

Design and Fabrication of Contra-Rotating Propeller Drone

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Abstract

Drones can go places that humans can't access, so they are an ideal solution for dangerous search and rescue efforts and deliver emergency supplies to remote locations and disaster areas. Drones are playing a significant role in following activities undertaken by the Military, Healthcare, Disaster & Rescue management, Fire Fighters, Warehouses, Municipal Authorities, etc. The current project aims to design and fabricate a contra-rotating propeller drone that can be used for carrying payloads.

Keywords

Drones, contra-rotating propellers, Fusion 360, Fusion deposition modeling printer, DLP Printer

1. Introduction

Drones are becoming increasingly popular and popular. Drones can go places that humans cannot because they are accessible from anywhere. Fixed-wing drones and rotary winged drones are two types of drones that are currently in use. Fixed-winged drones are nothing more than drones that lack rotors. They have two fixed wings and are controlled by the drone's tail. Rotary-winged drones contain rotors for lifting and forward movement the drone, so these are the types of rotary-winged drones. 1. Quadcopters/Hex copters/octocopters, 2. Remotely piloted helicopters. We aim to design a remotely piloted rotary-wing aerial vehicle with a contra-rotating propeller. This paper tells how to design and fabricate the contra-rotating propeller drone using fusion 360, and 3d printing, and FDM machining.

1.1 Problem Statement

Nowadays usage of drones is increasing rapidly, Drones are used in military applications and medical and emergency purposes that the problem is drones are available at a high cost in the market, So to reduce the problem, quadcopters are available at a high cost, So to reduce the cost, new design of the drone is needed, so the drone is contra-rotating propeller drone, Contra-rotating propeller drone contains only two motors, so weight and power will be reduced, This drone carries the same weight as quadcopter carries, then cost of the drone is reduced.

2. Literature Review

Flight dynamics is an important part in controlling a drone. Tanmay Kumar et al. and M. Khan et al. worked on the physics and flight dynamics of quadcopters and their applications and it is detailed in (Khan, 2014) (Kumar

and Hasan, 2020). Nadia Nowshin et al. (2018) worked on the designing of drones using Arduino Uno. C. Rajath et al. (Rajath et al., 2018) worked on an agriculture drone where it is used for monitoring agricultural fields to detect pests and spray insecticides on it using the agro drone.

Contrarotating propellers offer greater thrust. But noise is a problem for these drones. Gur, et al (Gur et al., 2022) discussed the problems during optimizing the contrarotating propeller design and used aerodynamic calculations to optimize the design. Experimental investigations into noise reduction of contrarotating propellers is presented in (Boychuk and Grinek, 2021). (Ma et al. (2020) executed CFD simulations to study flow and acoustic behavior in single and contrarotating propellers. McKay, et al (McKay et al., 2019) studied the noise of contra-rotating propellers. The blades used in drones are used. They indicated that contra-rotating propellers can largely reduce the size of the drone but will cause heavy noise. Tang, et al (Tang et al., 2015) investigated the use of contra rotating propellers for propelling stratospheric Airships.

Koronowicz et al. (2010) studied the complete design of contra-rotating propellers. They compared the tandem propellers and contra-rotating propellers. They, also, studied how the propellers' velocity fields change in the tandem and contra-rotating propellers. vanderover, J. S., & Visser, et al (Vanderover and Visser, 2006) Vanderover and Visser studied the analysis of contra-rotating propeller-driven transport aircraft. They are trying to reduce the noise of the contra-rotating propeller, so by doing this, they tested the different propellers with a variable number of blades. but they couldn't attain a better result. but finally, 5*6 bladed CRP, by using this CRP they got approximately 10% fuel consumption reduction. Zhao, et al (Zhao et al., 2019) They calculated the efficiencies of the different size propellers between the size of 139mm to 377mm. Storch, et al (Štorch et al., 2017) studied the contra-rotating propeller setup. They conclude that the how to set up the contrarotating propeller drones for drones. Piancastelli et al (Piancastelli et al., 2017) studied about the optimization of the contra-rotating propeller drones, they studied how to reduce the sound of the propeller, and also how to reduce the wait and how to increase the efficiency of the propeller.

3. Methods

3.1 Design of contra-rotating propeller drone.

The possible off-the-shelf components that can be used in contrarotating propeller drone that is planned are listed in Table 1. Of these 2200kV motor, 30A BLDC ESC, 8045 Propeller, 5200mAH and APM 2.8 controller are used. To make the necessary housings and the body, these parts are reverse engineered for creating 3D models of the same. Fusion 360 has been used for this purpose. Figure 1 shows the 3D model of the motor used in drone as modelled in Fusion 360. All the off-the-shelf components are first remodeled in Fusion 360. Then a skeleton model is created into which these models are assembled. Housing and the body are reverse engineered around these models to get the final drone. Then the drawings of the same are created. Figure 2 shows the controller housing modelled in Fusion 360, and Figure 3 shows the complete drone modeled in Fusion 360.

Table 1: Components that can be used in the designed drone

Type	Proposed Models
Motor Type	1000kV/ 2200kV
ESC	30A BLDC ESC
Propeller	1045 Propeller/8045 Propeller
Battery	3200mAH/ 5200mAH
Controller	KK 2.1/ APM 2.8

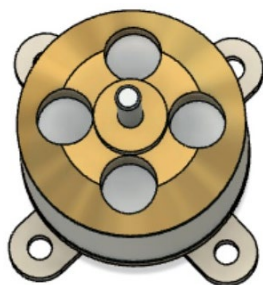


Figure 1: BLDC Motor model in Fusion 360

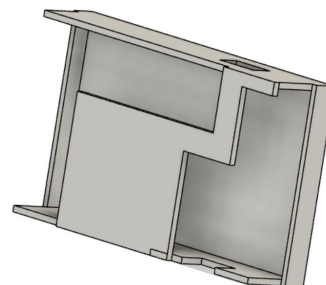


Figure 2: APM 2.8 controller housing model

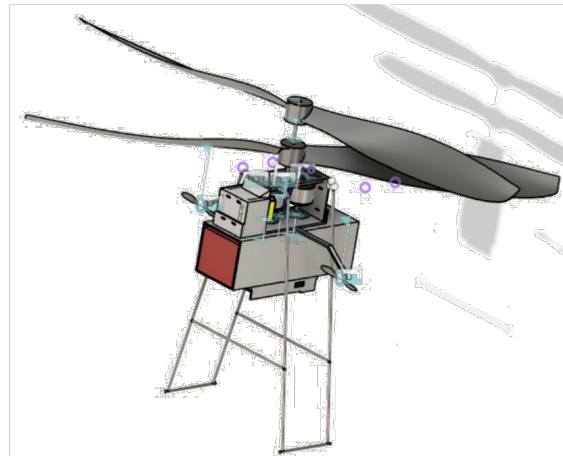


Figure 3: Complete Model of the contrarotating propeller drone created in Fusion 360

3.2 Fabrication of contra-rotating propeller drone

After completion of the design process, the next step is to fabricate the parts of the drone by using fused deposition modeling and DLP printing. Propellers and Base of the drone will be made by the DLP printing remaining parts are fabricated by Fused deposition modeling.

3.3 Fused deposition modeling

Fused Deposition Modeling (FDM) is the one of the type additive manufacturing technologies. The process works by extruding a filament through a hot nozzle and depositing the molten plastic layer by layer on a table. Slicing generates the path along with the layer is to be deposited layer by layer. APM housing, Propellers and Base are prepared using FDM printing. For this slicing is done using Repetier Host software. For this, the parts modeled in Fusion 360 are exported to stl format and then imported into Repetier Host software. Table 2 lists the printing parameters used for 3D printing the parts. Cura engine is used to slice the parts. The generated G-Code is then saved onto an MicroSD card. The card is then inserted to the 3D printing machine.

3D printing is done using Creality Ender 3 Pro printer. The printer is of build volume 220mm X 220mm X 250mm build volume and can print materials like PLA, ABS and PET. In the current project, PLA has been used to generate 3D printed components. Figures 4 & 5 show the 3D printed parts.

Table 1: 3D printing parameters

Parameter	Value
Shell Thickness	2 mm
Top and Bottom Thickness	2 mm
Infill Patern	Grid
Support Pattern	Grid
Fill Amount	15%
Print Speed	25 mm/s
Travel Speed	60 mm/s
Layer Thickness	0.2 mm

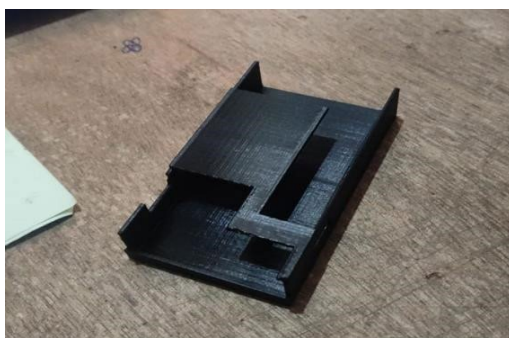


Figure 4: 3D Printed controller Housing

Figure 5: 3D printed wings

3.3 DLP printing

DLP means digital light processing printing, DLP printer is a 3D printing machine, it is used for printing the 3D solid models designed in design software. In this type of printer photopolymer resin is used, photopolymer resin is in liquid state. The liquid resin is solidified using UV light. This type of technique is also known as vat polymerization. Figure 6 gives the parameters used for DLP printing. DLP printer is used. Creality LD-002R printer is used to print the required housing and gears for the drone being designed. Chitubox software is used for slicing. Figures 7 shows sliced image of housing of motors. Figures 8 and 9 show the DLP printed components.

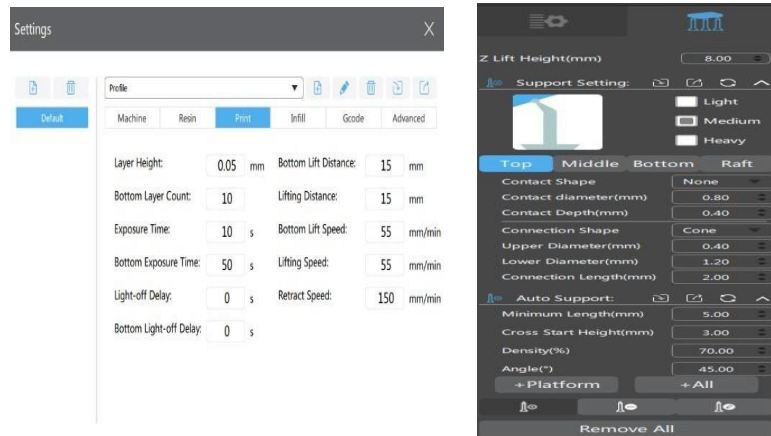


Figure 6: DLP Printing parameters and support structure parameters

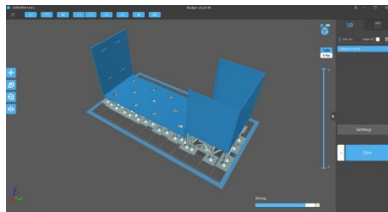


Figure 7: Slicing of Motor Housing



Figure 8: 3D printed motor Housing



Figure 9: 3D printed gears on build plate

4. Fabricated Assembly of Contra-rotating propeller drone

After getting all the components, the next step is assembling. Assembling is nothing but a group of parts combined in one place and it becomes a useful work part called assembly. After completion of assembly, Solder the ESCs to the power distribution board and set up the APM. And then give the receiver connections and connect the APM to the receiver, APM setup is done by the laptop. The setup is done as same as the quadcopter. After giving the same connections as the quadcopter, calibrations of ESC should be done, so this is the prototype and its in the testing stage, And the fabrication part is also completed. This paper explains the design and fabrication of a contra-rotating propeller drone. By using these parameters of the printer drone parts are printed, then the Fabricated assembly of the drone is shown in Figure 9. The fabricated drone is flight tested. The drone was hovered for 5 min.

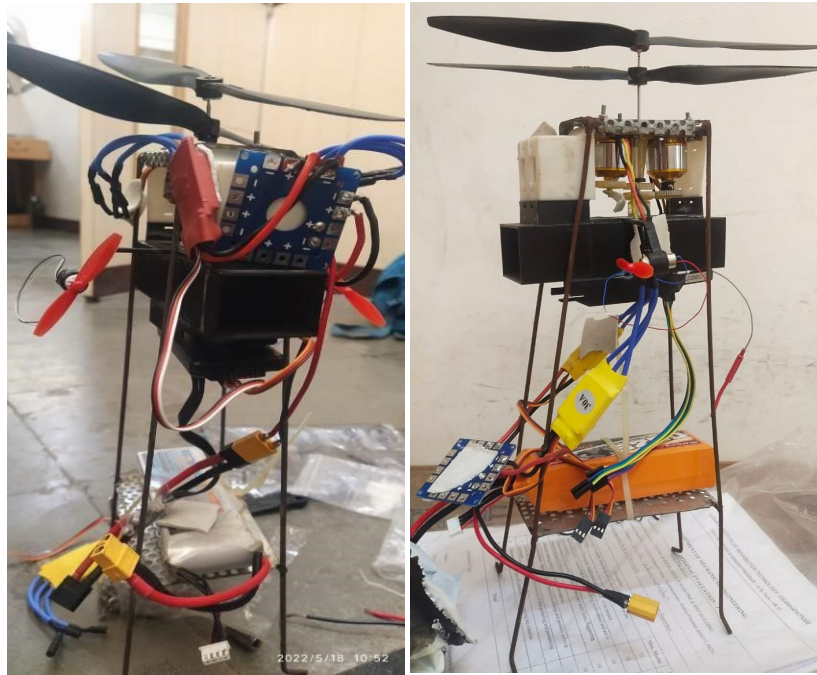


Figure 9: Fabricated assembly of the contra-rotating propeller drone

5. Conclusion

This paper gives detailed information on the modeling and fabrication of contra-rotating propeller drones. The drone is designed in Fusion 360 first. In house components are 3D printed and some are fabricated through welding process. DLP printing as well as FDM is used for 3D printing. PLA is used for parts manufactured using FDM while standard Elgoo polymer resin is used to 3D print the components. These components are then assembled to get the final drone. The assembled drone is successfully flight tested.

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Biography

Dr. N.V.S Shankar is currently working Associate Professor, Department of Mechanical Engineering, Vignan's Institute of Information Technology Visakhapatnam, Andhra Pradesh. He has a total of 13 years of both teaching and industrial experience and published around 28 articles in journals of international repute. He has good expertise in IoT, CAD/CAE software.

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