Modeling of Solar Electric Propulsion System for UAVs

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Abstract: UAVs are growing their importance in both civil and military applications. The endurance of UAVs are related to their on board fuel carrying capacity which is limited by the weight class of aircraft. There is a need for long endurance UAVs for persistent Intelligence, Surveillance, Target Acquisition, and Reconnaissance(ISTAR) missions. One of the solutions to overcome the endurance limitations for usage of UAV is the renewable energy. Among all renewable energy, solar energy is found more economical. Electrical powered aircraft/(UAV) propulsion system uses electrical energy to change the velocity of UAV. Electric propulsion system is now mature and widely used technology on spacecraft. In this work, UAV with solar cells on the surface of the wings as well as on board energy storage is discussed. This paper quantifies the requirement for perpetual endurance in solar-powered flight.

Keywords:UAV, Solar electric propulsion system, Perpetual Endurance

I. INTRODUCTION

Unmanned Aerial Vehicle (UAV) is a powered vehicle that does not carry a human operator and it can be operated autonomously or remotely. It can be expendable or recoverable. UAV can carry a lethal or nonlethal payload. This work is aimed to provide solar power to for aircraft for its continuous both in day-night cycle. In Military Applications UAVs are capable of performing a variety of missions supporting military and intelligence purposes. UAVs are used for applications like, Reconnaissance Surveillance and Target Acquisition (RSTA), Surveillance for peacetime and combat Synthetic Aperture Radar (SAR), Deception operations, Maritime operations (Naval fire support, over the horizon targeting, anti-ship missile defense, ship classification), Electronic Warfare (EW) and SIGINT (Signals intelligence), Meteorology missions, Route and landing reconnaissance support. In Civil Applications Today, the civilian markets for UAVs are still emerging. However, the expectations for the market growth of civil and commercial UAVs are very high. UAVs are used for applications like, Policing duties, Traffic spotting, Sports events film coverage, Communications relay and remote sensing. Most of the UAVs are run on fossil fuels, which are limited in resources. Due to limitations in fuel carrying capacity, long endurance is not possible. Fossil fuels increases pollution problems (carbon footprint).Need to use renewable energy is on demand due to reduction in fuel cost and green energy promotion. Fuel Propulsion System, Gas propulsion system store energy in the form of fuel and use an engine to drive propulsion devices. Various types of engines are used for UAVs, including two-stroke or four-stroke internal combustion engines running on gasoline fuels. Fuel systems are more difficult to setup and maintain the electric systems. They are noisier, less reliable, and cannot be controlled as precisely as electric systems. They provide significantly longer endurance, and can be quickly refueled. Due to this reasons, fuel power systems are often used. Presently the only viable technology to overcome the above issues is to use SOLAR ELECTRIC POWER. Analysis has been carried out to track estimation of Solar electric power supply for typical UAV, Placing solar cells on fixed wing, Propulsion system and it is part of UAV that makes the entire structure to fly. In a work came out by Morton et. al [1] the application, design considerations and validation of prototype is determined through several experimental steps of solar powered Unmanned Aerial Vehicle. Shiau et. al [2]designed solar power management system (SPMS) for an experimental UAV this will provide required power for on-board electronic systems on the UAV. Improvements to airframe design, variable pitch propulsion system and custom-designed power electronics are presented by D'Sa et. al [3] along with validation of designs through testing. Torobi et. al [4] analyzed solar cells used to increase the endurance of the aircraft a electrical circuit was developed by using this to measure the output power of the batteries of the UAV during flight. Flight test results showed in cruise phase that flight without battery is achievable. Sydorenko et. al [5] stated that solar energy considered potential source of power for UAV and energy input and consumption can be successfully balanced for typical Solar Photovoltaic Fundamentals, Technologies and Applications, each and every types of solar cells were explained by UAV. Singh et. al [6]. André NOTH [7] designed of Solar Powered Airplanes for Continuous Flight. Andrea [8] explains the battery management for large lithium battery packs. Héctor [9] proposed a design of solar UAV, construction and test of propulsion system for solar UAV. Trembly et. al [10] discussed about experimental validation of battery dynamic model for EV applications.

Perpetual endurance is the ability to collect more energy during day and excess energy is used to store in batteries for night flying. Different designs are compared by size, weight, battery used, energy power, and C-ratings. This paper considers energy balance for perpetual endurance to unmanned aerial vehicles (UAV) equipped with solar cells on the wings, which collect energy used to drive a propeller. The design requirement is formulated as a threshold of the Power Ratio that characterizes the ability of an UAV to fly while solar-powered.

Simulation

Sunlight which is emitted by the sun converted into electricity due to photovoltaic

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effect, the generated electricity is sent to load like BLDC motor through ESC & MPPT. The excess energy is stored in batteries in the form of chemical energy for night flying purpose. Figure1 represents the complete arrangements of solar electric propulsion

Result

LH / RHpanels:
Both the panels of Port side (panel of 120cell + 90 cells) are connected in series in order to give higher voltage and power at output. Figure.5 illustrates I-V characteristics of cells connected in panels calculated for given area, irradiation and efficiency of the cells.

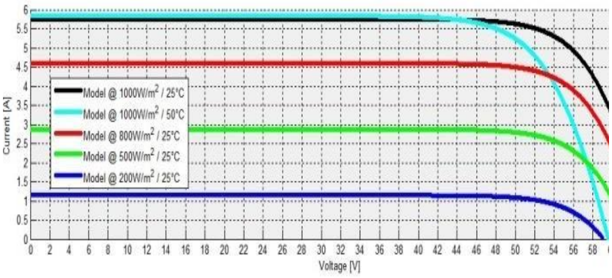

Figure. 5. I-V Characteristics for combined LH or RH wing panels

Discussions and Conclusion

In the above discussed UAV, 420 Solar cells are placed on the wing and 210 cells are placed on portside & mid wing PS Panel side. Voltage (VOC), Current (ISC) are achieved as 143.64 V, 6.26 A respectively. The other 210 cells are placed on star board & mid wing SB panel side Voltage (VOC), Current (ISC) are achieved 143.64 V, 6.26 A respectively. By adding power generated at both right side (RH) panels and left side (LH) LH panels, the total power generated is estimated as 17.98kW. As the power required by UAV is around 300 W the excess energy stored in battery bank of 20S20P which has 72V & 71.4Ah . This power is used for flight during night time. In this work UAV with solar cells on the surface of wing as well as on board energy storage is presented. It is evident from the results that the power generation capability of the solar modules positioned on the wing of the UAV may vary with the irradiation conditions and the ambient temperatures. A solar panel can convert only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel. A typical UAV was considered and the mathematical modeling of solar cell as well as arrangement of the cells/panels are simulated. Battery bank is designed for storage of energy and it is found capable of supplying for a complete night flight. The performance simulation of individual modules and also experimental evaluation is also performed. Finally the integrated system was simulated for energy balance requirements the power which is required and generated is balanced for continuous flying (24 hours) without any interruption.

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