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SUSTAINABLE DESIGN OF A COMPONENT FOR THE AEROSPACE INDUSTRY COMBINING ADDITIVE MANUFACTURING AND TOPOLOGY OPTIMIZATION

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INTRODUCTION

This work focuses on the development of a methodology in which, through a process of topological optimization, structural components used in the transportation sector can be lightweighted, achieving a perfect balance between cost, capacity, and reliability.

In addition to these factors, weight is a critical component with significant impact on cost, as reducing 450 kg of engine weight can lower fuel consumption by 1%.

This type of methodology based in iterative Finite Element Analysis (FEA) simulations using Solid Isotropic Material with Penalization (SIMP) [1], is growing exponentially alongside additive manufacturing, both metallic and plastic.

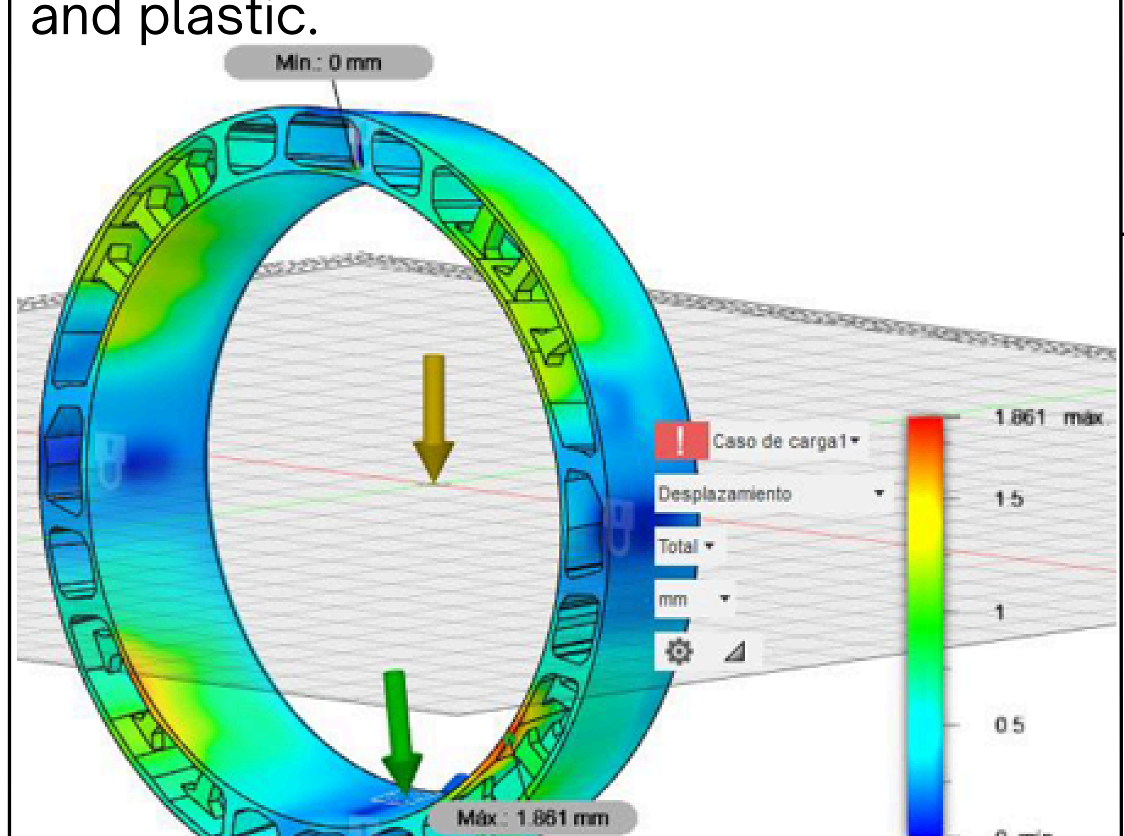

Figure 1: Simulated Displacements for a Bird Strike Test

OBJECTIVES

Demonstrate, through the simulation of a real component, how the integration of topological optimization and additive manufacturing can develop a methodology that enables significant savings in the design and manufacturing phases of components with high technical requirements like birdstrike test [2] .

Additionally, by lightweighting these components, the aim is to reduce energy consumption throughout the lifespan of these means of transportation.

METHODOLOGY

This work is predicated upon a methodology comprising five distinct stages: 1. Component analysis; 2. Design; 3. Topological Optimization; 4. Simulation of real working condicionts and testing; 5. Validation.
It begins by analyzing the mechanical, thermal, and physical requirements of the chosen component, in this case, the air intake of a turbofan capable of withstanding shock waves, i.e., flying at Mach > 1. This involves studying the tasks to be performed and the various standard tests that must be met.

Once the requirements are understood, a topological optimization simulation test is conducted using the FEA method in Fusion 360. Subsequently, the resulting design is simulated under the external and internal conditions it will face during its operational life, including forces, pressures, and even bird impacts.

The results are validated, demonstrating that the new air intake system is lighter while maintaining the same mechanical properties.

RESULTS

For an original air intake made of UNS A96061 weighing 13.400 kg, its internal shape was optimized to reduce down to 4.100 kg, a 71% reduction, with minimal displacements when subjected to working and testing condicionts (Figure 1).

Initial mass: 13400 KG
Final mass: 4100 KG

WEIGHT REDUCTION 71%

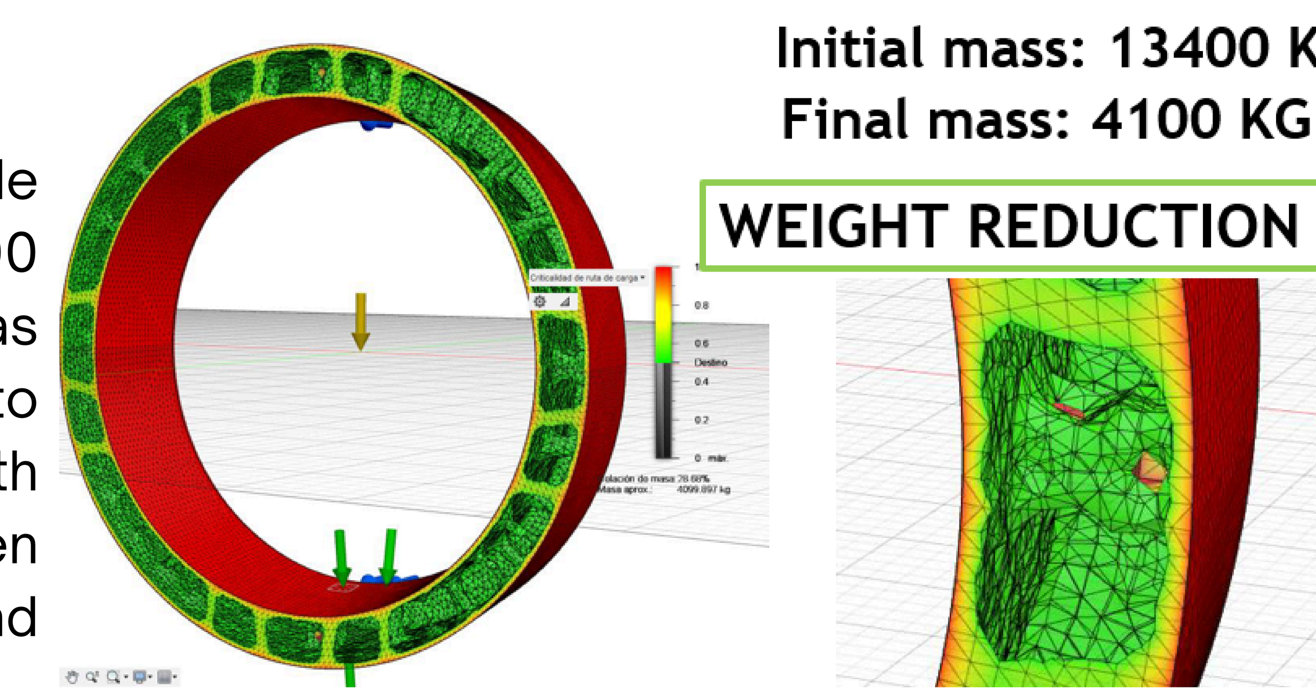

Figure 2: FEA Simulation results of Topological Optimization using SIMP Method

CONCLUSIONS

Through this approach, it is demonstrated that it is possible to achieve a weight reduction of up to 71.38% for the rigid air intake element made of UNS A96061 The final shape, shown in Figure 2, is considerably complex to manufacture using conventional machining methods.

To materialize the optimized design depicted in Figure 1 and Figure 2, a manufacturing technology distinct from conventional methods is required, such as additive manufacturing. In this case, the Selective Laser Melting (SLM) technology is considered the most suitable option in accordance with the specified requirements among other metallic additive manufacturing techniques.

[1] M.P. Bendsøe et al. (1988) “Generating optimal topologies in structural design using a homogenization method”. Computer Methods in Applied Mechanics and Engineering, 71(2), pp. 197-224. Doi:10.1016/0045-7825(88)90086-2
[2] EASA (European Aviation Safety Agency). (May 2013). Component of ESSI European General Aviation Safety Team.