ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
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www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

https://doi.org/10.5281/ijasem.2023.v17.i3.pp8-16

Vol 17, Issue 3, 2023

A COMPARATIVE ANALYSIS OF THE STATIC STRENGTH OF AIRPLANE SEAT BUCKLE AND LATCH MADE WITH CARBON FIBER T700 AND AISI 304 S.S

KOVURI ADITHYA[1], P. SENTHIL KUMAR[2]

[1]M.Tech Student, B V Raju Institute of Technology, Narsapur, Telangana

[2]Professor, B V Raju Institute of Technology, Narsapur, Telangana

Abstract

This research paper investigates the potential of carbon fiber in airplane seat buckle design. Carbon fiber is a lightweight and high-strength material that can be used to reduce the weight of seat buckles without compromising safety or efficiency. The study was conducted in two phases. In the first phase, carbon fiber-reinforced composite buckles were designed and subjected to rigorous experimental testing. The results of these tests showed that carbon fiber buckles can withstand loads that are comparable to those of traditional stainless steel buckles. In the second phase, the weight of carbon fiber buckles was compared to that of stainless steel buckles. The results showed that carbon fiber buckles are significantly lighter than stainless steel buckles. The findings of this study suggest that carbon fiber is a promising material for airplane seat buckles. Carbon fiber buckles can reduce the weight of airplanes, which can improve fuel efficiency and overall aircraft performance. Additionally, carbon fiber buckles are just as safe as stainless steel buckles, making them a viable alternative for the aviation industry. This study contributes to the ongoing pursuit of safer, more efficient, and environmentally conscious aerospace solutions. By establishing a foundation for the integration of innovative materials like carbon fiber, this project has the potential to revolutionize the aviation industry's approach to seat buckle design.

1. INTRODUCTION

The aviation industry is constantly looking for ways to improve safety, efficiency, and technological advancements. One fundamental aspect of this evolution lies in the design and engineering of aircraft components, with an emphasis on reducing weight while maintaining or enhancing performance. In this context, the current project sets its focus on a critical yet often overlooked component: the airplane seat buckle.

Airplane seat buckles are an essential safety feature that helps to protect passengers in the event of a crash. They work by securing the passenger to their seat, preventing them from being thrown around or ejected from the aircraft. However, traditional seat buckles are made of stainless steel, which is a heavy material. This can contribute to the overall weight of the

ISSN2454-9940

www.ijasem.org

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aircraft, which can reduce fuel efficiency.

Carbon fiber is a lightweight, high-strength material that has been gaining traction in aerospace applications. It is a good candidate for seat buckles because it can significantly reduce the weight of these safety-critical components. However, it is important to assess the impact of using carbon fiber on the safety and efficiency of seat buckles.

The primary objective of this project is to assess the impact of carbon fiber on the safety and efficiency of airplane seat buckles. Specifically, the project aims to achieve the following objectives: Investigate the extent to which carbon fiber-reinforced composites can reduce the weight of airplane seat buckles compared to traditional AISI304 stainless steel. Determine whether the weight reduction achieved through carbon fiber does not compromise the mechanical performance, strength, and integrity of the seat buckle under typical loading conditions.

Conduct a comprehensive comparative analysis between carbon fiber and AISI304 stainless steel buckles to evaluate their respective advantages and limitations. By attaining these objectives, the project endeavors to provide valuable insights into the feasibility of utilizing carbon fiber in aerospace seat buckle applications. The outcomes of this investigation hold the potential to inform future aerospace design decisions, leading to more efficient and environmentally conscious air travel solutions.

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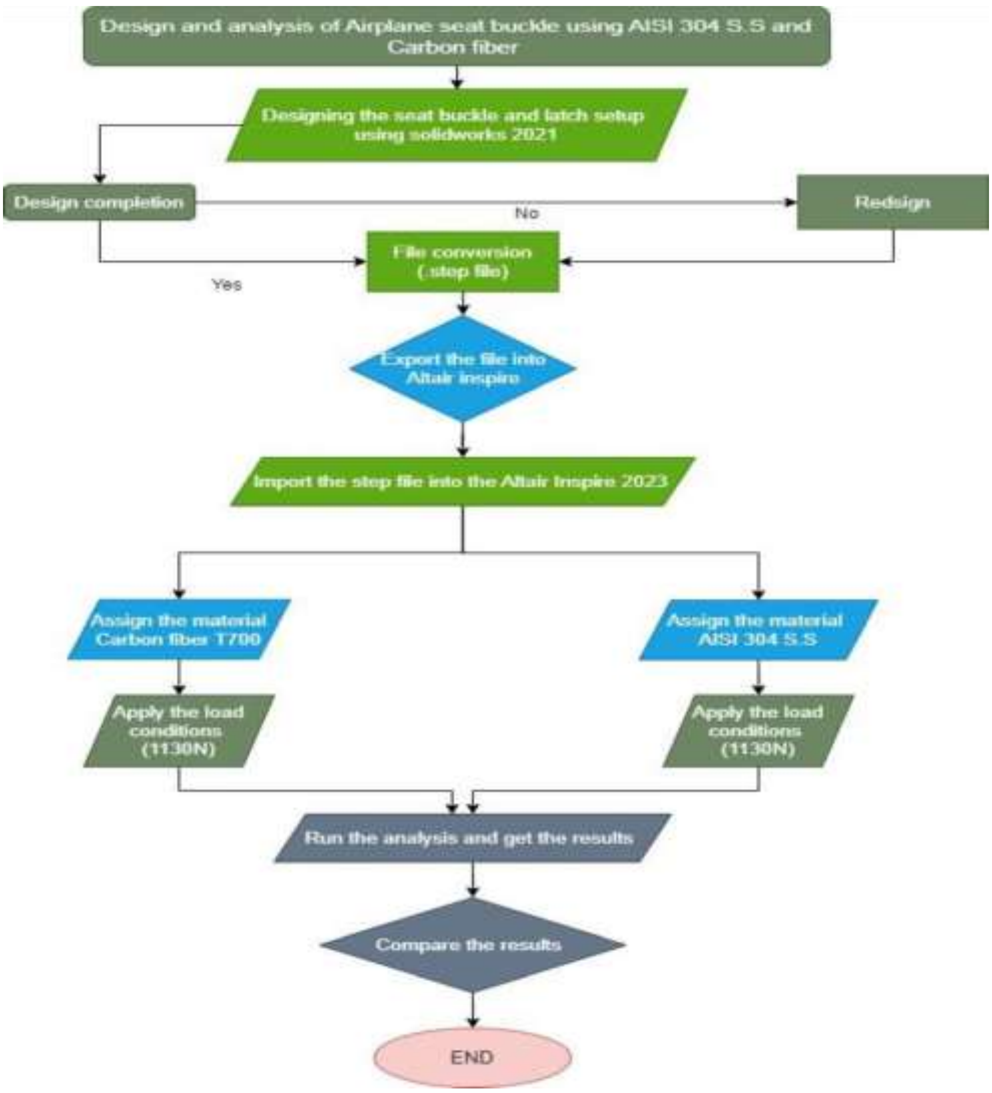
2. MATERIALS AND METHODS



The following materials and methods were used in this study:

Design: The airplane seat buckles were designed using SolidWorks. The buckles were designed to be as similar as possible, with the only difference being the material used.

Analysis: The buckles were analyzed using Altair Inspire. The analysis was performed using a finite element method (FEM). The buckles were subjected to a tensile load in the analysis.

Data: The data for the material properties of AISI 304 SS and carbon fiber T700 was obtained from the literature.

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2.1.1.1 Modeling in SolidWorks

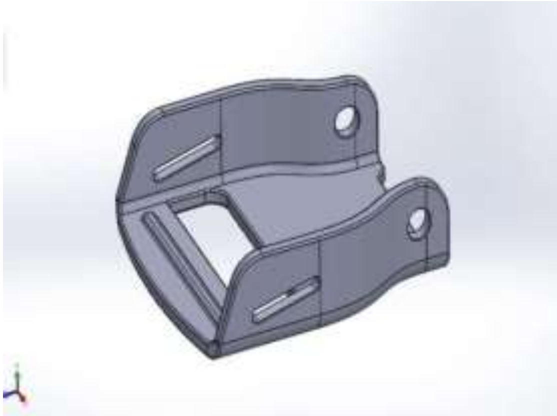
Figure 1 buckle base

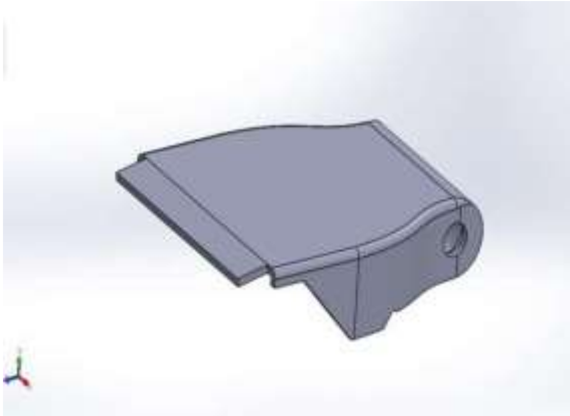
Figure 2 lever

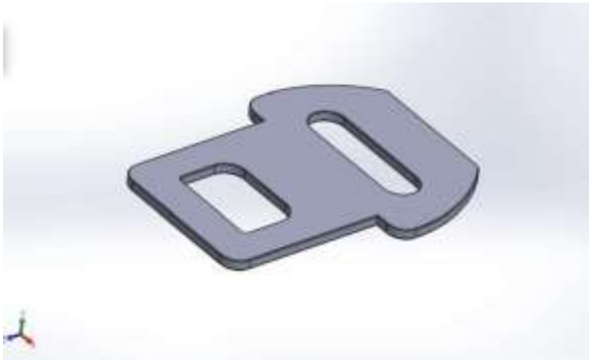
Figure 3 Latch

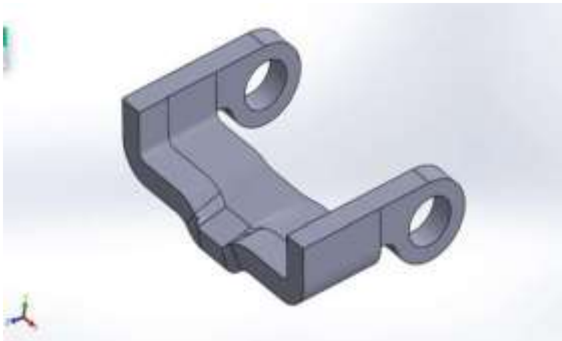
Figure 4 Pin


Figure 5 Axle F


Figure 6 Axle M

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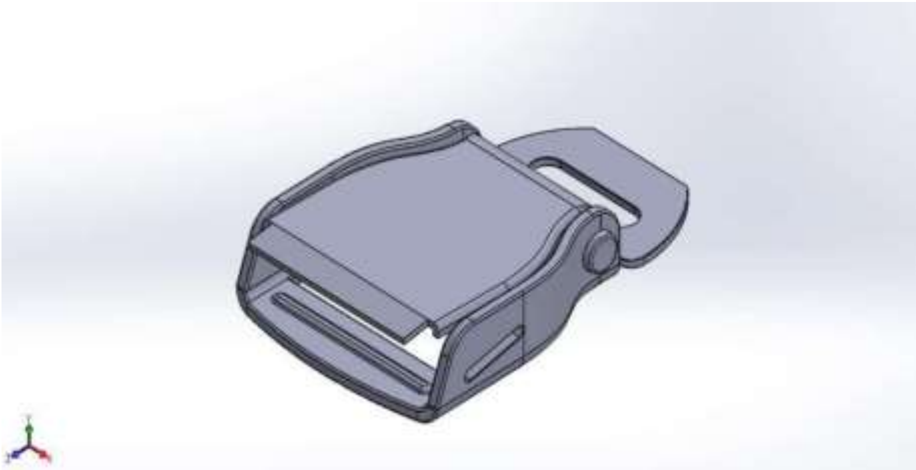

Figure 7 Seat Buckle assembly

The above mentioned Figures are the part files and the last Fig 7 is assembly file.

Analysis in Altair Inspire

Figure 8 Assembly File in Altair Inspire

Figure 9 Load conditions

Table 1 Mechanical Properties of AISI 304 S.S and Carbon Fiber T700

SNO	Mechanical Properties	AISI 304 S.S	Carbon Fiber T700
1	Elastic modulus { N/M^2}	1.9 e+11	2.3 e+11
2	Poisson's ratio	0.29	0.35
3	Shear Modulus {N/M^2}	7.5 e+10	1.25 e+11
4	Mass Density {Kg/M^3}	8000	1800
5	Tensile Strength {N/M^2}	5.2 e+8	4.9 e+9

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6	Yield Strength {N/M^2}	2.1 e+8	2.1 e+9
7	Thermal Expansion coefficient {/K}	1.8 e-05	1.8 e-0.6
8	Thermal Conductivity {W/M.K}	16	3.2
9	Specific Heat {J/Kg. K}	500	1700

Analysis with AISI 304 S.S:

Figure 10 Mesh Model of the Assembly

Figure 11 Displacement of AISI 304 S.S

Figure 12 Von Mises stress for AISI 304 S.S

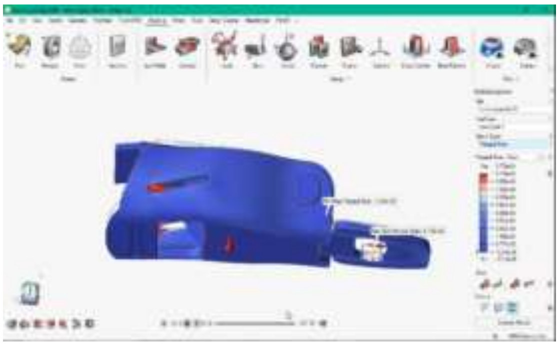

Figure 13 Strain for AISI 304 S.S

From the above Fig we get the results as follows

Max Displacement = 2.596e-02 mm

Max Von Mises stress = 2.763e+02 MPa

Factor of safety =0.8

Principal Strain =9.778e-04

Analyzing using Carbon Fiber T700:

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Figure 14 Von Mises Stress for CF T700

Figure 15 Displacement for CF T700

Figure 16 Principal Strain for CF T700

Figure 17 FOS for CF T700

From the above Fig we get the results for CF T700 as follows

Max Displacement = 2.211e-02 mm

Max Von Mises stress = 2.630e+02 MPa

Factor of safety =8.2

Principal Strain =8.264e-04

Table 2 Results for AISI 304 S.S and CF T700

SNO	Results	AISI 304 S.S	CF T700	Difference %
1	Displacement	2.596e-02 mm	2.211e-02 mm	15.12%
2	Von Mises stress	2.763e+02 MPa	2.630e+02 MPa	4.9%
3	Principal Strain	9.778e-04	8.264e-04	15.48%
4	Factor of Safety	0.8	8.2	925%
5	Mass	219.84 grams	49.46 grams	78.09%

ISSN2454-9940
www.ijasem.org
https://doi.org/10.5281/ijasem.2023.v17.i3.pp8-16
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3. DISCUSSION FROM THE RESULTS:

- **Displacement:** CF T700 is 15.12% more flexible than AISI 304 S.S.
- **Von Mises stress:** CF T700 is 4.9% less susceptible to stress than AISI 304 S.S.
- **Principal strain:** CF T700 is 15.48% less likely to deform under stress than AISI 304 S.S.
- **Factor of safety:** CF T700 is much less likely to fail under load than AISI 304 S.S.
- **Mass:** CF T700 is much lighter than AISI 304 S.S.

Overall, CF T700 is a more flexible, less susceptible to stress, less likely to deform and fail under load, and much lighter material than AISI 304 S.S.

4. CONCLUSIONS

From the above results I can conclude that the Carbon fiber T700 is a high-performance material that is used in a variety of applications, including aerospace, automotive, and sporting goods. It is known for its strength, lightweight, and durability.

Carbon fiber T700 can be used in the manufacture of seat buckles and latches. This is because it offers a number of advantages over traditional materials, such as steel and aluminum as follows

- First, carbon fiber T700 is much stronger than AISI 304 Stainless steel. This is important for seat buckles and latches, which must be able to withstand a lot of force.
- Second, carbon fiber T700 is much lighter than AISI 304 Stainless steel. This is important for aircraft, where every gram counts.
- Third, carbon fiber T700 is very durable and can withstand a lot of wear and tear. This is important for seat buckles and latches, which will be used frequently.
- Fourth, carbon fiber T700 is corrosion-resistant. This is important for applications where the buckle or latch will be exposed to moisture or other corrosive substances.
- Fifth, carbon fiber T700 can withstand high temperatures. This is important for applications where the buckle or latch will be exposed to heat.

Overall, carbon fiber T700 is a versatile material that offers a number of advantages over traditional materials. It is strong, lightweight, durable, corrosion-resistant, and can withstand high temperatures. These properties make it a good choice for a variety of applications, including seat buckles and latches.

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