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Analysis of Water Ingress of Composite Sandwich Structure on Cabin Floor of Airbus A330 Aircraft Using ANSYS

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Abstract - The rapid advancement of aviation technology necessitates rigorous structural evaluations to ensure safety and efficiency. This study focuses on analyzing water ingress in sandwich composite structures used on the cabin floor of the Airbus A330, employing Non-Destructive Testing (NDT) and simulation methods. Using thermography, areas with water ingress were identified, with darker regions indicating trapped moisture within the composite layers. Two cases were analyzed: one with areas requiring repair and another within acceptable damage limits as per the Structure Repair Manual (SRM). The study simulated the effects of pressure and temperature using ANSYS. Results revealed minimal pressure differences, with values ranging between 0 and 0.80 atm. Temperature simulations showed a range of 21°C to 24°C, suggesting potential condensation that could lead to water ingress. Structural simulations evaluated the composite's deformation, elastic strain, and stress distribution. The maximum deformation was 5.1138 mm, with elastic strain peaking at 0.0033772 mm/mm and stress von Mises reaching 591.74 MPa, well within the material's safety threshold. This research highlights the importance of periodic inspections and advanced simulation techniques in maintaining composite structures. Recommendations include utilizing additional NDT methods, such as ultrasonic testing, to enhance detection accuracy and investigating actual cabin conditions to refine future analyses.

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1. INTRODUCTION

The development of technology today has progressed very rapidly, one of which is the development in the world of aviation, especially airplanes. Airplanes are a mode of transportation that is quite popular with many people because of the distance and time that can be traveled quickly and safely. Airbus A330 aircraft is one of the aircraft used by several airlines in Indonesia to transport passengers from one area to another with a relatively extended route coverage. The technology used by the aircraft follows the manual issued by the relevant company, which affects the safety and comfort of the flight [1].

The increasing development of existing technology has increased demand for the materials used. Moreover, the aircraft industry is currently experiencing quite advanced progress. The demand for materials from various industrial worlds requires new materials that are needed today. Various types of new materials are currently made to meet this demand, one of which is composites [2].

Composites are materials formed from a combination of two or more forming materials and have properties different from those of the forming components. The use of composites has skyrocketed because composites have the advantage of being stronger, resistant to corrosion, more economical, and so on. Composites consist of a matrix that serves as an adhesive or binder and reinforcement from external damage and serves as a reinforcement [3]

Sandwich composites are made with the aim of optimal weight efficiency, yet high stiffness and strength. There are many different definitions of sandwich composites, but the main factor of the material is the lightweight core that minimizes the specific gravity of material and the strength of the skin layer that provides strength to the sandwich composite [4].

Based on the above description, periodic inspection of the composite, especially the cabin floor, is highly recommended. Considering that the cabin floor is one of the components that is quite meaningful for the accommodation of the crew and passengers on the airplane. Therefore, here the author will analyze the water ingress of the composite sandwich structure on the cabin floor using the Non-Destructive Test method and using ANSYS.

2. METHODOLOGY

In this research, a research flow chart depicts the steps in a process, system, or computer algorithm. These diagrams often use symbols, shapes, and arrows to show how one step leads to the next. So, the proper sequential research steps are needed to get maximum results. The research steps that will be carried out can be seen in the flow chart in Figure 1.

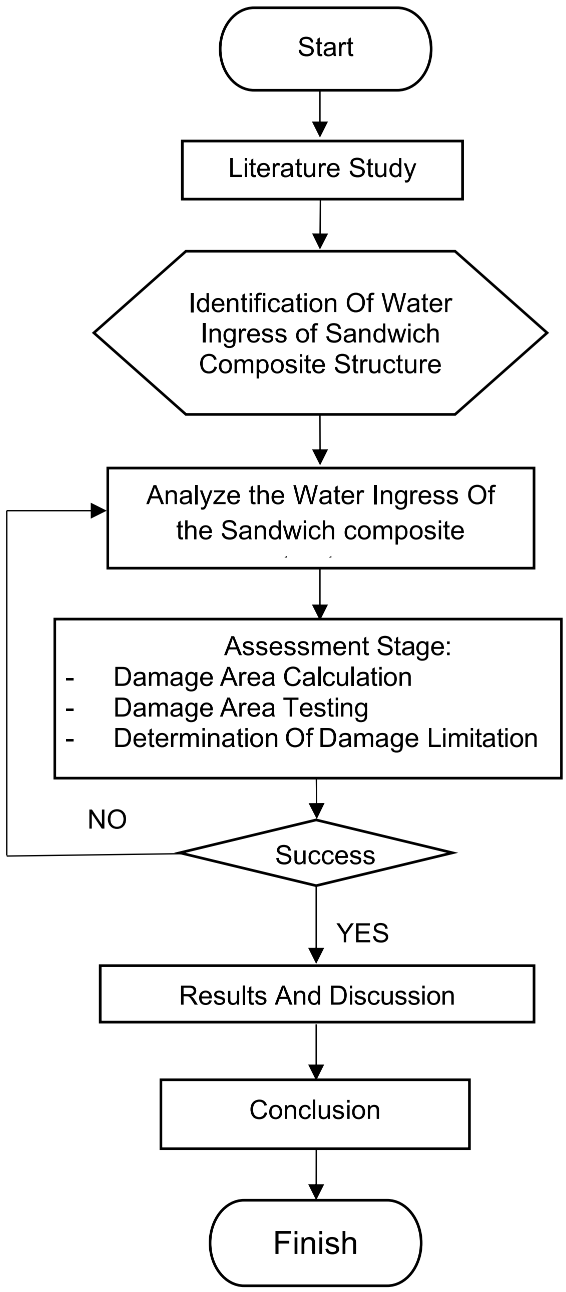


Figure 1. Research Flow Chart

Based on Figure 1, the initial process of research work begins with an oval shape filled with the word start. Then, it continues with a rectangular shape containing literature studies related to water ingress of composite sandwich structures. Then, proceed with the symbol preparation using a hexagon shape containing water ingress analysis. After that, it continues with the assessment stage, which contains calculations, testing, and determining the limitation of the damage area assisted by a rectangular shape. Then, the assessment process will be declared successful or not with the help of a parallelogram. If the assessment process is unsuccessful, the re-assessment process will be carried out, and if it is successful, it will continue with the process of determining the results and discussion; then, conclusions will be conclusions were drawn, and the entire research will be completed.

In this research, the object of this research is the cabin floor structure that uses composite sandwich materials on the Airbus A330. It can be shown at Figure 2.

Figure 2. Cabin Floor

The workflow of completing this thesis proposal in terms of damage analysis of the composite sandwich structure on the cabin floor of the Airbus A330 aircraft. It consists of several stages, namely as follows:

1. Initial preparation stage
2. Data analysis stage
3. Data review stage
4. Completion stage.

2.1 Initial Preparation Stage

This initial preparation stage will describe the preparatory steps that the author will take in the process of identifying the water ingress area of the composite sandwich structure on the cabin floor as follows:

A. Thermograph Method Instrument Setup Process

The process of setting up this instrument is carried out to determine the emissivity, which will be a measure of the ability to emit infrared energy, then determine the temperature range that will be used and adjusted to the temperature around the test location, and also the color palette which functions determine the color we will choose which consists of primary colors, accent colors, and colors that are lighter or darker than the primary color.

The thermograph method uses infrared camera techniques to detect and measure temperature variations or heat that will be emitted by firing directly at the cabin floor surface to be tested. The detection and measurement results will be converted into an image called a thermogram. The process of setting up the thermograph instrument that will be used during the water ingress identification process can be seen in Figure 3 below:

- Emissivity: 1 %
- Temperature Range: -20° C to 120° C
- Color Pallete: Hot White

Figure 3. Thermograph

B. Honeycomb Replacement Process

Honeycomb is one of the composite materials that serves to reduce the weight of the structure while maintaining the required characteristics and also the old honeycomb is inevitably damaged due to water trapped in it. The following are the stages in the process of replacing the honeycomb identified by water ingress so that the damaged composite core can be replaced with a new honeycomb so that it can return to its original composite structure.

The first step that must be done is to open the outer skin in the area indicated by the water ingress with sandpaper or sanding using a sanding machine. This sanding process aims to remove the outermost layer of the water ingress area. This sanding process is done slowly until it meets the honeycomb core. The sanding machine used can be seen in Figure 4 below.

After the sanding process is completed, the second step is the process of cutting the honeycomb core in the area that has been determined by the marking. The honeycomb core cutting process uses a cutting wheel tool so that the cutting results are neat and precise. The cutting wheel tool can be seen in Figure 5 and the results of the honeycomb cutting can be seen in Figure 6.

Figure 4. Sanding Machine

Figure 5. Cutting Wheel

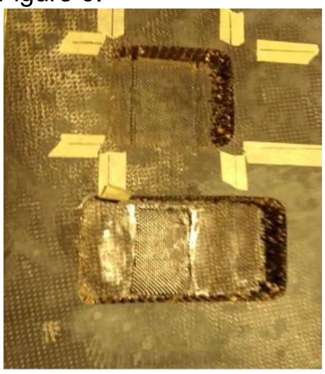


Figure 6. Honeycomb Cut

The third step is to replace the honeycomb that has been cut to be replaced with a new honeycomb. The size of the new honeycomb is adjusted to the size of the old honeycomb cut so that it is precise when installed so that there is no space around the honeycomb that has been cut and the new honeycomb.

Honeycomb that does not suffer from water ingress. Before installation, the honeycomb is coated with resin. The outside is coated with paste adhesive (epoxy) according to the thickness of the surface around the area that is not repaired. The process of coating paste adhesive (epoxy) is done thoroughly and in as much detail as possible without leaving the slightest gap so that no water re-enters the honeycomb. The process of replacing the new honeycomb can be seen in the Figure 7.

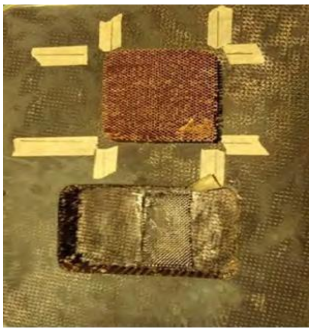


Figure 7. New Honeycomb Replacement

The fourth step is the wet lamination process. In this wet lamination process, several steps must be taken, namely providing a green nylon cloth that serves to coat and separate the honeycomb that has been given resin and coated with paste adhesive with a plain iron plate that will serve to press the surface of the area that has been replaced with a new honeycomb. The nylon cloth can be seen in Figure 8, and the plain iron plate can be seen in Figure 9. Then, on top of the plate, we coat it with an air breather that functions air circulation so that no air is trapped during the vacuum process. The air breather can be seen in Figure 10. After that, the topmost layer is vacuum foil plastic, which will be the outermost layer when the vacuum process is carried out. The plastic vacuum foil can be seen in Figure 11.

Figure 8. Nylon Cloth

Figure 9. Iron Plate

Figure 10. Air Breather

Figure 11. Vacuum Foil

The fifth step is the vacuum process. This process requires vacuum foil plastic that is wider than the repaired area and is installed using bagging tape or foam so that it is easy to shape following the vacuum foil plastic. Bagging tape can be seen in Figure 12. This vacuum process is assisted by using a hose as a link between the repair area and the vacuum generator, and the hose can be seen in Figure 13. Then, the vacuum generator functions as a tool for suctioning air in the repair area, which can be seen in Figure 14, and also the infrared lamp functions for the repair area.

accelerates the curing of the resin used and can also be seen in Figure 15. Maximum vacuum generator pressure at -0.9 bar. The vacuum process lasted for 3 hours and can be seen in Figure 16. Then the vacuum process has been completed. So that the plastic vacuum foil can be removed.

Figure 12. Bagging Tape

Figure 13. Hose

Figure 15. Vacuum

Figure 16. Infrared Lamp

2.2 Analysis Stage Data

At this stage the author analyzes the water ingress of composite sandwich structures on the cabin floor, supporting tools are needed to get the right results. The analysis stage is carried out at PT GMF AeroAsia.

2.3 Assessment Phase Data

After analysis, the next stage is assessment, where the data obtained is converted into reports and writings. At this stage, if the research results are not correct, then the analysis can be carried out again.

2.4 Stage Completion

This stage is the last. At this stage, the author will complete all deficiencies in analysis, research, and writing.

3. RESULTS AND DISCUSSION

This chapter will discuss the results and data analysis of the results of the NDT process that was carried out on the composite sandwich structure on the cabin floor that had been prepared and measured. In this chapter, there will be several sub-chapters that will be described, including the results of identifying water ingress with the thermograph method, analyzing test results and measurements, identifying water ingress areas that require repair processes, analyzing the results of areas experiencing water ingress, repairing areas experiencing water ingress and replacing honeycomb.

3.1 Results of Water Ingress Identification with Thermograph Method

The results of the identification of Water Ingress in the composite sandwich structure on the cabin floor with the thermograph method can be seen in Figure 17. The process of identifying water ingress using a cleaning cloth tool.

Then, after determining the area indicated by water ingress, the following process is marking to get a visual image and the area of water ingress that has been identified. The marking process is carried out using a tool, namely a marker, with the marker used to draw directly on the cabin floor surface by looking at the area found on the thermograph screen during the NDT process, the marking results can be seen as in Figure 18 below.

Figure 17. Identification results with Thermograph

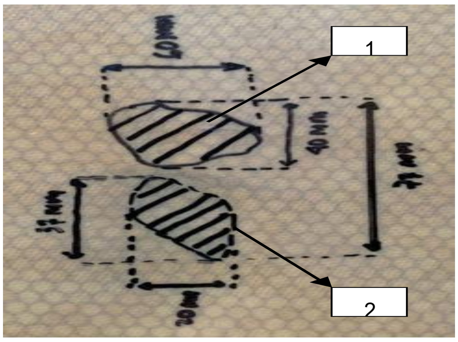


Figure 18. Results of Water Ingress Area Marking

3.2 Result Analysis Testing

Based on the results of the thermograph testing that was carried out, which can be seen in Figure 18, it is found that there are areas that indicate the presence of trapped water (water ingress) in the composite sandwich structure on the cabin floor. Through the thermograph tool, it can be seen on the monitor that the area containing water is dark in color. The darker the color, the more water content is trapped in the composite sandwich structure on the cabin floor.

In this area, two areas of water ingress must be calculated as follows:

Measurement in area 1 obtained an area of :
Area 1 = Length x Width
Area 1 = 60 mm x 40 mm
Area 1= 2,400 mm²

Measurements in area 2 obtained an area of:
Area 2 = Length x Width
Area 2 = 20 mm x 37 mm
Area 2= 740 mm²

So, to determine whether the area is still limited or not, it will be compared with the following Table 1. The results of the above measurements have obtained the results of area 1, which is 2,400 mm², and the results of area 2, which is 740 mm². Based on the damage limitation table, which can be seen in Table 4.1, it has been circled with a blue line which states that the damage size when the area or A≤ 3,000 mm^2, then the recommended repair reference is no repair necessary or needs for repair in the area that has indicated damage. So, when viewed from the two areas that have experienced water ingress, they fall into the no repair necessary category because the area is below 3,000 mm².

Table 1. Pure Fluid Ingress Table (Airbus, 2024)

						Inspect ion	Minimum distance between	Maximum number

Type of Damage	Damage size	Type of solution	Repair Category	Life Limit	Repair Reference	required after completion	ADL X"	ADL Y"	of damages per side shell and zone
Pure Fluid Ingress Damages in Zone P	A ≤ 3,000 mm^2(4.65 in^2)	Permanent ADL	A	None	No Repair necessary	No	<1>	100 mm (3.94 in)	2
	A ≤ 15,000 mm^2(23.25 in^2)	Permanent Repair	A	None	TASK 55-41-13-400-018 Figures 004, 005, and 006	No	<1>	75 mm (2.95 in)	<2>
	A > 15,000 mm^2(23.25 in^2)	Contact Airbus							

3.3 Identification of Water Ingress Areas That Need a Repair Process

In this research process, the author provides an example of identifying the water ingress area that needs a repair process with the aim of comparing the water ingress area that needs a repair process and the water ingress area that does not need a repair process according to the limitations.

The following is the water ingress area on the composite sandwich structure on another cabin floor, which can be seen from the identification results of the water ingress area, as shown in Figure 19.

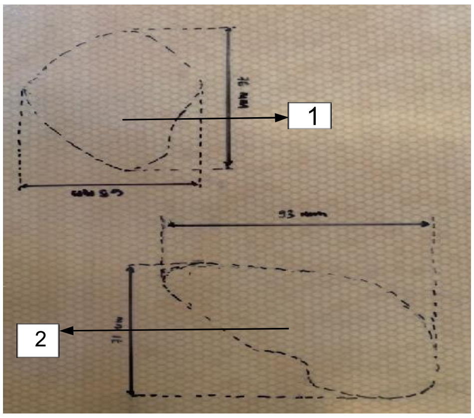
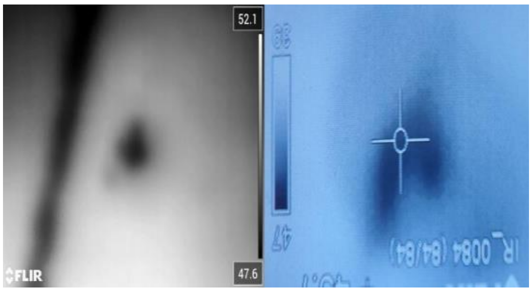


Figure 19. Water Ingress Area Marking

Based on Figure 19, it has been identified that two areas experience water ingress in the composite sandwich structure on the cabin floor, which has been given a number for each area. The identification results were obtained using the thermograph method. The visual screen on the thermograph can be seen in Figure 20.



(1) **(2)**

Figure 20. Visual Thermograph of Water Ingress Area

3.4 Results Analysis of Areas Experiencing Water Ingress

The results of the thermograph testing that was carried out can be seen in Figure 20, obtained from numbers 1 and 2. Get the result that an area has been found that indicates the presence of trapped water (water ingress) in the composite sandwich structure on the cabin floor. Through the thermograph method, it can be seen on the monitor that the area containing water is dark in color.

The darker the color, the more water content is trapped in the composite sandwich structure on the cabin floor.

After analysis, water ingress was found in the composite sandwich structure on the cabin floor. Therefore, it is necessary to measure the area indicated by water ingress as follows:

Measurement in area 1 obtained an area of:

Area 1 = Length x Width
Area 1 = 76 mm x 65 mm
Area 1= 4,940 mm²

Measurements in area 2 obtained an area of:

Area 2 = Length x Width
Area 2 = 93 mm x 71 mm
Area 2= 6,603 mm²

So, to determine whether the area is still limited or not, it will be compared with Table 2 as follows:

Table 2. Pure Liquid Entry Table (Airbus, 2024)

Type of Damage	Damage size	Type of solution	Repair Category	Life Limit	Repair Reference	Inspection required after completion	Minimum distance between ADL X"	ADL Y"	Maximum number of damages per side shell and zone
Pure Fluid Ingress Damages in Zone P	A ≤ 3,000 mm²(4.65 in²)	Permanent ADL	A	None	No Repair necessary	No	<1>	100 mm (3.94 in)	2
	A ≤ 15,000 mm²(23.25 in²)	Permanent Repair	A	None	TASK 55-41-13-400-018 Figures 004, 005, and 006	No	<1>	75 mm (2.95 in)	<2>
	A > 15,000 mm²(23.25 in²)	Contact Airbus							

The results of the above measurements have obtained the results of area 1, which is 4,940 mm², and the results of area 2, which is 6,603 mm². Based on the damage limitation table, which can be seen in Table 2, it has been circled with a blue line which states that the damage size when the area or A≤ is 15,000 mm², then the recommended repair reference of the two areas that have been calculated is permanent repair or the need for repair in areas that have indicated water ingress.

3.5 Water Ingress Repair Process

The repair process for areas experiencing water ingress is only outlined in the outline of the repair process for handling the composite sandwich structure on the cabin floor. The stages of the composite repair process that indicate water ingress are as follows:

a. opened the outer skin on the area indicated by water ingress with the help of a sanding machine,
b. cut the honeycomb core with the cutting wheel,
c. Replace the honeycomb that has been cut with a new honeycomb that is sized according to the area that has been cut,
d. The wet lamination process has many stages, starting from the provision of nylon fabric, plain iron plate, air breather, and vacuum foil plastic.
e. Vacuum the area to be repaired with the help of bagging tape, a hose, and a vacuum generator.

3.6 Honeycomb Replacement

After the vacuum process has been completed, the next step is the *heating* process for 1-2 hours on the *repaired* area with a temperature of 35 ° C. then the last step is the finishing process, namely the *sanding* process so that the surface is flat with the skin surface. The final results of the *composite sandwich* structure repair process on the *cabin floor* can be seen as shown in Figure 21.

Figure 21. Final Result

3.7 Analysis of Water Trapped Between Outer Layers with Honeycomb

Water ingress that has been identified between the outer layer and the honeycomb, it is found that the trapping of water in the composite sandwich structure is due to its location in the lavatory or toilet area inside the aircraft. And also quite adjacent to the location of the galley or kitchen area of the aircraft whose location tends to contain more water so that it is possible that the area can experience leaks from any existing system.

The identified water ingress has also been found to be influenced by the pressure and temperature at the location. Air pressure in the aircraft cabin is set at an altitude of about 2,500 meters to maintain passenger comfort. The ideal air pressure in an aircraft cabin when flying at cruising altitude is between 6,000 and 8,000 feet.

The temperature inside an airplane cabin usually ranges from 22-24° Celsius or 71-75° Fahrenheit. This lower temperature is regulated to keep passengers and crew comfortable and to improve aircraft performance. The air temperature inside the aircraft cabin tends to be very dry. The cooler temperature helps to slow down the loss of body fluids so that our body feels too cold temperature in the area around the aircraft cabin. Even though the temperature has been set in the range between 21 – 24° Celsius, the actual temperature felt tends to be below the range. The temperature is not only felt by passengers and crew but also by materials and components around the aircraft cabin, such as the lavatory area, galley, and cabin area, so dew may occur in the area of the composite sandwich structure that has been identified as water ingress.

The sandwich composite structure that has been identified with water ingress is also found to have a deviation in the composite. This is indicated by the disbanding between the outer layer and the honeycomb when opening the outer skin of the composite material, therefore increasing the results of the water ingress analysis on the composite sandwich structure. The author will add some simulation data using ANSYS related to pressure and temperature in the area around the composite that identified water ingress, namely the lavatory.

3.8 Pressure and Temperature Simulation Using ANSYS

Simulation of pressure and temperature using ANSYS aims to analyze how much *pressure* and *temperature* in the lavatory with the air speed in the cabin entering the *lavatory*. Thus creating different *pressure* and *temperature* in the *lavatory*.

Simulations were conducted with a compressible fluid flow model using the k-epsilon RNG turbulence model to describe the flow. Boundary Condition The air inlet velocity is 0.5 m/s. The air velocity inside an aircraft lavatory may range from 0.1 to 0.5 m/s, depending on the design of the aircraft ventilation system and the airflow arrangements in the area. These velocities are low enough to avoid disturbing passenger comfort and maintain the air quality inside the *lavatory*. However, this speed may vary depending on the design of the aircraft and the ventilation system used.

The following will describe the simulation results related to water ingress analysis using ANSYS:

A. Pressure

The outlet pressure used is 0.75 atm. Aircraft cabin pressure is usually maintained at the equivalent of 8,000 feet above sea level (approximately 75-80 kPa or 0.75 atm). Although airplanes fly at altitudes of 30,000 to 40,000 feet, the air pressure in the cabin is controlled to maintain passenger comfort, with a pressure equivalent to 8,000 feet.

The pressure in an airplane lavatory follows the same principle as the rest of the aircraft cabin, which is about 75-80 kPa or 0.75 atmospheres in general. So, the pressure in an airplane lavatory is approximately 0.75 atmospheres or about 75-80 kPa, just like the pressure in a typical airplane cabin.

The following are the main results of the airflow simulation in the lavatory design using ANSYS related to pressure.

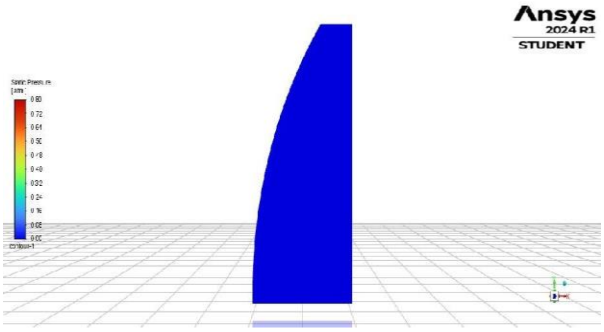


Figure 22. Simulation Results of Air Flow in Pressure-Related Lavatory Design

Based on Figure 22, the simulation of airflow assembled pressure or pressure, and the results show that the minimum value of pressure is at point 0 atm and the maximum value of pressure is 0.80 atm because the input value is minimal, so there is no significant difference in pressure or pressure.

B. Temperature

The temperature in a lavatory (airplane bathroom) is usually controlled to provide comfort for passengers. In general, the temperature inside an airplane lavatory ranges from 21°C to 24°C (approximately 70°F to 75°F), although this can vary slightly depending on the type of aircraft and airline preferences.

However, it is important to note that the temperature inside the airplane lavatory tends to be slightly cooler compared to the airplane cabin space due to the limited heating and air circulation system present in space. Typically, the airplane cabin temperature itself is set within the range of 22°C to 24°C.

The following are the main results of the airflow simulation in the lavatory design using ANSYS related to temperature or temperature.

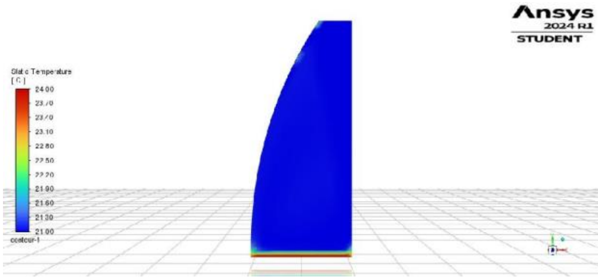


Figure 23. Simulation Results of Air Flow in Lavatory Design Related to Temperature

Based on Figure 23, simulation air flow-related temperature, the results show that the minimum value of temperature or *temperature* is at point 21°C, marked in blue, and the maximum temperature or *temperature* at point 24°C, marked in red on the floor.

So, the CFD test results above show that this lavatory design has a maximum pressure value of 0.80 atm and a maximum *temperature* value of 24 degrees Celsius.

3.9 Simulation of Structural Test of Composite Floor Using ANSYS

The composite floor structural test simulation aims to analyze the structural strength of the composite floor. This test also aims to ensure that the component can withstand the pressure received during regular operation without failing due to excessive stress or deformation.

The structural test simulation of the *composite floor* was carried out using the ***Finite Element Method*** (***FEM***) to calculate the distribution of stress, deformation, strain, and stress von Mises. Model Geometry is performed using a 3D *composite floor* model created using CAD software and then imported into ANSYS for further analysis. The limiting conditions used in the form of tensile *pressure* are determined with a value of 500 MPa, and the limiting / *fixed* conditions are determined at the opposite end of the pressure direction. The material used is *composite carbon fiber* with material properties such as elastic modulus of 230 GPa, Poisson's ratio of 0.2 - 0.4, and tensile strength of 9,000 MPa.

The following will describe the simulation results related to *water ingress* analysis and the main results of the *composite floor* structural test simulation using ANSYS in the form of total deformation, elastic strain, and stress von Misses results as follows:

A. Deformation

Deformation is one of the results that have been carried out on *composite floor* structural tests using ANSYS. The results of this deformation aim to determine the description of changes in the shape of the *composite sandwich* material on the *cabin floor*. Simulation results related to the deformation formed can be seen in Figure 24.

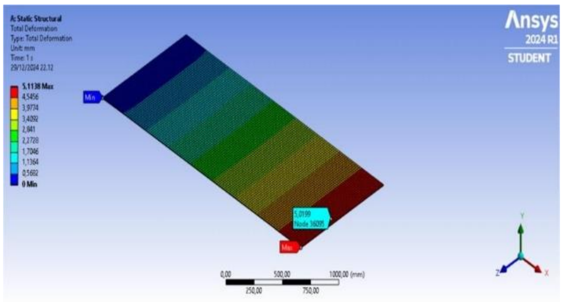


Figure 24. Deformation Simulation Results

If you look at Figure 24, it has illustrated the total deformation resulting from the simulation using ANSYS and obtained the results of the *composite floor* structural test related to the deformation that occurs as follows:

- Min deformation 0 mm
- Max deformation 5.11 mm

B. Elastic Strain

Elastic strain is a form of tension that causes distorted objects to return to their original shape and size when the deformation force is removed. The elastic strain test aims to determine the description of elastic strain on the *composite floor* that has been tested using an ANSYS structure and obtained elastic strain simulation results, which can be seen in Figure 25.

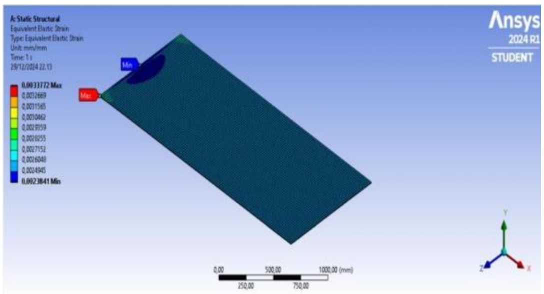


Figure 25. Elastic Strain Simulation Results

If you look at Figure 25, it has illustrated the results of the elastic strain simulation generated from the simulation using ANSYS and obtained the results of the *composite floor* structural test related to the elastic strains that occur as follows:

- Strain min 0.0023841 mm/mm
- Strain max 0.0033772 mm/mm

C. Stress Von Misses

Von Misses stress is a stress that is an indicator of material failure calculated by analyzing the resultant of three principal stresses. This von misses stress structural test aims to predict the yield of the material under loading condition. The simulation results related to von misses stress can be seen in Figure 26.

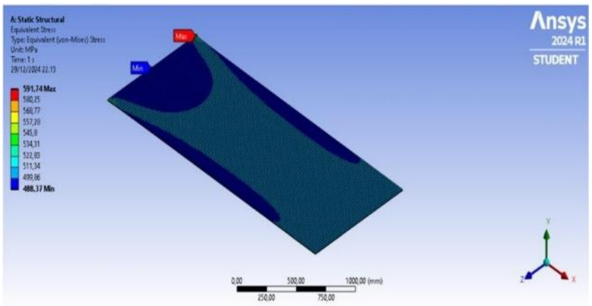


Figure 26. Simulation Results of Stress Non-Misses

When viewed in Figure 26, the following stress von Misses simulation results have been obtained:

- Stress min 488.37 MPa
- Stress max 591.74 MPa

Based on the results of the stress von Misses analysis using A, the *composite floor* has a maximum stress value of 591.74 MPa; this figure is still far from the safe word of 900 MPa tensile strength. Since the maximum stress observed (591.74 MPa) is significantly lower than the tensile strength threshold (900 MPa), the composite floor is not at immediate risk of failure due to excessive stress. However, it's still essential to assess other factors, such as fatigue, stress concentration areas, and environmental conditions, that could impact long-term performance. If necessary, further refinements in design or material selection could enhance durability.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

The results of research and analysis that have been carried out regarding the analysis of *water ingress of composite sandwich* structures on the *cabin floor* using ANSYS can be concluded according to the research objectives:

1. The results of *water ingress* detection using the NDT process, namely *thermograph*, found two areas of the *composite sandwich* structure on the *cabin floor* that indicated *water ingress*. Through the *thermograph* tool, it can be seen on the monitor that the area containing water is dark in color. The darker the color, the more water content is trapped in the *composite*.
2. The measurement results of the first case area 1 amounted to 2,400 mm² and area 2 amounted to 740 mm². while the second case area 1 amounted to 4,940 mm² and area 2 amounted to 6,603 mm².
3. Simulation analysis found that the *composite sandwich* structure area has a minimum pressure value of 0 atm and a maximum pressure of 0.80 atm so that it can experience a decrease in the strength of the *composite sandwich* structure on the *cabin floor.*
4. Simulation analysis found that the minimum temperature value is 21°C, and the maximum temperature value is 24°C. However, suppose the actual temperature conditions are below the minimum conditions. In that case, it can cause condensation and make water trapped on the *cabin floor* due to the lack of heating and air circulation systems in the area.
5. The analysis of the structural test value of the *sandwich composite* on the *cabin floor* obtained the results of the total deformation test with a minimum result of 0 mm and a maximum result of 5.1138 mm, the *elastic strain* test with a minimum result of 0.0023841 mm/mm and a maximum result of 0.0033772 mm/mm, and the *stress von misses* test with a minimum result of 488.37 MPa and a maximum result of 591.74 MPa.

4.2 Suggestions

From the research and analysis conducted by the author, several things need to be addressed and improved, namely as follows:

1. NDT methods carried out using *thermographs* can only see *water ingress*, so it is necessary to use other NDT methods in order to get more varied results and analysis.
2. It is hoped that further research will use the actual dimensions of the design in the *lavatory* room where the damage to the *composite sandwich* structure on the *cabin floor* occurs.
3. It is hoped that in future research, other NDT methods such as ultrasonic can be used to detect damage such as *disbonding* in a composite material.

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