Design of Delivery Drone

[1]Mohaneshwar S,[2]Karthik R M,[3]Rahul Batapagari,[4]Ninganna Gangappa Bani, [5]Varun Kumar Reddy N

[1,2, 3, 4] Student, [5] Assistant Professor

School of Mechanical Engineering, REVA UNIVERSITY, Bangalore, Karnataka, India

Abstract: At present, delivery system should be fast and efficient in various fields like medical, foods, package deliveries etc. Traditional method for delivery is slow and inefficient in last mile delivery. So, introducing drones in last mile delivery makes faster and more efficient. This paper represents Quadcopter as a low weight and low-cost autonomous flight capable of delivering parcel. This quadcopter drone is capability of delivering parcel ordered and coming back to the starting point. The promising result of this method enables future research on using quadcopter for delivering parcel.

KEY WORDSs: Quadcopter, Autonomous, Delivery System, Online Ordering, Low Cost, Secured, Android Device;

I. Introduction

The term last mile delivery refers to the final leg of a business-to-customer (B2C) service, in which a product is shipped from a depot or a retail store to the final point, that can be either customer's home or a designated pick-up point. It is the final part of a bigger logistic and production chain that starts from the manufacturing and ends when the product is delivered to the end user. The market for delivering goods is massive, shopping, logistic online shopping businesses are investing heavily in the entire supply chain up to the last mile delivery to make it fast and efficient. Drone Delivery could allow accelerated delivery time, improved accuracy and reduce human cost associated with delivery.

Figure 1 Drone Delivery

Drone delivery aims to overcome that limitation by exploiting the vertical dimension above city streets. This report explores the vehicle design aspects of the delivery drone problem, including flight efficiency, energy consumption, noise, and safety, which are central to the viability of delivery drones. Importantly, key design constraints and expected performance levels also speak to the potential scalability of the concept. The primary outputs of interest are the energy consumptions and masses of converged delivery drones, which have been properly sized (including cruise, hover, and reserve flight segments) to carry all the payload and onboard systems.

II. Scope Of Work

- **COVID 19 Pandemic**

Drones are playing a critical role in the fight against the Covid-19 pandemic delivering vaccines to communities that need them the most.

(In NEWS on 7th May 2021): The ministry of civil aviation and the Directorate General of Civil Aviation has given conditional exemption to the Telangana government to deliver covid vaccines using drones. The Centre has also allowed the Indian Council of Medical Research to conduct a feasibility study on vaccine delivery using drones in collaboration with IIT Kanpur for one year or until further orders.)

Figure 2 Drones Delivery Medical Supplies

- **Health Care Delivery**

Drones can be used to transport medicinal products such as blood products and other supplies such as pharmaceuticals and medical samples. Medical deliveries have become one of the leading applications for drone delivery because they can more easily fly into and out of remote or otherwise inaccessible regions, maybe compared to trucks or motorcycles.

Medical drone delivery is credited with saving lives during emergencies.

- **Food Delivery**

Food delivery something which is very important for the future of delivery drone as we know the human can never make delivery in time without putting their lives at stack and drone can do the same work in half of the time and half of the power of fuel used.
Drone technology is about to change. It's going to change the game for food delivery.

- **Postal Delivery**

Regulated by Federal Aviation Administration rules, the Postal Service anticipates integrating drones to support services such as "long driveway delivery" by launching drones from vehicles to make deliveries and then return on their own as carriers continue along their routes. They could support difficult deliveries to remote places like small islands or across rugged terrains.

- **Ship Resupply**

Delivery Drones is also used to resupply offshore ships instead of sending smaller boats.
In 2019, the Skyways UAV demonstrated an autonomous resupply of a moving ship without knowing its position ahead of time. The aircraft's round trip was nearly 80nm and it carried a 9.1kg payload. According to a company spokesperson, the aircraft has a range of 500 miles, and it can transport up to 25 lbs.

III. METHODOLOGY

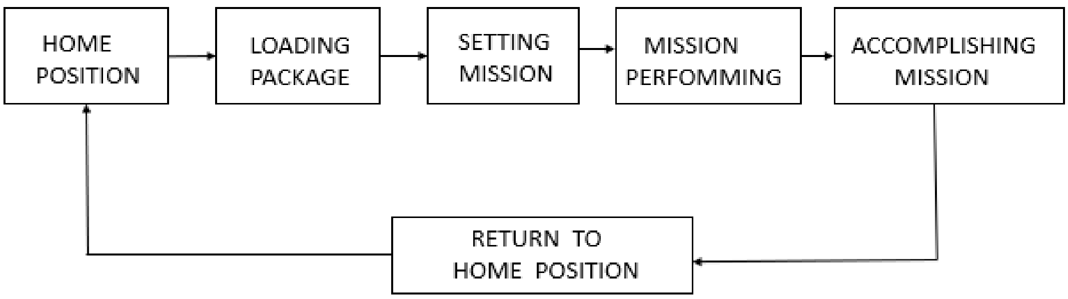

Figure-3. Methodology Flow Chart.

A drone is flown to the delivery point which is loaded with necessary packages that needed to be deliver using GPS coordinate, which taken from the customer that package needed to be delivered. The drone is set to fly from origin point.
Once the delivery drone is in the air, current drone proposals describe these vehicles as autonomous (having the ability to not require a pilot). In order for delivery drones to fly alone, they will rely on beyond visible line-of-sight technology through telemetry. Guided by GPS systems, delivery drones will be able to travel directly to the customer's location. While travelling, a prevailing concern among potential customers and development teams are the potential obstacles the drone may encounter. Whether it is a bird, tree or even another drone, automatic sense and avoid (SAA) systems will be needed to prevent in-air and ground accidents. Built-in sensors will be able to identify a nearby object's proximity and speed, enabling the drone to take a responsive action to avoid the obstacle. when it reaches the location. It drops the package and deliver and will come back to the original position where we launched a drone (Origin Point).

IV. Design And Fabrication

4.1 Model Development

Figure 4. Delivery Drone

4.1.1 Planning and Prototyping:

Resource and design planning is a key element in any manufacturing process, as it ensures that all potential issues are addressed before large-scale production.

A drone starts with a proposed design, which should be completed to scale before any parts are purchased. The plan should also clearly indicate the purpose of the drone. Is it a multi-purpose device that does a few basic functions or will it serve a specific purpose, such as Transportation? These decisions indicate key considerations, such as how much it will need to be able to carry which translates into the weight of the materials and the size of the motor.

4.1.2 Framing:

The frame of a drone is the main contributor to structural integrity. This is often comprised of a sturdy, yet lightweight material to find a balance between aerodynamics and durability.

The frame assembled here is X formation, to provide additional support for the motors, motor mounts are used and added durability overall.

4.1.3 Inner Working:

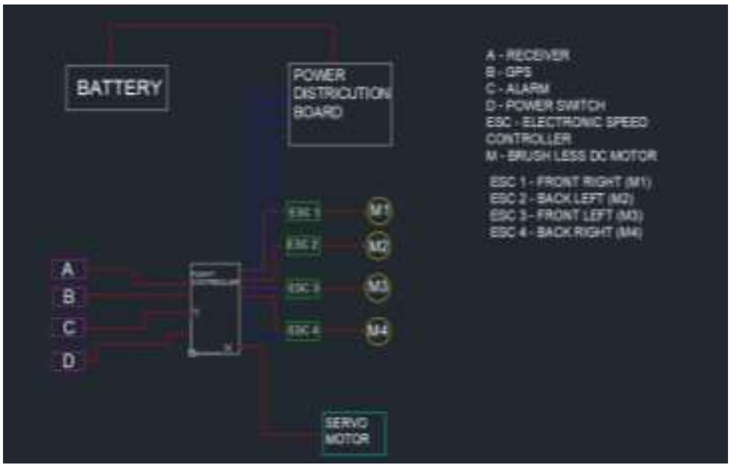

Figure 5. Block Diagram of Delivery Drone designed using AUTOCAD

After the propellers are attached to the motors and frames, it's time to make the drone operational. The drone will require electronic speed control (ESC), an RC receiver, batteries, a power distribution board, and connectors to complete the internal circuitry that allows the motors to run.

The ESC devices will ultimately direct power from the battery to the motors to make them run; thus, one is required for each motor. The RC receiver receives signals from the transmitter, which is how the user controls the device. The battery is connected to the power distribution board and the connectors, to generate energy to power the motors; this completes the circuitry at a very basic level.

Other components include the wiring used within and adherence methods to stabilize the circuit board. Additionally, a mounting pad may be installed to reduce vibration. A flight controller may also be added to help with stability in the air.

4.2 Software Used

We are using Mission Planner V1.3.74 to monitor our Delivery Drone. Mission Planner is a full-featured ground station application for the ArduPilot open-source autopilot project.

Mission Planner is a ground control station for Plane, Copter and Rover. It is compatible with Windows only. Mission Planner can be used as a configuration utility or as a dynamic control supplement for your autonomous vehicle.

Figure 6. Mission Planner V1.3.74

V. CALCULATIONS

5.1 Design Calculations and Stress Analysis of the Frame

Most important parameter that determines the possibility of flight of a quadcopter is the overall weight of the aircraft and its entire component. The weight of the entire aircraft is estimated to be 1500g, the total thrust required to lift the aircraft is twice the weight of the aircraft.

Mathematically T = 2 x W, where T is thrust and W is the weight if the craft Hence T = 2 x 1500 = 3000g, since a quadcopter has 4 rotors, each rotor will have a thrust of T=W/4, therefore each motor should be capable of delivering a thrust of 750g.

The following decisions were made.

a. Four (4) 1000KV brushless motors

b. 3000mAh 3S LiPo batteries producing 11.1v

c. Max RPM is therefore 11.1x1000 = 11,100N

d. Propeller of pitch is fixed at 4.5’’ and diameter at 10’’

Power required $W = K \times N^3 \times D^4 \times P \times \eta$ ......where K is propeller constant, it depends on the design of the propeller blade thickness, width, aerofoil profile etc.

$K = 5.3 \times 10^{-15}$

N = Speed of the rotor in rpm $\eta = 0.75$ (efficiency)

D = Propeller diameter in inch = 10”

P = Pitch of the propeller = 4.5”

$$W = 5.3 \times 10^{-15} \times 11100^3 \times 10^4 \times 4.5 \times 0.75$$
$$W = 244.63 \text{ watts}$$

$$\text{Maximum current drawn at full throttle } I = W/V$$
$$I_{max} = 244.63/11.1$$
$$I_{max} = 22.039 \text{ A}$$

5.1.2 Thrust Calculations

The thrust generated by the rotors is given as.

$$T = [(\eta W)^2 \times 2\pi R^2 \times \rho]^{1/3}$$
where $\eta=0.75$ (is taken as the efficiency)
W = Propeller power = 244.63W
D = 10’’ = 0.254m
R = 0.127m
$\rho=1.22 kg/m^3$ (density of air)
$$T = [(0.75 \times 244.63)^2 \times 2\pi\,(0.127)^2 \times 1.22]^{1/3}$$
$$T = 16.085N$$

5.1.3 Velocity of Air Accelerated Downward

The velocity of air accelerated downward is given as.

$$V_d = (2W\eta)/T$$
$$V_d = (2 \times 244.63 \times 0.75) / 16.085$$
$$V_d = 22.81 \text{ m/s}$$

The flight speed or aircraft speed.

$$V_a = 1/2 \times V_d$$
$$V_a = 1/2 \times 22.81$$
$$V_a = 11.406 \text{ m/s}$$

5.2 Design Simulations

We have used www.ecalc.ch website for our design simulations. It is based on common physics and a mathematical model that is able to simulate the resulting flight characteristics of a multicopter by simply choosing your setup among the comprehensive database.

Figure 7. Results of Delivery Drone design using ecalc

5.2.1 Range Estimator

By analyzing our design, we estimated a best flight range of 34-42 km/h. So that in this range our design gives out best for Delivery purpose.

5.2.2 Motor Characteristics

Motor Characteristics at Full Throttle of our design is as shown in Fig. 7.

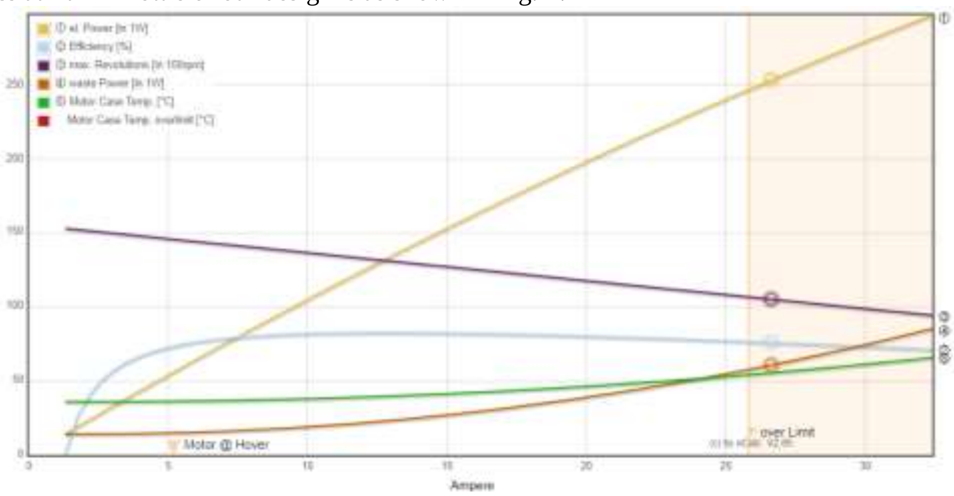

Figure 8. Motor Characteristics at Full Throttle

VI. CONCLUSION AND FUTURE SCOPE

Delivery drones are set to become the future of logistics with their reduced cost, higher convenience, and delivery time less than traditional method. This paper explores the vehicle design aspects of the delivery drone problem, including flight efficiency, energy consumptions, which are central to the viability of delivery drones. This paper deals with a systematic process of delivery with an autonomous quadcopter using an interfaced android device as its core processing unit. Drone will deliver the parcel to the customer by following Google map which will reduce both time and manpower using for delivery. Battery power will be replaced by solar system as a power source in future.

In future, the manual delivery will not be able to satisfy the demands of human race in the future. Drones will become a necessity and will be of immense use in delivery of packages to the respective customers. In future, people will become so engrossed in their own work that they would not have time for collecting parcels and packages separately. Thus, these drones will ensure the correct delivery of their demands in their current positions that is wherever they are. For this system to work properly image processing also has to be implemented in order to remove obstacles in the delivery path. If the dangers or obstacles are intermittent and sudden due to a storm or a bad weather which is harmful, the drones will eliminate it from the path. For a more advanced and efficient system of work and delivery the drone delivery system in the future will be AI controlled that is self-processing and implementing. They will be self-processing the path if there are any living object as an obstacle through algorithms.

REFERENCES

[1] Gabriel M. Hoffmann, Haomiao Huang, Steven L. Waslander, “Quadrotor Helicopter Flight Dynamics and Control: Theory and Experiment” AIAA.

[2] Michael Russell Rip, James M. Hasik, “The Precision Revolution: GPS and the Future of Aerial Warfare,” Naval Institute Press. p. 65. ISBN 1- 55750-973-5. Retrieved January 14, 2010.

[3] Michael Leichtfried, Christoph Kaltenriner, Annette Mossel, “Hannes Kaufmann Autonomous Flight using a Smartphone as On-Board” ACM 978-1-4503-2106, MoMM2013, 2-4 December 2013.

[4] D. C. L. Kristen Boon, "Warrant Requirement and Suspicionless Drone Searches," in The Domestic Use of Unmanned Aerial Vehicles, USA, Oxford University Press, 2014, p. 228.

[5] J. Cohen, "Drone Spy Plane Helps Fight California Fires," Science Journal, vol. 318, no. 5851, p. 727, 2007.