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Study for Structure Analysis for Different Material Use for VTOL Drone

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Abstract: This project research was focusing on making the structure analysis for different material that can be used for VTOL drone. In this research there are five different configuration of material use for VTOL drone. The best material will be choosing. The study involved analyzing the 3D model of the base design of VTOL drone to understand its components, connectors and other elements. static analysis was conducted on the respective assemblies to observe the strain, displacement, and von Mises stress experienced by the wings and quad arms during the drone hovering. The research methodology employs with designing the 3D VTOL drone and static simulation. Subsequently, the results that been obtained are carefully evaluated. The simulation findings that selecting the material give different effect on VTOL drone during hovering.

Keywords: Acrylonitrile Butadiene Styrene (ABS), Polycarbonate/Acry lonitrile butadiene styrene (ABS PC), High Density Poly Ethylene (HDPE), Expanded Polystyrene (EPS).

1. Introduction

Drones, also known as unmanned aerial vehicles (UAVs), are aircraft that operate without a human pilot, crew, or passengers on board. They are essentially flying robots controlled remotely by human operator. Initially developed for military purposes during 20th century, drones now become indispensable assets for most militaries. However, with advancements in control technology and reduced costs, the use of drones has expanded beyond military applications. Today, drones find numerous non-military uses like aerial photography, product delivery, agriculture, law enforcement and surveillance, infrastructure inspections, amusement, scientific research and drone racing [1].

In this research, it focusing only on VTOL drone design. These drones are a combination of helicopters and fixed-wing aircraft, incorporating the functionalities of both. They have advanced features, including improved payload capacity, efficient hovering similar to helicopters, and faster cruise speeds compared to fixed-wing aircraft. VTOL drones also have ability to vertically take off and

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land at high speeds, and they are being developed in various countries. The objective of this research is to analyze five different configuration of VTOL drone using the different materials. The aim is to compare these configurations and determine which materials yields the best results for structural analysis of VTOL drones [2].

2. Materials and Methods

The objective of this research is to analyze five different configuration of VTOL drone using the different materials. For the simulation, the base design of VTOL drone was created, the force that held for this simulation is 38N which it have been multiply with safety factor value of 1.5. In this simulation they were held with five configurations which contain different material properties for every single component at VTOL drone body part. For configure 1 the main mate rial is ABS PC, configure 2 use ABS plastic, configure 3 use Polystyrene (High Density Poly Ethylene (HDPE) material, configure 4 use EPS) material and configure 5 use carbon fiber as main material. Expanded. Four forces will be applied, each positioned at a different rotor location additionally, the center of gravity will be placed at the center of the drone’s body [3].

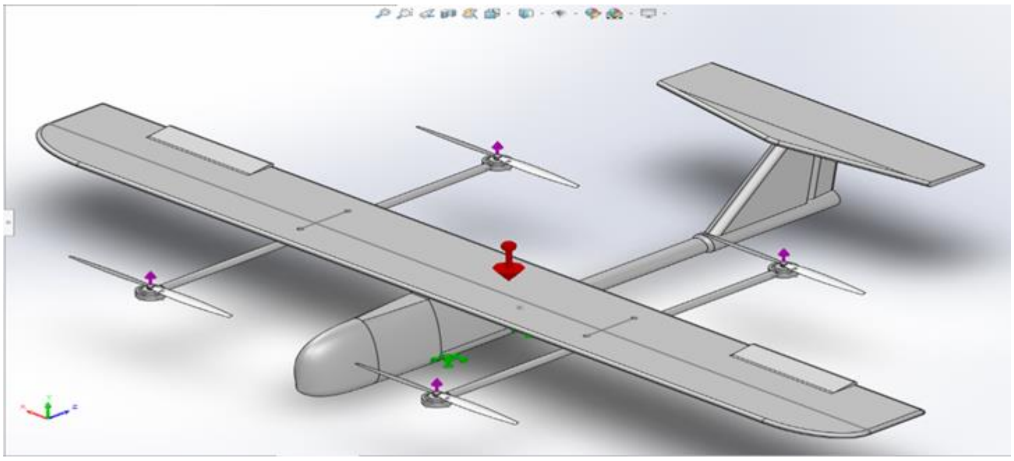

Figure 1: The forces is being placed on different position on VTOL drone

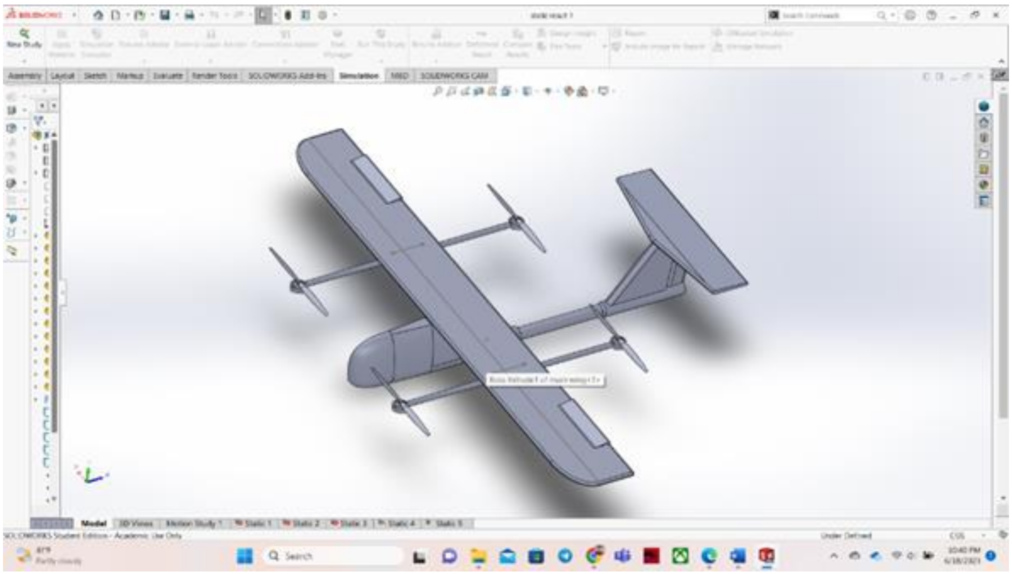

Figure 2: The base design of VTOL drone use for material simulation

2.1 Methods

There are steps for this research to be completed which by designing the base model for VTOL drone and the static simulation.

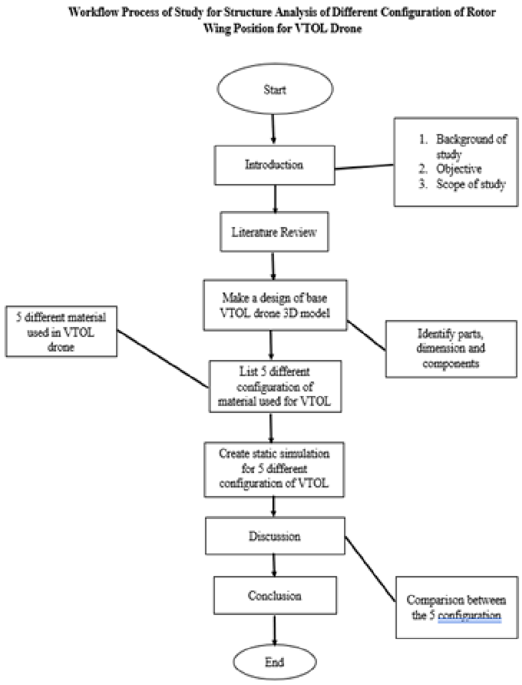

Figure 3: Workflow Process of Study for Structure Analysis of Different Configuration of Rotor Wind Position for VTOL Drone

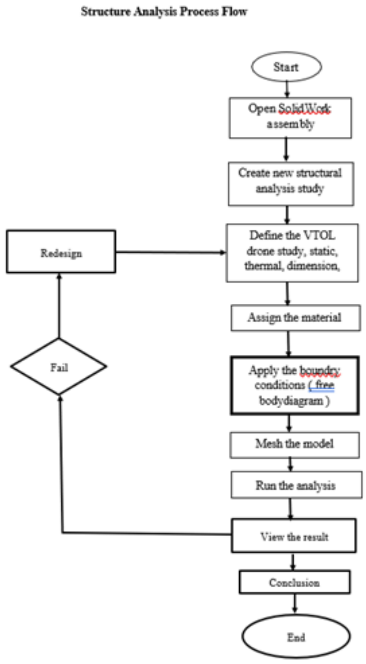

Figure 4: Structure analysis process flow

There are some mechanical properties of material that need to applied during the static simulation for VTOL drone, thus it will give different results for every different material.

Table 1: The material properties that being applied in this simulation

Properties	Carbon Fibre	ABS Plastic	Aluminium (2014)	HDPE	EPS Foam
Elastic Modulus (N/m^2)	231000E+6	2.00E+09	7.30E+10	1.07E+09	3300E+06
Mass Density (kg/m^3)	1.78E+03	1.02E+03	2.65E+03	9.52E+02	32
Poisson's Ratio	2.80E-01	0.394	3.30E-01	4.10E-01	0.12
Yield Strength (N/m^2)	4.55E+09	2.09E+07	2.17E+08	1.89E+07	1.55E+07
Tensile Strength (N/m^2)	4.55E+09	3.00E+07	2.24E+08	2.21E+07	3.00E+07

3. Results and Discussion

In this chapter, it shows the static simulation results that obtained from five different material use for VTOL drone.

3.1 Static simulation Analysis

According to Figures 5, 6 and 7, configuration 1, which uses (ABS-PC), demonstrate the lowest von Mises stress value of 1.920e+07 N/m^2. Also exhibits lowest strain value of 3.921e-04, while configuration 2 have higher strain value of 4.506e-04 for (ABS) plastic. Additionally, configuration 1 has smallest displacement of 1.816mm where configuration 2 has 2.425mm. Based from the comparison, it is clear that (ABS-PC) is a stronger material for VTOL drone compared to (ABS) plastic.

According from Figures 5, 6 and 7 also, configuration 3 uses (HDPE) material. It shows a higher von Mises stress value of 2.075e+07 N/m^2 compared to configuration 1 and 2. Furthermore, configuration 3 has higher strain value of 1.332e-03 compared to configuration 1 and 2. It also exhibits higher displacement values of 3.205e+01 compared to configuration 1,2 and 4. Based on this comparison, it is clear that (HDPE) is weaker than (ABS-PC) and (ABS) plastic material.

Configuration 4 shows a von Mises stress value that is lower than configuration 3 and 2, but higher than configuration 1 and 5, measuring 2.057e+07 N/m^2. In term of strain, configuration 4 has higher value than configurations 1, 2, and 5 but lower than configuration 3, with a value of 3.685e-04. Additionally, for displacement, configuration 4 has lowest value than configuration 1, 2, 3, and 5, measuring 1.083e+01mm. from this comparison, (EPS) foam material exhibits greater strength than (ABS) plastic, (ABS-PC) and (HDPE).

Configuration 5 use carbon fiber material, it shows the von Mises stress value is higher than configuration 1 but lower than configuration 2, 3, and 4, measuring 2.002e+07 N/m^2. In terms of strain, configuration 5 has lowest value compared to others measuring 4.822e_05. Furthermore, configuration 5 exhibits the lowest displacement compared to configuration 1, 2, 3, and 4, measuring 3.358e_01 mm. from this comparison, it is evident that carbon fiber material possesses greater strength than (ABS-PC), (ABS) plastic, (HDPE) and (EPS) foam. Therefore, carbon fiber material is stronger than others [4].

Among the different configurations, it was found that configuration 4, which used Expanded Polystyrene (EPS), is the most suitable material despite not being as strong as carbon fiber. (EPS) has a lower displacement value, making it more appropriate for VTOL drone. Other materials like (ABS) plastic, (ABS-PC), (HDPE), and carbon fiber can be considered. However, carbon fiber is the most appropriate choice in terms of strength and low displacement. On the other hand, (EPS) foam is superior to carbon fiber in terms of cost and material strength. While carbon fiber requires a higher investment, (EPS) foam is comparatively cheaper. Despite its lower cost, carbon fiber still possesses sufficient strength with von Mises stress value of 2.002e+07 N/m^2, considering the yield strength condition of 4550 Mpa [5].

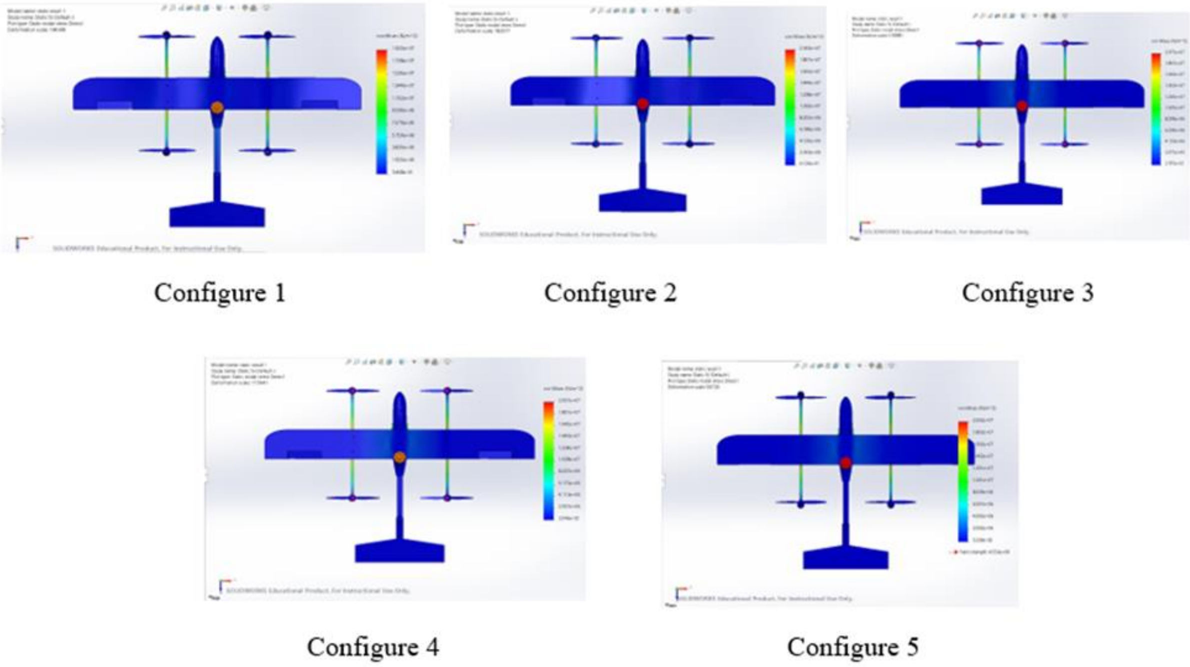

Figure 5: Five configuration of VTOL drone static simulation for von Mises stress results

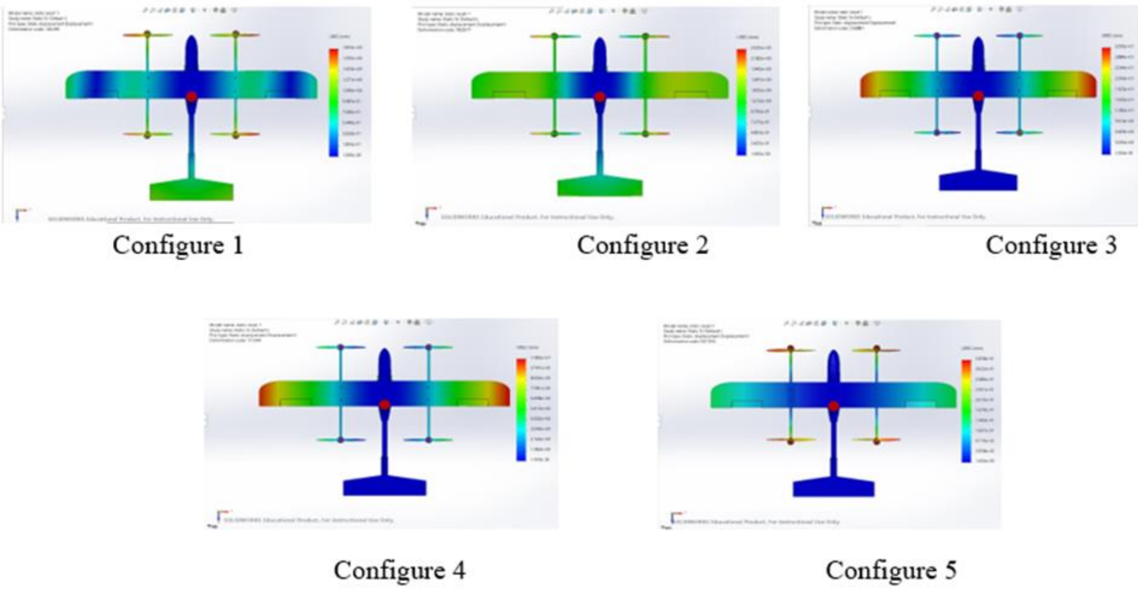

Figure 6: Five configuration of VTOL drone static simulation for displacement results

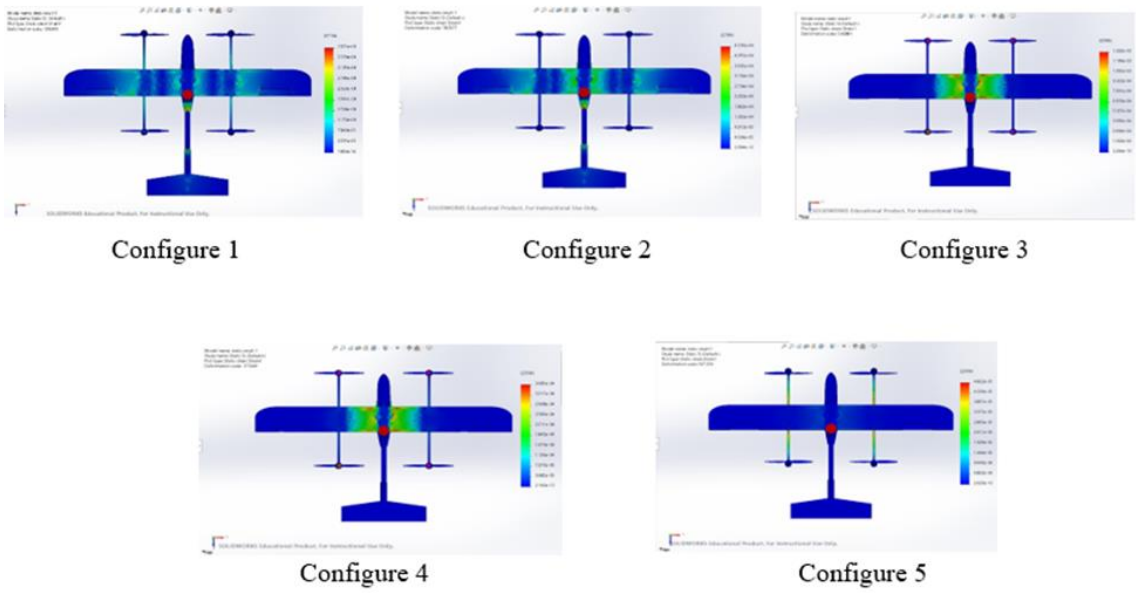

Figure 7: Five configurations of VTOL drone static simulation for strain results

4. Conclusion

In summary, the research successfully achieved its objective by conducting an effective static simulation of the 3D model of VTOL drone. The study presents the results of this simulation, which explored different materials for the drone. Based on the results presented in table 4-2, the best material for VTOL drone production is Expanded Polystyrene (EPS), offering low displacement value and high durability. Although carbon fiber has higher durability and the lowest displacement value, (EPS) foam material is cost-effective. As a result, all the objectives set at the beginning of the research in Chapter 1 have been successfully accomplished.

There are some recommendations in order to improving the accuracy of VTOL drone structure analysis research include focusing on specific materials for drone manufacturing and comparing them with different classifications or manufacturing processes used in industry. Additionally, utilizing software such as Ansys, Lisa, Sim center Nastran, and others to simulate the same material and design can help comparing the results and enhance the accuracy of the project. Lastly, improving the dimension of original VTOL drone design can be achieved by obtaining detailed catalogs from drone manufacturers or directly measuring from a real VTOL drone product by using precise measurement tools.

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