Design & Concept Development of a Ducted Fan for an eVTOL Aircraft

OntarioTech Engineering & Applied Science

Team Members: Izzy Cossarin, Jacob Gotzmeister, Daimen Landori-Hoffmann, Natalie Shears, Allison Yuen

Faculty Supervisor: Dr. Sayyed Ali Hosseini, P.Eng

Project Description

Horizon Aircraft, a Canadian aerospace company developing an electric vertical takeoff and landing (eVTOL) aircraft, provided the team with a model of their current ducted fan. The team was tasked with optimizing the design of the fan to produce the maximum possible lift within the torque limitations of the selected motor. The selected motor must fit within the hub of the duct, and the diameter of the total fan cannot exceed 800 mm. To test the effects of design modifications on lift and torque, computational fluid dynamic (CFD) simulations were to be used. The results of the CFD simulations were then to be verified by constructing and testing a physical prototype.

Design Objectives

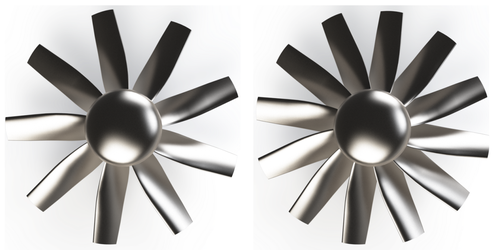
- Maximize the lift produced
- Minimize the required torque
- Ensure produced lift is 500 lbf per fan
- Ensure the torque is within supplied limits of the motor selected by Horizon

Design Optimization

Variables that were modified to determine the optimal fan design include:

1. The angle of attack of the fan blades

2. The angle of attack of the stator blades
3. The number of blades on the fan

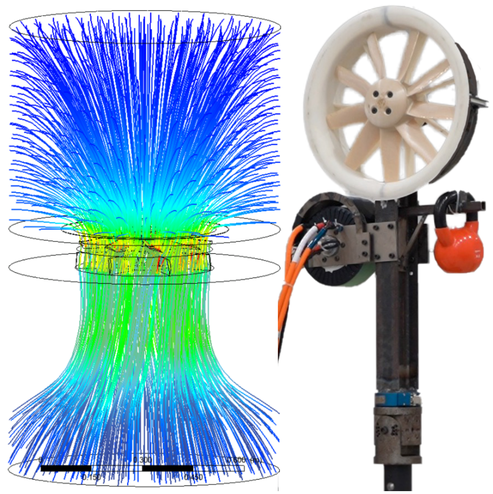


4. Modifying the hub size (to accommodate a stronger motor)

It was determined an angle of attack of **49.5 degrees** of the fan blades produced the most lift within the torque limitations of the selected motor.

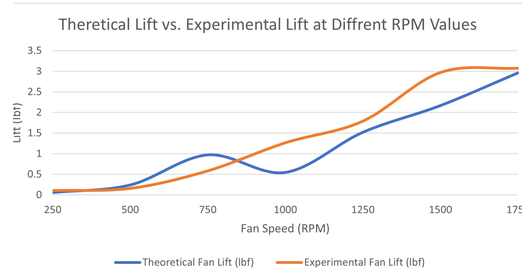
Simulations & Testing

- The virtual simulation was conducted using ANSYS Fluent
- Used a Shear Stress Transport (SST) K-Omega calculation which is a two-equation eddy-viscosity model
- Accounts for various different flows such as internal, separated, and jet flows

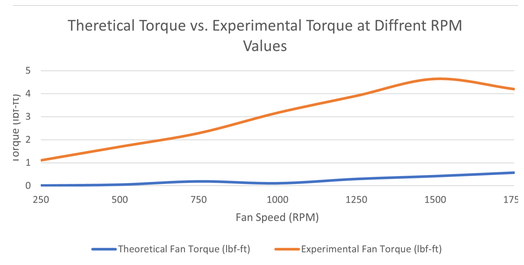


- 50% scale model manufactured through additive manufacturing techniques
- The model was mounted on a custom-built test rig which includes a load cell to measure the thrust force produced through the moment
- An EMRAX 208 externally mounted motor powered the fan through pulleys and belts
- 400V power supplied to the motor

Data Analysis



As seen in the chart above the experimental lift and the theoretical lift begin to converge around 3.1 lbf, at 1750 RPM. This indicates that the test data is relatively accurate and this model can be used to reliably predict the produced lift.



As expected, the results of the experimental torque far exceed the results of the theoretical torque, as the CFD simulations did not account for the friction losses in the prototype model. The prototype provides a scalable glimpse into the torque requirements of the 100% fan.

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