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TOWARDS A COMPACT WIND TUNNEL DESIGN

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Introduction. In recent times, there has been a surge in interest surrounding the development and deployment of unmanned aerial vehicles (UAVs), encompassing both fixed-wing aircraft and copter configurations, with sizes ranging from mere tens of centimeters to several meters. For many developers, the aerodynamic characteristics of UAVs may not pose an immediate concern, especially when the aircraft boasts substantial power capabilities. However, as missions extend to longer durations, achieving optimal aerodynamic performance becomes increasingly pertinent.

One potential avenue for addressing this challenge lies in modeling through various Computer-Aided Engineering (CAE) software. Nevertheless, the issue of validating such simulations remains unresolved. A promising approach to validation involves conducting wind tunnel tests on a smaller scale, owing to the compact dimensions of UAVs. The construction of such a scaled-down wind tunnel can be accomplished without exorbitant expenses.

In light of these considerations, this paper delves into the essential parameters requiring attention in the development of such a compact wind tunnel.

Materials and methods. Wind tunnels are classified based on various parameters including their circuit type, test-section configuration, Mach number range, and principle of action. Fig. 1 presents a comprehensive classification scheme of wind tunnels [1,2].

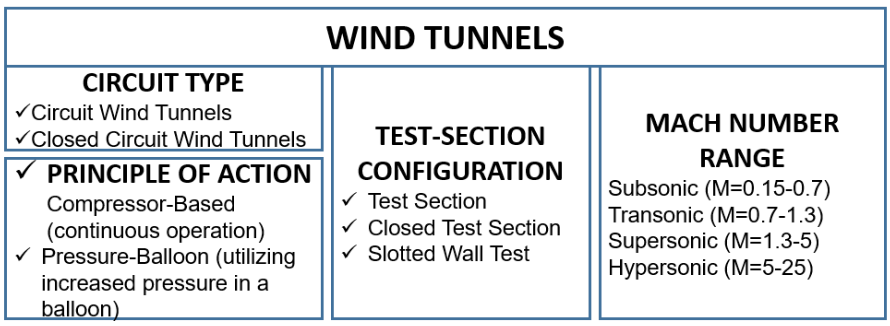

Fig.1. Wind Tunnels classification

Key parameters in wind tunnel design are the Reynolds number, Mach number, Freud number, and the Navier-Stokes equation.

Results. Ideally, the size of a tunnel is determined by its intended use, with larger tunnels generally allowing for a wider range of experiments and applications. On the other hand, tunnels with smaller test sections are used primarily for research and education purposes, offering a more controlled environment for detailed analysis and experimentation. The test model should be less than 0.8 the width of the test chamber. The length of the chamber is greater than the width by 1.5-2 times. The typical equivalent cone angle of diffuser is in the range of 2-3,5º with the smaller angles being more desirable. The area ratio is typically 2-3, again with the smaller values being more desirable. Contraction or nozzle. Typical area ratins are in the range of 7-12, although lower and higher values are not uncommon. [1, 2]

Also, when designing a wind tunnel, it is important to consider such factors as noise reduction and acoustic isolation, energy efficiency and operating costs, safety and accessibility, vibrations (can be reduced by the strength and stability of the structure).

In regards to the materials available, the choice is usually between acrylic and polycarbonate sheets. Of course, the choice between these two materials should be based on the specific requirements of the individual case, taking into account the balance between the advantages of durability and simplicity of processing. Polycarbonate is more resistant to vibration while acrylic is easier to machine.

To measure lift and drag in a wind tunnel an Arduino-based system with load cell beams can be used. The system consists of an Arduino board and HX711 amplifiers. The aluminium beams load cells rotate to measure lift and drag. The lift beam configured as a lever to detect upward movement caused by lift. The second upper beam measures drag by moving backwards. This design allows for accurate measurement of both lift and drag forces during wind tunnel testing. [3]

Conclusion. For a compact wind tunnel, it is better to choose open circuit tunnel. Polycarbonate is the preferred material for the wind tunnel casing because of its vibration resistance. An Arduino-based system using beams with strain gauges can be developed to accurately measure the lift and drag forces.

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