University of Cambridge
Department of Engineering

Masters Project Report

Propulsion Systems for e-VTOL UAV

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Abstract

Abstract here..

Contents

5. Future Work

5.1 Propulsor Design

5.1.1. Stationary Propulsor Tests

This is what you could have done this year to finish off analysis of propulsors. Acoustics?

5.1.2 Contra-rotating Ducted Fan

This could have some design work in, bit more theory, plus a section on why CRFs might be a good idea. Bit more literature?

5.1.3. CFD →

Discuss limitations of design method (e.g. deviation for high s/c) and why CFD is useful

Could reference Megan here, show that CFD can get close to experimental measurements

5.2 Flying Test Bed Experiments

– Eriksen manoeuvre ideas.

6. Conclusions

Electric Vertical Take-Off and Landing	e-VTOL	
Flying Test-Bed	FTB	
Axial Flow Velocity	V_x	
Fan Speed	Ω	
Fan Hub Radius	r_h	
Fan Casing Radius	r_c	
Fan Mid-line Radius	r_m	
Mid-line Fan Speed	U	$= \Omega \cdot r_m$
Flow Coefficient	ϕ	$= \frac{V_x}{U}$
Stage Loading	ψ	$= \frac{\Delta h_0}{U^2}$

NOMENCLATURE TO DO

Introduction

Intro and motivation

1.1 Literature Review

1.2 Research Questions

Propulsor and Experimental Design

2.1 Propulsor Design

2.1.1 Diffusing Ducted Fan

Theoretical thrust and power
Derive $M_f = \sqrt{2\sigma}$
ESDU diffusion tables?

2.1.2 Turbomachinery Design

Blade design code.
Profiles
Deviation
Span-wise psi distribution
Boundary conditions (Constant P exit, Vx, etc)
Sweep/Lean
Blade number

2.2 Mechanical Design

2.2.1 Weight Reduction

Thrust = Weight condition
Mass model to close the problem

2.2.2 Shroud Tip Clearance

Shroud thickness
FEA
3D printer tolerances

2.2.3 Hollow Stators

Power supply
Weight reduction
Tolerance
How to

2.2.4 3D Printing

Printer used
Printer tolerance
Design adjustments to enable good printing
- Straight TRAILING edge
- Raft and reduce air-gap

2.3 Electrical Design

2.3.1 Choice of Electric Motor

Size ($d < 36mm$)

2.3.2 Power vs Torque Design Space

2.3.3 Power Supply

Want to simulate using a battery pack for actual flight conditions but increase run-time. Choose 12V steady state operating voltage (14.8V nominal Li-Po).

2.3.4 Instrumentation Design

RPM
Thrust
- Calibration

Power
Pressures

2.4 Systems Design

2.4.1 Precursory UROP

Platform design chassis etc
Pixhawk 4
RPi
ADC

2.4.2 Subsystem Function

Pixhawk 4
RPi
ADC

2.4.3 Subsystem Interaction

2.4.4 Telemetry

QGroundControl - Telemetry module
SSH

Method

3.1 Experiments

3.1.1 Stationary Propulsor Test

Setup
- Stand

Test variables
- Speeds
- Sigma
- Rotor design

3.1.2 Computational Fluid Dynamics

3.1.3 Hover Test

3.2 Experimental Method & Data Processing

3.2.1 Non-dimensional Quantities

Pressure quantities, FOM, ϕ, ψ.

3.2.2 Instrumentation

Power (DC Current and Voltage), Thrust, FOM, RPM, Pressures

3.2.3 Flight Management for Auto Position Hold

System not used.

3.2.4 Data Acquisition

Acquisition and integration of systems and software.

3.2.5 Cage Design & Tether

Experiment

4.1 Stationary Propulsor Test

4.1.1 Version 1.0 EDF

Heavy Blue: 3 exits and 3 rotor vortex designs. Comparison of intake performance (long and short).

- Power (Current and Voltage)
- Thrust
- FOM
- RPM

4.1.2 Version 2.0 EDF

1 exit and 2 rotor vortex designs. Long intake only.

- Power (Current and Voltage)
- Thrust

- FOM
- RPM
- Pressures

4.1.3 Version 3.0 EDF

1 exit and 1 rotor vortex designs. Long intake only.

- Power (Current and Voltage)
- Thrust
- FOM
- RPM
- P1 Only

4.1.4 Propeller

4.2 Computational Fluid Dynamics

4.2.1 Comparison to Static Test Data

4.2.2 Propulsor Performance

4.3 Hover Tests

4.3.1 Propeller Performance

4.3.2 Hover Test Limitations