. 19.** Transition Point



**Fig. 20.** Separation Point

One of the factors that affect the improvement of performance on the airfoil is the addition of a vortex generator. As stated by Hariyadi [11, 12], with the addition of a vortex generator compared to without a generator vortex on the airfoil the separation can be delayed when using a vortex generator. This suggests that the shape and arrangement of the vortex generator caused a separation delay.



**Fig. 21.** Wake Point

## 4 Conclusion

Based on the results of the experiment and simulation analysis in the previous chapter, the following conclusions can be drawn:

1. The airflow characteristics on the upper surface of the airfoil with a gothic vortex generator are more stable than airfoils without a gothic vortex generator at an angle of attack  $\alpha = 0^\circ, 4^\circ, 10^\circ, 16^\circ, 20^\circ$ . Because the generator vortex can reduce air separation and prevent the occurrence of turbulent boundary layers.
2. The addition of Gothic VG converts the flow of air through the upper surface of the Eppler 562 airfoil from the laminar into a turbulent flow, which occurs faster than an airfoil without a vortex generator.
3. Airfoils that use a gothic vortex generator more efficiently can be seen between the angle of attack range of  $\alpha = 16^\circ$  to  $20^\circ$  there is still an elevator because there is still a stall delay that occurs at the separation point compared to airfoils that do not use a vortex generator that at an angle of attack  $\alpha = 16^\circ$  there is still a slight lifting force (lift) seen on the upper surface in the form of a turbulent boundary layer.

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