MECOMARE, 10 (2) (2021) pp. 51-60

Published by: TRIGIN Publisher

International Journal of Mechanical Computational and Manufacturing Research

Journal homepage: www.trigin.pelnus.ac.id

Noise Reduction Simulation on Usu Nvc Unmanned Aircraft with Capsuling Method Using Ansys 15.0 Software

Ahmad Fiqri Oemry

Department of Mechanical Engineering, University of North Sumatra, Indonesia

ARTICLEINFO

Article history:

Received June 11, 2021
Revised July 01, 2021
Accepted August 28, 2021

Keywords:

Capsuling Method
Dle Gasoline Engine 30
Noise Contour
Noise Reduction
Unmanned Aerial Vehicle

ABSTRACT

USU (University of North Sumatra) Unmaned Aerial Vehicle use DLE (data life engine) gasoline engine 30 machine as motor. The machine is classificassed as 2 stroke machine that produced major noise on vehicle. To fix the noise need study and further reaserch about acoustic or sound science. This research use capsuling method to ruduce noise factor and use rockwool as acoustic material. This study was conducted to look at the characteristics of acoustic material produced by the drone of the variation of engine speed at 3000, 4000, 5000, 6000, and 7000 rpm with a measurement distance of 1 meter. Tests done by simulation using FEM software by dividing the four major components, namely testing model airframe, engine, exhaust, and the capsuling draft. Directions were used in the simulation are horizontal, vertical, and axial (X +, X-, Y +, Y-, Z +, Z-). From the results of the simulation capsuling methods on DLE gasoline engine 30, capsuling method has no effect either to decrease the noise in the axis Y- and more dominant produces noise reduction is evenly distributed on the Y axis +. The highest noise value is generated at 7000 RPM on the Y axis and the lowest at 3000 RPM on the Y axis +. From the simulation results produced the greatest reduction in the amount of 11.9 dB on the Y axis + with a round of 3000 rpm and the smallest reduction in the amount of 0.15 dB on axis Z + with a round of 6000 rpm. The greater the rotation of the engine will be highly effective against acoustic material properties in damping vibrations that occur, so that contour noise that occurs will be scattered and produce fluctuations in the plane of unmanned aero vehicle geometry.

Corresponding Author:

Ahmad Fiqri Oemry
Department of Mechanical Engineering
University of North Sumatra
Jln. Dr. T. Mansur No.9, Medan City, North Sumatra, 20222, Indonesia
Email: ahmad@gmail.com

1. INTRODUCTION

An unmanned aircraft (Unmanned Aerial Vehicle or abbreviated UAV) is an aircraft (Putra et al., 2015) flying without a pilot in it that can be operated remotely using a controller system operated by pilots who are at the station or can (Eko Prasetyo, 2020)operates independently based on pre-programmed flight plans and more complex dynamic automation systems (Arif, 2017). Unmanned aircraft have the advantage of not being burdened by the physiological limitations of human pilots (Abdillah et al., 2020), which allows it to be designed with maximum use of space to condense several important functions with minimal aircraft size (Nurdyansyah, 2019). Therefore, its use itself can reach the most difficult aspects which usually tend to be difficult for humans to do (Sudaryono, 2022). Unmanned aircraft are intended to be able to carry out aerial monitoring missions to see objects that are still or moving above the ground (Aji, 2007). The mission is carried out in areas with minimal infrastructure support, such as forest areas (Muta'ali et al., 2018), mountains, swamps and others. Research on drones has been done a lot, especially on the development of the functions and objectives of this drone (Boelaars, 1986). In the military field, the use of unmanned aircraft is used as a monitoring or spying aircraft where it is expected to be very low in noise (Eddyono, 2021). Mechanical engineering, University of North Sumatra until now has developed a UAV aircraft step by step as one of the students' research (Saleh, 2018). It is noted that until now USU Mechanical Engineering has developed a UAV aircraft in the third generation (Perwita et al., 2021). The DLE Gas Engine 30 engine is one of the main parts of the third generation USU Mechanical Engineering UAV aircraft, where the function of this engine is as a driving motor that drives the propeller so as to produce thrust for an aircraft. This engine is a 2 stroke engine so that it produces a higher noise than a 4 stroke engine (Hendrawan, 2020).

The noise can affect the UAV aircraft system or the surrounding environment. In this engine, the component that produces the most noise is the exhaust (Rahmawati, 2015). Therefore, it is necessary to analyze the noise on the engine to determine the characteristics of the noise in the engine and it is necessary to reduce the noise generated by the exhaust so as to reduce the negative impact on the aircraft system and the environment (Tambunan et al., n.d.). The USU Faculty of Engineering's Noise and Vibration Control (NVC) Laboratory specifically for drone research has conducted several studies, some of which can be seen in table 1.1 below.

Table 1. USU Mechanical Engineering Unmanned Aircraft Research

No	Peneliti	Tahun	Judul	Fokus Kajian
1	Arifin Fauzi Lubis,dkk	2012	Analisa Gaya Impak yang terjadi pada Bahan Pesawat *Aeromodelling* Tipe *Glider* saat *Landing* dengan Variasi Sudut Pendaratan yang Disimulasikan dengan menggunakan *Software Solidwork*	Mengkaji gaya angkat dan gaya impak dari pesawat tipe glider dengan melakukan perhitungan secara analitik dan numerik.
2	Juliono Susanto	2014	Analisis Gaya Dan Pembuatan Badan Pesawat Tanpa Awak Dari Bahan Material Komposit Yang Diperkuat Polyester Dan Serat *Rockwool* Dengan Metode *Hand Lay Up*	Mengkaji nilai dari titik berat secara teoritis pada badan pesawat tanpa awak dan nilai tegangan regangan dengan perhitungan numerik.
3	Nazwir Fahmi Damanik	2015	Simulasi Karakteristik Kebisingan pada Mesin DLE Gas Engine – 30 Sebagai Penggerak Pesawat Tanpa Awak	Mengkaji nilai kebisingan yang dihasilkan dari mesin dle 30 dengan perhitungan numerik
4	Irwan Rosyadi Nst	2014	Studi Eksperimental Karakteristik Kebisingan Knalpot DLE Gas Engine – 30 Sebagai Penggerak Pesawat Tanpa Awak Prototipe NVC USU.	Mengkaji nilai kebisingan yang dihasilkan dari mesin dle 30 dengan perhitungan analitik.

6	M. Tri Zulfi Sahab	2016	Studi Eksperimental Kebisingan Dan Simuasi Kontur Kebisingan Pesawat Tanpa Awak *Prototype* NVC USU	Mengkaji nilai kebisingan yang dihasilkan pesawat secara menyeluruh dengan perhitungan analitik
7	Dedi Agustianto	2016	Simulasi Uji Kebisingan Pada Pesawat Tanpa Awak *Prototype* NVC USU Menggunakan Perangkat Lunak FEM	Mengkaji nilai kebisingan yang dihasilkan pesawat secara menyeluruh dengan perhitungan numerik
8	Agung Nugroho	2016	Studi Eksperimental Reduksi Kebisingan Mesin DLE Gas *Engine* 30 Sebagai Penggerak Pesawat Tanpa Awak Prototipe NVC USU Dengan Metode *Capsuling*	Mengkaji nilai kebisingan dari knalpot yang telah dibungkus dengan material akustik rockwool
9	Ghazali Adam	2016	Studi Eksperimental Kebisingan Pada Propeller Pesawat Tanpa Awak NVC USU	Menganalisa nilai kebisingan yang dihasilkan oleh propeller

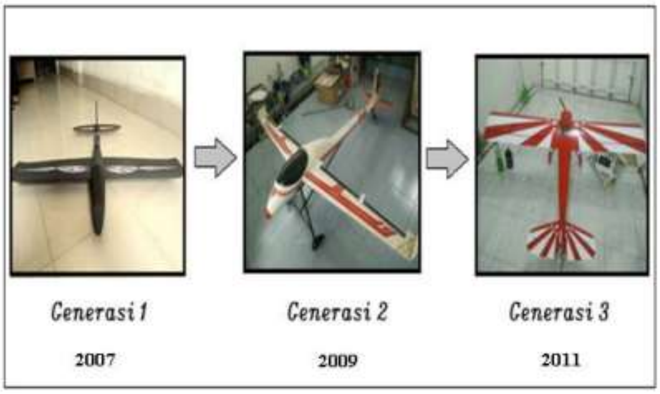

Figure 1. USU's NVC Lab Unmanned Aircraft Development

Figure 1.1 above shows an unmanned aircraft from the USU NVC laboratory. In this study, the effect of the capsulating method on the characteristics of noise that occurs in generation 3 unmanned aircraft will be studied. In this case, research on noise in unmanned aircraft is carried out with ANSYS simulations to analyze the noise reduction produced by applying the capsuling method. In this case the simulation used because it has the advantage that it can analyze more complex systems, conditions that can be adjusted and can compare several alternative designs to get the best capsuling design (Susanto, 2021).

The objectives of this research are as follows: (1) To build a computational model of an unmanned aircraft and a capsuling system design that has been carried out experimentally which will be simulated using Finite Element Methods (FEM) to display a noise contour plot that occurs between the exhaust and the material. noise absorber. (2) Conducting simulations on USU's NVC unmanned aircraft to compare the value of the noise generated with the exhaust design using the capsuling method. (3) Validate by comparing computational results with experimental on capsuling exhaust design. (4) Calculating the percent error from the experimental noise measurement results with the simulation results on the capsuling exhaust.

2. RESEARCH METHOD

2.1 Research Flowchart

In general, the implementation of the research can be seen in the research flow chart in Figure 3.9 below.

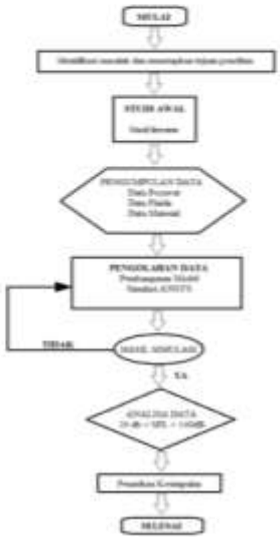

Figure 2. Research Flowchart

3. RESULTS AND DISCUSSIONS

3.1. Building CAD (Computer Aided Design) Models

The simulation of the capsuling method on the USU NVC unmanned aircraft is carried out by building a design model of exhaust silencer in the form of a 3-dimensional model of the drone model, by determining the main components that produce noise and play a role in the distribution and absorption of sound in the overall structure of the aircraft. The following are the main components that play a role in generating noise on aircraft, namely: (1) Unmanned Aircraft, (2) DLE Gasoline Engine 3 Engine, (3) Propeller, (4) Muffler.

3.2. Noise Reduction Simulation Results

From the simulation that has been done previously, the SPL value is obtained for each rotation on each measuring axis X+, X-, Y+, Y-, Z+, Z-. The noise value obtained from the simulation will then be displayed in the form of a graph to see an overview of the increase in the SPL value on each measuring axis.

3.2.1. Axis X+

The graph of the SPL reduction value to changes in rotation on the X+ axis is shown in Figure 4.11 below.

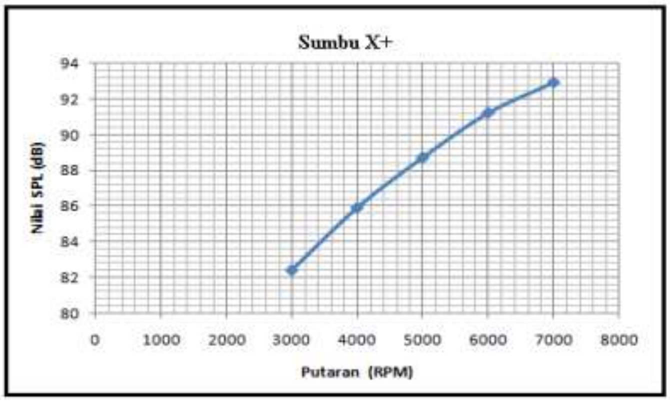

Figure 3. SPL vs Lap Graph on X+ . axis

From the graph above, on the X+ axis the highest SPL noise value occurs at 7000 RPM rotation with a value of 92.9 dB. It can be seen on this axis that the increase in noise level is directly proportional to the increase in engine speed.

3.2.2. Y axis +

The graph of the SPL reduction value to changes in rotation on the Y+ axis is shown in Figure 4.13 below.

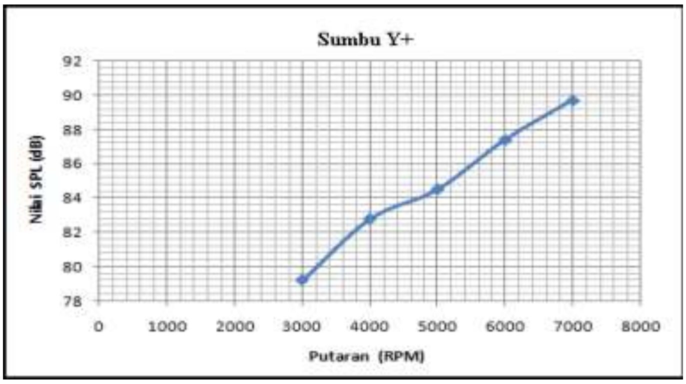

Figure 4. SPL vs Lap Graph on Y+ . axis

From the graph above, on the Y + axis the highest SPL value occurs at 7000 RPM rotation with a value of 89.7 dB. It can be seen from the graph on this axis that the capsuling method works well for the spread of noise generated by the exhaust because this axis is a loose plane that is not bound by aircraft components that produce vibrations due to engine activity. This is because the noise pressure that occurs is absorbed by the plane of the plane which has balsa wood material which is also included in the sound-absorbing acoustic material and is inhibited from spreading to the plane of the plane, namely on the Y+ axis.

3.2.3. Axis Z+

The graph of the SPL reduction value for changes in rotation on the Z+ axis is shown in Figure 4.15.

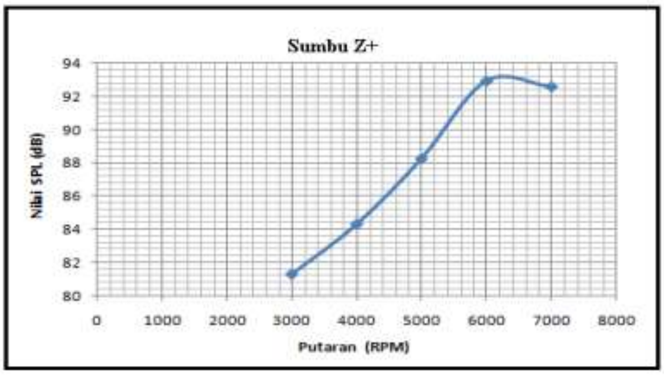

Figure 5. SPL vs Lap Graph on Z+ . axis

From the graph above, on the Z + axis the highest SPL value occurs at 6000 RPM rotation with a value of 92.9 dB. From the graph, it can be seen that at 7000 RPM rotation on the Z + axis, the noise level decreases compared to 6000 RPM rotation. This is influenced by sound waves that fluctuate with the resulting air pressure.

3.3. Comparison of Exhaust Noise Using Capsuling and Without Capsuling

Previous research conducted by M. Tri Zulfi Sahab regarding USU's NVC aircraft noise before being reduced by the capsuling method, measurements were carried out by researchers experimentally, with measurement data in table 4.2 below.

Table 2. Noise Measurement Results Without Capsuling At 1 Meter Distance

No	N (rpm)	X+ (dB)	X- (dB)	Y+ (dB)	Y- (dB)	Z+ (dB)	Z- (dB)
1	3000	90,2	89,2	91,1	92,1	89,1	89,9
2	4000	91,7	91,2	92,9	94,2	90,9	91,5
3	5000	92,9	92,3	94.2	95,5	92,2	92,7
4	6000	93,9	93,3	95,3	96,4	93,1	93,6
5	7000	95,0	94,2	96,5	97,7	94,0	94,5

From the data from the measurement results of the USU NVC aircraft engine noise without capsuling, a simulated noise reduction was obtained which can be seen in the following table.

Table 3. Noise Reduction Simulation Value at a Distance of 1 Meter

No	N (rpm)	X+ (dB)	X- (dB)	Y+ (dB)	Y- (dB)	Z+ (dB)	Z- (dB)
1	3000	7,8	8,23	11,9	8,3	7,82	7,9
2	4000	5,8	6,33	10,12	7,4	6,6	5,9
3	5000	4,2	4,7	9,7	5	3,94	5
4	6000	2,7	2,4	7,91	3,7	0,15	2,4
5	7000	2,1	1,75	6,8	3,1	1,4	4,15

In table 4.3, it can be seen the noise reduction value at a measurement distance of 1 meter with variations in rotation of 3000, 4000, 5000, 6000, and 7000 rpm with the measurement directions X+, X-, Y+, Y-, Z+, and Z-. In the table, it can be seen that the lowest noise reduction value is on the Z+ axis at 6000 rpm rotation which is 0.15 dB and the highest noise reduction value is located on the Y+ axis at 3000 rpm rotation which is 11.9 dB.

3.4. Data validation

As a data validation, the researchers compared the computational results of the capsuling exhaust noise reduction test on aircraft with the experimental results. To then calculate the difference in the results of the noise reduction in the form of percent error. The following is the data from the measurement of the SPL exhaust capsuling on an NVC aircraft with a measurement distance of 1 meter with the same direction of the measurement axis using the Sound Level Meter tool which was carried out at night in the postgraduate mechanical engineering building of the NVC laboratory. The results of experimental SST measurements can be seen in table 4.4.

Table 4. SPL Value From Experimental Measurement

N (RPM)	Sumbu Pengukuran (dB)					
	X+	X-	Y+	Y-	Z+	Z-
3000	83,7	83,0	82,9	84,1	84,3	83,8
4000	88,8	88,0	87,8	89,0	87,6	87,6
5000	89,6	88,9	89,0	89,8	89,8	88,9
6000	90,5	89,8	89,9	91.2	91,4	90,3
7000	91,4	90,6	90,7	92,0	92,4	91,0

3.5. Calculating the Percentage of the Capsuling Exhaust Error on the Aircraft Calculating the Percentage of the Capsuling Muffler Error on the Aircraft

By using the same equation using the help of Microsoft Excel software, calculations are carried out for the percent error value on each measurement axis. Then the calculation results are plotted into Table 4.5.

Table 5. Percent Error

N (RPM)	Persen Ralat (%)					
	X+	X-	Y+	Y-	Z+	Z-
3000	1,5	2,5	4,6	0,3	3,8	2,2
4000	3,3	1,6	6	2,5	3,9	2,3
5000	1	1,4	5,3	0,8	1,7	1,3
6000	0,7	1,2	2,8	1,6	1,6	0,9
7000	1,6	2	1,1	2,7	2,2	1,4

The factors that cause the percent error on unmanned aircraft are as follows: (1) Experimental. Noise testing is carried out at the position of the aircraft touching the ground surface, this factor causes the vibration and noise flow that occurs to be partially absorbed and not spread evenly. (2) Unstable environmental noise factor. (3) There is no limit to the test area because the test is carried out in an open environment which is strongly influenced by air flow and pressure changes that occur around it. (4) The noise generated is the noise generated by the engine, propeller, aircraft construction joints. (2) Computing: (1) The test is carried out with a material that has been limited and is a solid material structure. (2) The difference in the geometry of the plane and the thickness of the construction plane on the plane in the development of the empirical model. (3) Simulation limitations in analyzing tests in dynamic conditions.

3.6. Validation of Experimental and Computational Results

To get reliable results, it is necessary to validate the experimental and computational measurement results. The validation process is as follows:

3.6.1. Axis X+

The validation of the X+ axis is shown in Figure 4.17 below.

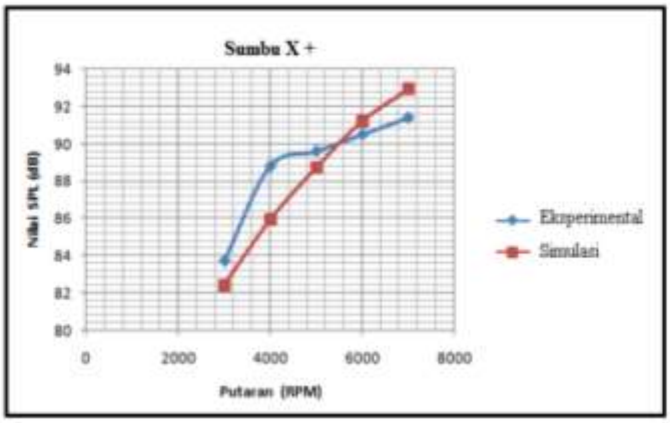

Figure 6. X+ axis validation graph

From the comparison graph above, where the X+ axis is the axis that leads to the right side of the aircraft wing, it can be seen that the noise value obtained from the simulation is directly proportional to the increase in engine speed with the highest noise, which is 92.9 dB. While in experimental testing, the noise that occurs is not directly proportional to the increase in engine speed with the highest noise, which is 91.4dB.

3.6.2. X-axis

Validation of the X-axis is shown in Figure 4.18 below.

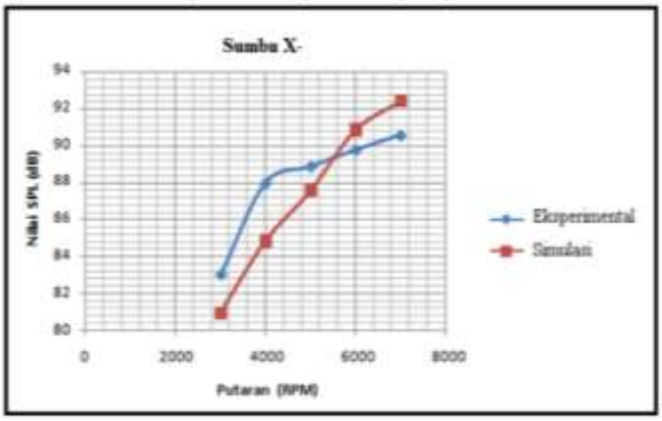

Figure 7. X-axis validation graph

3.6.3. Z-axis

The validation of the Z-axis is shown in Figure 4.22 below.

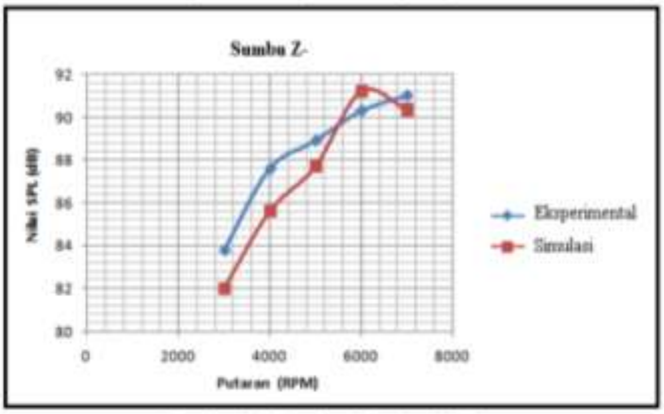

Figure 8. Z-axis validation graph

From the comparison chart above, where the Z-axis is the axis that leads to the front position of the aircraft right on the propeller. It can be seen that the results obtained from the simulation are not constant to the increase in engine speed with the highest noise, which is 90.3 dB. While in experimental testing the noise that occurs is not directly proportional to the increase in engine speed but is quite constant with the highest noise, which is 91.4 dB. This is due to differences in factors in computational and experimental tests, where experimental testing is strongly influenced by unstable environmental noise factors with the selection of different material properties in computational testing.

4. CONCLUSION

The conclusions in this study are: (1) Based on the simulation test results, it can be seen that the contour plot of noise that occurs between the capsuling exhaust and the aircraft tends to be uneven and breaks between 5000 to 7000 rounds, this is due to the fatigued acoustic properties of the material and loses its properties as a material. reducer as the engine speed increases. (2) Based on the simulation results of noise reduction on USU's NVC unmanned aircraft, the largest SPL noise value on the Y-axis is 94.6 at 7000 rpm rotation which leads to the bottom of the aircraft because the capsuling method applied is a partial enclosure where the exhaust exhaust holes are point where this method cannot be applied. While the capsuling method works well on the Y+ axis on the top plane of the aircraft which is a loose plane that is not bound by its distribution due to vibrations generated by other components on the aircraft with a noise generated of 79.2 dB at 3000 RPM rotation. (3) From the simulation results, the largest reduction is 11.9 dB on the Y+ axis with 3000 rpm rotation and the smallest reduction is 0.15 dB on the Z+ axis with 6000 rpm rotation. (4) From the results of computational and experimental noise reduction, it is found that the exhaust noise reduction value is close to but there are still differences in the noise value. (5) % error from experimental and simulated noise measurement results on USU's NVC aircraft (Table 4. 5) occurs due to the selection of the type of material that can be used during the simulation is a general material and is limited in nature so that the construction material is the same for each design. Another factor that causes the error is the difference in the shape of the aircraft geometry and the actual exhaust capsulating design with the geometry in the simulation and this simulation is carried out in a 3-dimensional acoustic room with a steady position, while experimental testing is carried out in an open environment where it is strongly influenced by factors surrounding the condition of the aircraft. dynamic one.

Suggestions in this study are: (1) For further researchers, it is hoped that they can design a low noise exhaust design from composite materials to get a better noise reduction value. (2) For further researchers, it is hoped that they can build designs from different materials for each component of the aircraft so that the results obtained are better. (3) Future research is expected to be able to conduct tests in dynamic conditions to obtain actual results.

ACKNOWLEDGEMENTS

We would like to thank all those who have contributed to this research, so that the research can be carried out properly.

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