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Abiding Drone: Onboard power generation in UAV

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Abstract: The electric propulsion system of Unmanned Aerial Vehicles (UAV) is shifting from open propeller to the shrouded or ducted propeller due to its several advantages over open propellers. Numerous efforts and works have been made to improve the efficiency of the ducted propeller since its introduction in the 1930s. There was a significant increase in flight time due to increase in propulsive efficiency. One factor taken in consideration for overall efficiency of a UAV is its flight time. There has been much research and work on optimization of UAV to increase the flight time, either through minimizing the weight/introducing composite materials or by improving the efficiency of the electronic system or both. This work is an attempt to develop an onboard electricity generation system through an efficient duct equipped with a generator-turbine assembly. This is to increase the flight time without reducing the overall efficiency of the Unmanned Aerial Vehicle (UAV).

Keywords: Re-charging while flying, dynamo, ducted propeller, increased flight time, long range, high endurance, onboard power generation, increased overall efficiency and FM.

INTRODUCTION:

Duct is a shape which encloses the propeller by covering the circumference of the propeller to make the flow of air in a particular direction. In a single-ducted propeller, it increases the lift force production at a rate of 24.5% and 38.1% in FM efficiency as compared to the non-ducted single-propeller [4].
Duct eliminates the formation of vortices at the blade tips. It increases the thrust by reducing the losses occurring at the tip of the blade. Ducts are used to produce much more stability and reduce the wastage of thrust produced by the rotor. As the turbine situated under the motor also rotates, it does not bring the air to rest.
After the introduction of the turbine at the end of the duct, the thrust produced by the ducted propeller with the obstacle (turbine) would be nearly the same as that of the open propeller. If the thrust is not affected by the turbine, the flow around it can be converted to useful energy through a generator assembly connected to an electronic circuit on board.
The current generated is fed to a voltage regulator and then charged the battery through a charging circuit. Battery checker and temperature sensor are used to constantly check the battery voltage and temperature. As the drone is going to be used indoors, obstacle avoidance sensors are used. The battery will be recharged at a slow rate so the battery does not get damaged after many cycles of charging-discharging. So this can be very useful in the industrial applications and also for many indoor and outdoor purposes.

Fig1: An open-propeller UAV in flight

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Fig2: A ducted-propeller UAV in flight
[Source: https://www.amatek.com/case-studies.html]

PROPOSED SYSTEM:

A rotorcraft (UAV) pushes air downwards to produce thrust in order to stay aloft. The magnitude of the thrust produced by an open propeller is increased by introducing a duct. The flow of air at the exit can be used to generate current to recharge the battery or use in other components onboard. An efficient nozzle has to be designed to have much higher propulsive efficiency than the open propeller to trade with a part of thrust to produce current. This proposed system will increase the flight time of the UAV, thus increase the overall efficiency and the figure of merit of the UAV.

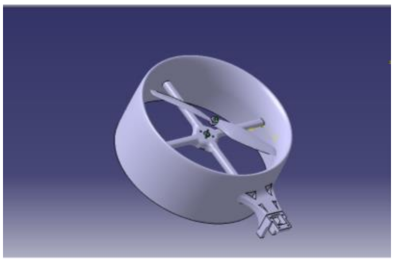

Fig3: CAD model of the duct for 8 inch propeller.

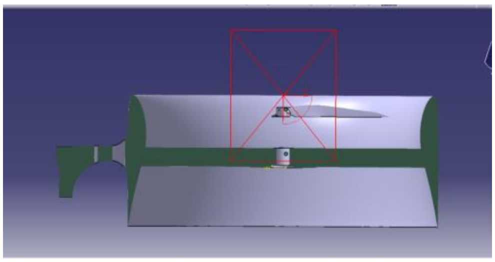

Fig4: Cut section of the ducted-propeller CAD model.

MODEL DESCRIPTION:

A duct is designed with the airfoil ah-80-140. The propeller is enclosed in the duct and is placed at a particular height of 0.3H of the total height (H) of the duct from the inlet [12]. The duct is designed in a way to provide an adequate clearance at the blade tip of 0.1L of the total diameter (L) of the duct. The diffusion ratio of the duct is 0.5 to 1. Diameter of the duct at 0.3H from the inlet is calculated to accommodate an 8 inch propeller having the above stated clearance. The support for the motors is provided from four sides of the duct to hold the motor rigidly. The generator and the turbine assembly is placed under the support of the motor in the same axis.

PARAMETERS OF THE DESIGN:

Clearance area: 0.1L of the total diameter of duct (L)
Diffusion ratio: 0.5 to 1 for ducted propeller [13]
Placement of propeller in duct: 0.3H of the total height of duct (H) from the inlet [12]
Gap between the propeller and turbine: It comprises the height of the motor, base/support and the generator.

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CIRCUIT DIAGRAM:

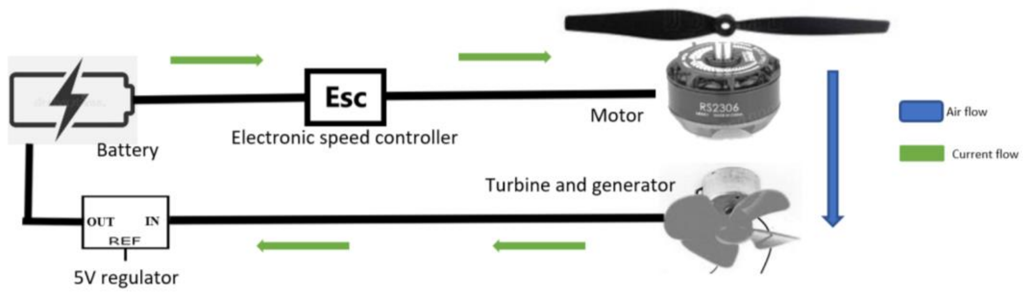

Fig5: Circuit diagram
{Sources: Motor- [15], generator-[14], and propeller - [16]}

CONCLUSION:

In this paper the advantage of the ducted propeller has been considered primarily to discuss the proposed concept of a system to use the thrust for propulsion as well as onboard generation of current to either recharge the battery or use to power other electronic components or both. The proposed system can be a major factor in the evolution of the Unmanned Aerial Vehicle (UAV) increasing the flight time, thus increasing the overall efficiency and figure of merit (FM).

FUTURE WORK:

Our research and work on this concept is in progress.
In future, this concept of propulsion cum power generation can also be equipped on fixed wing UAV which will be more efficient than a rotorcraft UAV.

DECLARATION OF CONFLICTING INTERESTS:

The author(s) of this paper declared no potential conflicts of interest regarding the ideas, concepts, design, research, authorship, and/or publication of this paper.

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[15]Source2:https://www.google.com/url?sa=i&url=https%3A%2F%2Fcommons.wikimedia.org%2Fwiki%2FFile%3AVoltage_Regulator.svg&psig=AOvVaw0I05rYPuGQD9XQe6R0_tuQ&ust=1639892847833000&source=images&cd=vfe&ved=0CAsQjRxqFwoTCLiNpNnb7PQCFQAAAAAdAAAAABAD

Source3:https://www.electronicscomp.com/emax-black-rs2306-2400kv-bldc-fpv-racing-motor?gclid=CjwKCAiAh_GNBhAHEiwAjOh3ZMU-33l1wOPVDJPjrC4BHcZj-s9aNhOvbHjBUSR6kvO7JB6gLII6QRoCoGMQAvD_BwE