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LOW-COST OPEN-CIRCUIT SUBSONIC WIND TUNNEL: ACHIEVING BALANCE BETWEEN REPRODUCIBILITY, AFFORDABILITY, AND PERFORMANCE

Abstract

From the first man in flight in an engine-controlled aircraft, to the first rover on the ground of another planet. A Wind Tunnel is a tool without which this would not have been possible, but only accessible at high cost. This paper deals with the design, construction, evaluation and analysis of a low budget Open Circuit Subsonic Wind Tunnel and the results obtained in it. The objective is to provide a low-cost tool that complements and allows aerodynamic testing, illustrating and quantifying the effects of airflow on scale models, facilitating the identification of weaknesses in the design prior to prototype manufacture. It also seeks to facilitate the construction of these tools for other students and universities that do not have the full resources for a certified Wind Tunnel but are looking to complement their learning.

Additive manufacturing and computational fluid dynamics (CFD) were pivotal in the development of this low-cost wind tunnel, enabling precise prototyping and performance validation. Additive manufacturing allowed for the rapid fabrication of critical components with tailored geometries, optimizing the tunnel's functionality while significantly reducing production costs. CFD simulations complemented the design process by providing detailed insights into airflow behavior, pressure distribution, and drag forces, ensuring the tunnel's effectiveness before physical construction. With a total investment of less than $1,000 USD, this approach demonstrates how advanced tools can be utilized to create affordable, high-impact technologies.

This project integrates knowledge from various disciplines, including spacecraft and space exploration, by enabling the simulation and analysis of aerodynamic conditions affecting aerospace vehicles and probes. The data obtained from the tests, such as wind resistance and pressure distribution, are essential to optimize the design of space components and improve their performance in future missions. In addition to the theoretical research carried out for its design, construction and data collection, a first two-metre physical prototype is presented in which visualization and analysis tests were performed on a scale model of different geometries.