An application of thermoplastics in aircraft fuselage and wing design

Conor Franks K00272541

Aim of the Project

The Aim of the project is to carry out a SolidWorks/Ansys study on the fuselage and wing ribs of an aircraft to see if thermoplastic composite materials can be used instead of traditional metal material.

The aim for using thermoplastic composites instead of metal materials is to reduce the overall weight of the aircraft which will in turn reduce carbon emissions helping reach the net zero goal in aviation by 2050.

Aircraft Components and Thermoplastics

The fuselage is the main body of the aircraft which houses the passengers, flight staff, pilots and cargo. It is the heaviest part of the plane and is typically made from Aluminum or other lightweight metals that can withstand the forces applied to the aircraft when flying, taking off and landing.

The wing ribs are the supports in the wing which give it shape and structure. The ribs are designed to provide support and integrity to the wings of the aircraft and other types of ribs are present in the fuselage and tail of the plane. The ribs are designed to take most of the pressure and forces that the aircraft experiences in flight to prevent deformation on the sheets that are placed on top of them.

Thermoplastic composites are plastic materials that are being tested for the aerospace industry due to the lightweight but strong structural properties. Thermoplastic can be reshaped when heated to extreme temperatures and this property makes them an ideal material to be used in the aerospace industry as they can be reshaped and recycled if they are manufactured incorrectly. This would reduce production costs to manufacture aircraft, and their lightweight but strong structure would mean less fuel would be burned in flight further reducing carbon emissions.

Design Methodology

SolidWorks was used to create a basic design model of the aircraft wing rib. This would be used for carrying out the testing in Ansys.

Figure 1 SolidWorks Rib model

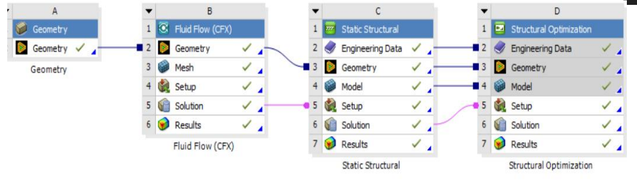

Figure 2 Ansys Project Schematic

CFX Fluid/Air flow analysis is a feature in Ansys which allows for a fluid/air flow simulation to be carried out on an object. An air solid shape is created around the rib model and air inlet and outlet forces are applied to calculate the pressure that will simulate the pressure experienced in flight on the rib.

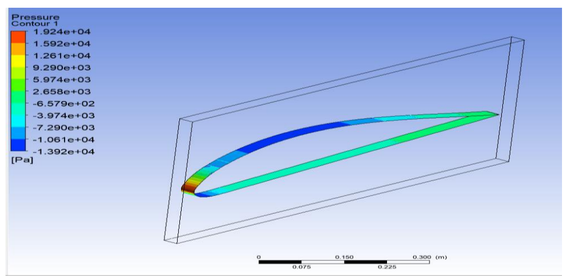

Figure 3 CFX Fluid/Air flow pressure results

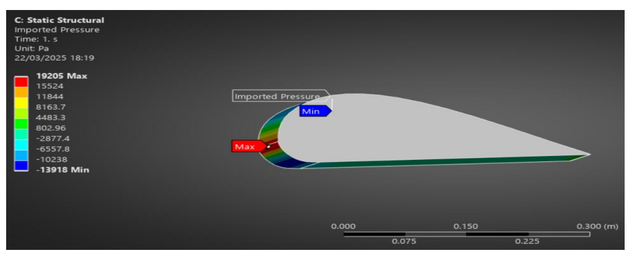

Figure 4 CFX Fluid/Air flow pressure applied to rib

A static structural analysis was conducted by using a fixed face at the rear of the rib and the pressure obtained from the CFX Fluid/Air flow analysis. The results showed that the pressure acted on the front of the rib but the fixed face at the rear of the rib was under the most stress and strain.

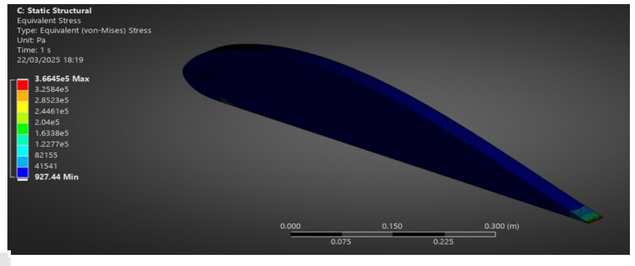

Figure 5 static structural Von-mises stress results

Results

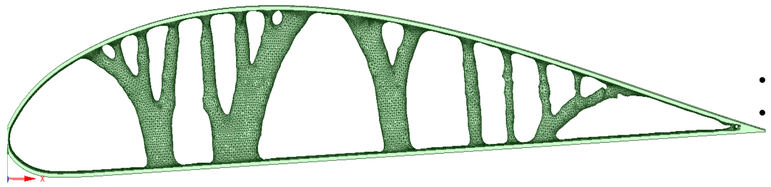

Figure 7 Topology Optimisation results In Space Developer

The topology optimisation produced a model of the rib that would be strong enough when exposed to the pressure experienced in flight while also retaining the least amount of material as possible.

The design of this rib was achieved with a 10% material retain on the body of the rib. This design would be easy to manufacture and test and due to its low material weight, it would be very effective at reducing weight of an aircraft which would improve fuel consumption.

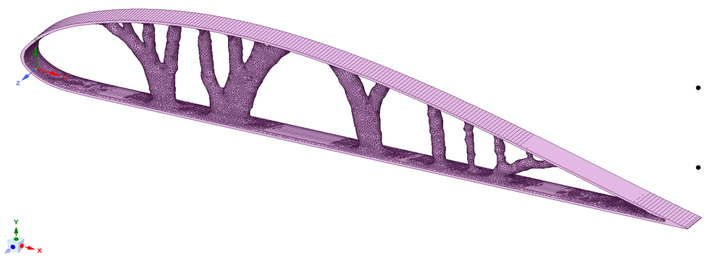

Figure 8 Topology Optimisation results In Space Developer

A topology optimization was carried out to remove any excess material from the rib that would not be crucial in keeping the strength that it needs. This was carried out in Ansys using the information acquired in the static structural analysis. The results obtained were with a 10% retain on the rib and the materials as both Structural steel and carbon fiber.

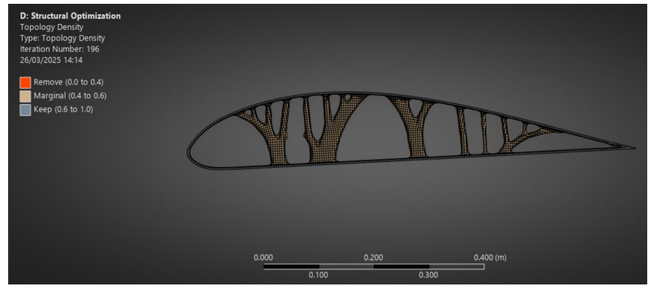

Figure 5 Topology Optimisation results

Conclusion

- A literature Review was Carried out to acquire background information about thermoplastics and aircraft structure/design.
- A basic rib was successful modelled on SolidWorks
- A successful CFX Fluid/Air flow analysis was carried out to obtain pressure experienced in flight on the rib model.
- A Static structural analysis was successfully carried out to show how the calculated pressure would act upon the rib.
- A Topology optimisation was carried out and showed how a thermoplastic material could be used to manufacture the wing and the structure it would be most effective with.

Bibliography/References

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