Reusing Materials in the Aerospace Industry – Utilizing Recycled PEEK and Aluminum 2024-T3 for Wing Spar

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Abstract

This research explores the material recycling methods used by the aerospace industry, particularly in comparison to the reusability of aerospace materials and with the objective to find uses for recycled materials from aircraft. Through an analysis of various other material mitigation methods, it is apparent that the physical degradation of materials after they go through recycling processes and the cost of recycling are the most prominent issues holding the aerospace industry back from being able to recycle aircraft up to 100%. From a comparison of the physical characteristics of materials after reprocessing, several materials were found to meet industry standards, while still being profitable, like poly ether ketone (PEEK) and aluminum. Not only is it necessary for material recycling methods to be improved to reduce the percentage of materials wasted, but the materials themselves. Regulations are closing in on materials that cause serious, long-term side effects on the environment and people. By using new manufacturing methods, these materials are strong enough to be candidates for structural components in the aircraft while also being safe to live long-term. However, the aerospace industry would need to be ready to change and work towards a similar goal.

Introduction

For decades, the aerospace industry has searched for ways to be more sustainable. Almost every company has a sustainability project that aims to reduce the waste and the cost of constructing and operating aerospace vehicles. The problem with most of these projects is that companies focus on creating entirely new concepts that the world does not have the means to insure. Although harmful byproducts of the aviation industry have been reduced recently, it is essential to continue with new ideas and research, as there are always things to improve. This paper analyzes a new wing spar made of core Recycle PEEK Filament printer by 3D printer and cover with Aluminum 2024-T3. PEEK plastic is one of the more robust thermoplastics used in the interarea of aircraft. Covering the Recycle PEEK Filament core with the Aluminum 2024-T3 will help increase the material's solidity and make it less deformity. Different exams have been made to test the material and conclude the results in this paper.

Materials & Methods

To theoretically test PEEK in a structural design, a composite-inspired design made of three c-sections was used. Starting with the PEEK Filament, which has a 19.05 mm thickness (for both the horizontal and vertical sides), a width of 85.6 mm, a height of 254 mm, and a length of 4000 mm. After that, the first c-section for the Aluminum 2024-T3 is in the inner part of the PEEK Filament with a thickness of 8.13 mm (for both the horizontal and vertical sides), a width of 66.5 mm, a height of 216 mm, and a length of 4000 mm. Lastly, a c-section of Aluminum 2024-T3 was created for the outer part with an 8.13 mm thickness for the horizontal portion and 16.3 mm for the vertical, a width of 102 mm, a height of 271 mm, and a length of 4000 mm. Figure 1 shows the measurements of the design created. The reason for making the outer part's vertical thickness larger than the horizontal is that this part will face the direction of the wing tip, which needs to be stronger to handle the effect of air, temperature, and pressure. After designing these parts, they will be joined together by rivets. The best way to put the part together is using rivets because they have lower weight, and it is easier to do maintenance on the material parts instead of destroying the design during a repair. The measurement of the part (Figure 1) was completed using CATIA-V5 since this program gives the correct design measurement needed to avoid high stress and add more strength to the part.

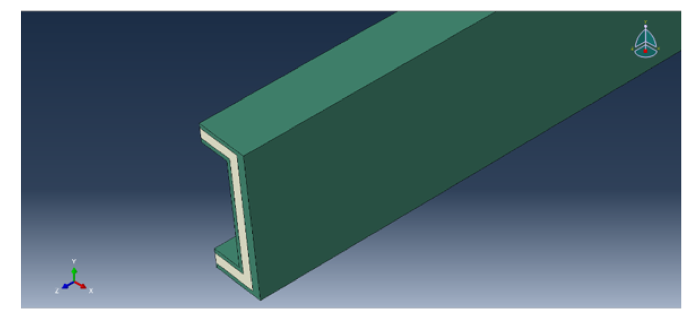
Acknowledgements

I would like to thank my mentor, Dr. Dae Won Kim, for all the help in guiding me through the research,

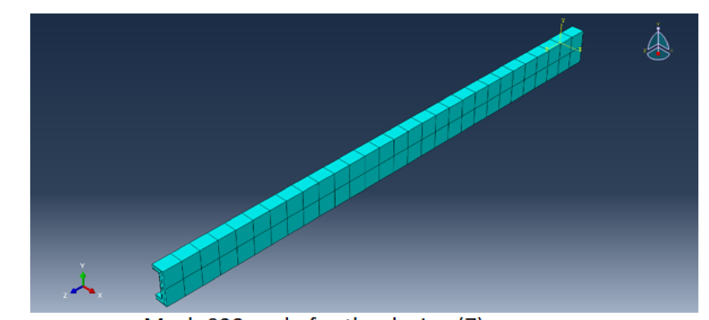
Dr. Habib Eslami for helping with the calculation,

Dr. Boutros Azizi for the help with the Abaqus analysis.

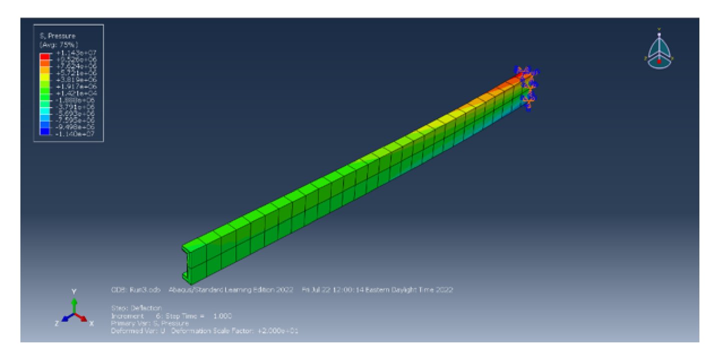
Results



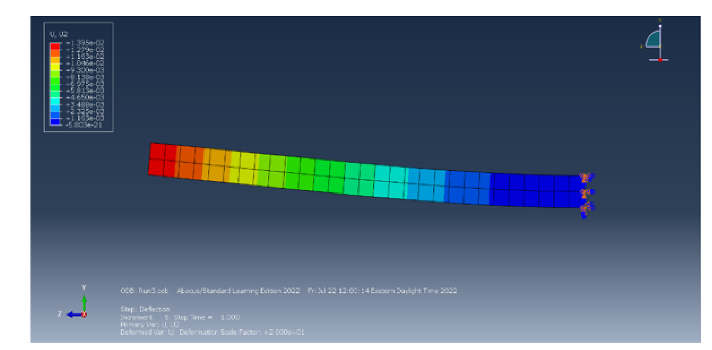
The front shape of the design (6)



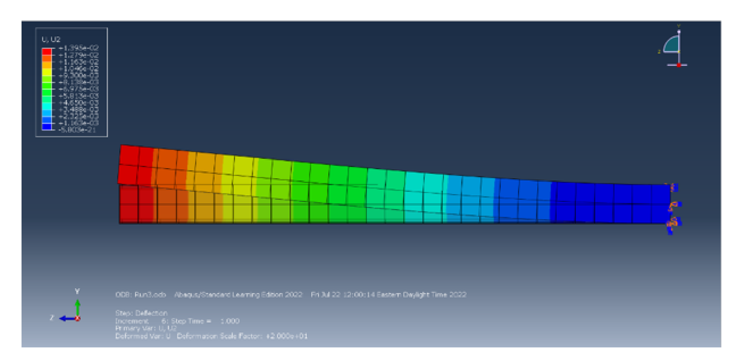
Mesh 930 node for the design (7)



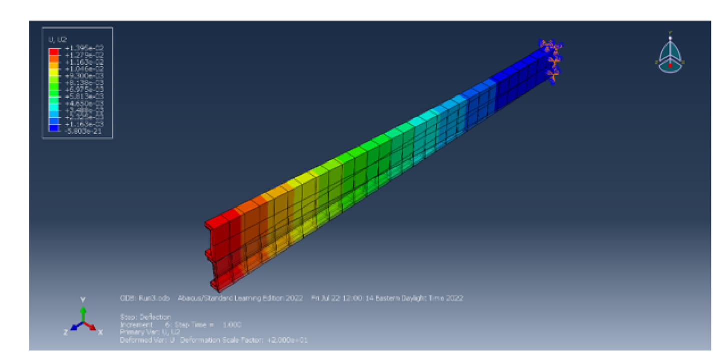
The affect pressure on the spar (8)



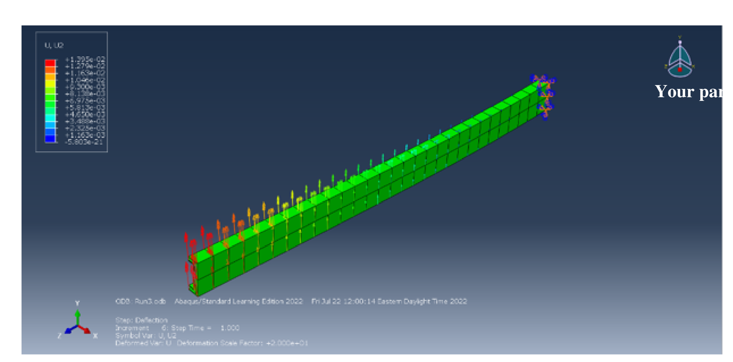
The deflection that created by lift force (9)



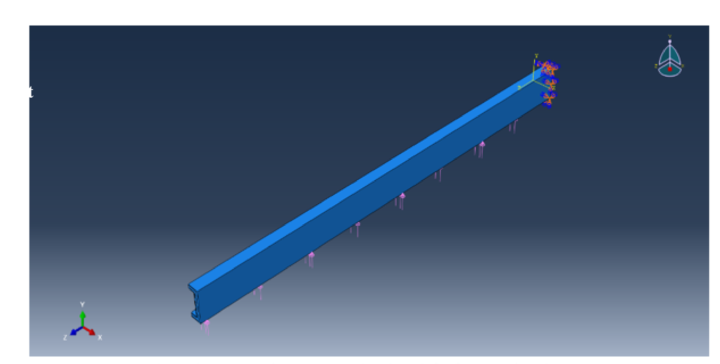
The side view for the deflection movement (10)



The front view for the delection movement (11)



The deflection with the lift force (12)



The design shape with the lift force (13)

Mechanical Variable	Value
I_z (Al 2024-T3)	216.2913 (in)
I_z (PEEK Filament)	92.5591 (in)
Cross Sectional Area (Al)	9.5104 (in^3)
Cross Sectional Area (PEEK)	14.86 (in^3)
Volume (Al)	1497.7 (in^3)
Volume (PEEK)	2340 (in^3)
Density (Al)	0.1 (lb./in^3)
Density (PEEK)	0.0469655 (lb./in^3)
Weight (Al)	199.4579 lb.
Weight (PEEK)	80.9876 lb.
Total Weight	280.4455 lb.
Allowable Yield Strength (Al)	5.8165E3 (lb./in^2)
Allowable Yield Strength (PEEK)	1.3592E4 (lb./in^2)
Young's Modulus, E	75.1 (GPa)

Table 1. The mechanical values of the wing spar design

Mechanical Properties	Regular, Small Wing Spar	Wing Spar Design
Young's Modulus, E	73.1 (GPa)	75.1 (GPa)
Total Weight	50 (lb.)	280.4455 (lb.)
Poisson's Ratio, ν	0.33	0.33
Thickness, t	2 (mm)	35.306 (mm)
Free Length, l_{tip}	706 (mm)	3999.992 (mm)

Table 2. Table comparing the mechanical properties of wing spar designs.

Results Analysis

Figure 9-12 shows how the wing spar deflects after applying twice the force of lift at the bottom of the wing spar. The wing spar design shows good strength. In this test, the spar was cut into 930 nodes (Figure 7). The more increase nodes the less deflection becomes. The 930 node is the max node to use in the Abaqus program but still shows how good the design is.

Figure 6 shows the final design shape of the wing spar. The yellow part is the core that is made from PEEK Filament while the green part is the aluminum 2024-T3 part that will cover the PEEK Filament. Combining these two materials will result in a high stand for fatigue cycle with good roughness which will make the design strong and not easy to bend. The design part joined together in the picture as perfectly as they create from the same material but in real life, they will join using a rivet which will not affect the result that much because they have a lower weight.

The way to test this design is by having a lower allowable yield strength of the material used in the design compared with the original value of the allowable yield strength of the same material. Table 1 shows the mechanical values of the wing spar design.

Table 2 shows the comparison between the wing spar design and a regular small wing spar in real life with 2 GPa differences but it has lightweight, and lower deflection because the regular wing spar has a small length compared with the design one. Besides that, the design uses recycled material which helps to protect the environment and lower the cost of production. This design will have the ability to live longer than the regular one since it is strong and has a high thickness to the weight which will be able to stand through multiple flights without getting affected.

Conclusion

In the aerospace industry, Plastic has never been used as the main part of aircraft due to safety reasons. This wing spar design is made from a composite plastic PEEK that has high strength covered by Aluminum 2024-T3 alloys that show successfully good intensity with young's modulus = 75.1 GPa, a lower weight, and a small deflection. This composite structure can be used to improve the aerodynamic efficiency of the wing for commercial aircraft or training aircraft. The change needs to start within aerospace manufacturers. Many companies are already pushing for this goal, but the aerospace industry would need to be willing to change and adapt to each other. I recommend expanding the work on this composite design to open the door to more ideas about a way to use recycled plastic in the aerospace industry. This will help grow the green industry and reduce environmental pollution.

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