Modeling and Design of an Energy Harnessing Electric Powered RC Aircraft

Muzamil Bostan, Asim Mustafa, Syed Ali Sajjad, Muhammad Ali Bangash and Adil Farooq
Department of Electronic Engineering,
Faculty of Engineering and Technology,
International Islamic university Islamabad Pakistan
adil.farooq@iiu.edu.pk, muzzamilbostan@yahoo.com

***Abstract*— This paper presents the harnessing of environmental friendly solar energy and its application to the Electric battery powered RC Aircraft. Main purpose was to establish highly efficient solar RC aircraft system with improved flight time. Designed aircraft is capable to fly on solar energy having increased flight time. To ensure lesser energy consumption and economic in cost, aircraft was considered to be light weight. Therefore several precautions were taken in terms of material and the basic geometry. A 3D model of RC aircraft with limitations was designed. Specific number of solar cells is installed on wing solely dependent on onboard load. Maximum power is provided by solar cells to increase its flight time. Likewise different mathematical calculations were carried out to make it energy efficient.**

Keyword: Solar Power, RC aircraft, Energy Harnessing, Highly Efficient, Flat bottom, Lift, Top winger, Drag, polycrystalline solar cell

I. Introduction

Mostly RC Aircrafts are electric powered rather than petrol engine or turbine engine which are cause of pollution. major problem with electric powered aircraft is that its battery drain quickly and backup is required to increase its flight time. These are used in various applications especially for military purposes [1]. Most of the designed aircrafts are very complicated [2]. The trend has shifted from engine powered sircrafts to electic powered [3] and now renewable sources are being integrated as hybrid to existing aircraft systems. Solar energy is best source because of environmental friendly and one time investment. Though task is challenging to situate solar panels over an aircraft due to limitation of size and weight on RC Aircraft. Therefore, to tackle such issues polycrystalline cells were selected having max efficiency and light weight. then a 3D model was designed on Pro-engineering software according to dimensions. Calculation were done to select motor, servos and propeller which is suitable for such kind of aircraft, as solar panel are to place over the top of wings. Solar cells were placed in combination of series and parallel to get desired power which will capable to fulfill the required load. Number of solar cells were totally dependent on load power of onboard components. Main problem to tackle is the efficient utilization and harnessing of solar energy according to our purposes. So the solar energy is directly supplied to our power consuming system and also in parallel supplied to charge the on board battery, and battery charged energy is also supplied to power consuming system, making a hybrid system for the increased flight time as shown in Fig. 1 below.

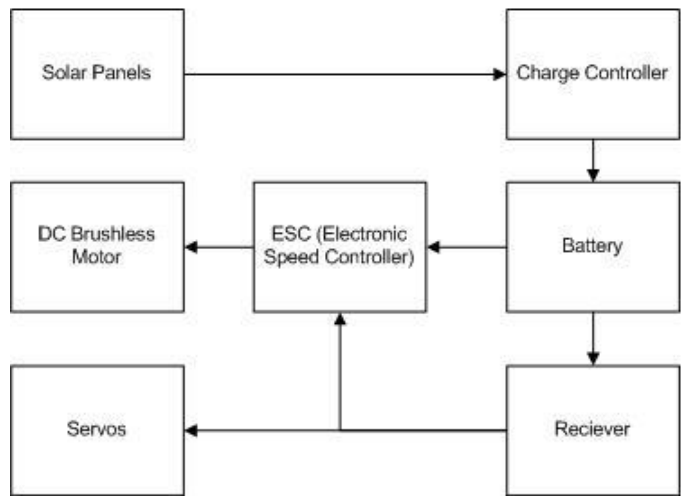

FIG. 1 SYSTEM OVERVIEW

The paper is organized is as follow. Section II explains the modeling and design. Section III presents the solar panel implementation and section IV. Design of solar charge controller. Conclusion and future work is given in section V and VI .

II. Modeling and Designing

The construction material preferred is balsa wood other than Styrofoam and Coroplas due to its very light weight strength. We deigned 3D aircraft model using Pro Engineering CAED 2010 software as shown below.

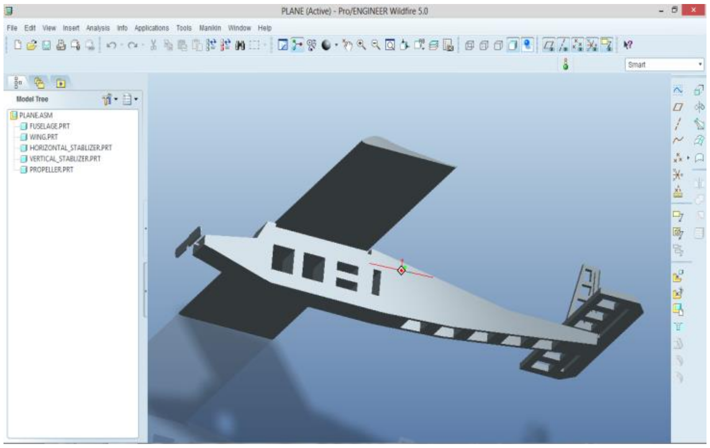

FIG. 2. 3D DESIGN

A. Selecting a wing/airfoil

Solar cells required a surface which should be flat because in our case cells are very thin in size. Without breakage they can be easily placed over wing surface. NACA has many types of airfoil. We come up with “CLARK Y” Flat Bottomed airfoil having wing cord 9.5”, wing span 46.5”, wing area 441.75 sq. Inches. Wing taper ratio tends to affect weight, tip stall and cost [4]. For aircraft to be light in weight and cost effective in manufacturing, wing with constant chord are the most palpable choice with $\lambda = 1$. Wing taper ratio is selected considering the effects of lift required; distribution of lift constant also affects the weight of wing. Average flow velocity on upper surface is kept higher than that the bottom surface to stream line below the airfoil [5]. The drag on airfoil is mainly due to viscous upshot at low speed and compressibility causes at high speed. In [6], analysis is shown of renolds number and angle of attack. Aspect ratio is the key dimension for our analysis because it is of particular significant and determining the performance while calculating lift and drag. Below Fig.ure gives the 3D picture is made using Pro Engineering.

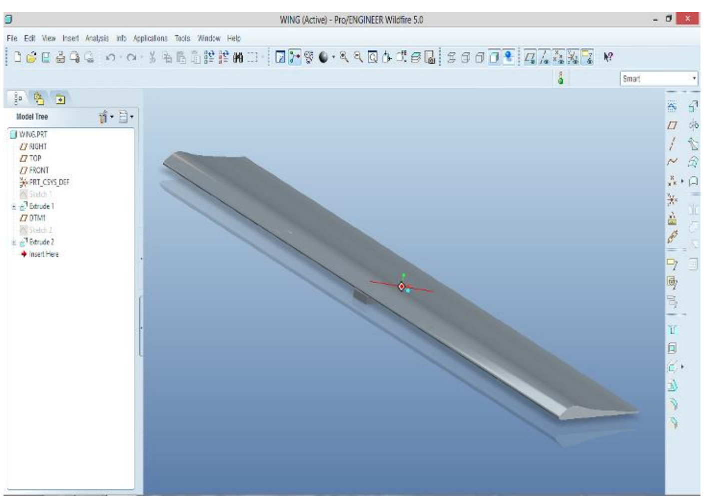

FIG. 3. WING SPAN DESIGN

B. Fuselage

The length of fuselage model selected was 39 inches to place onboard components which require suitable area and length.

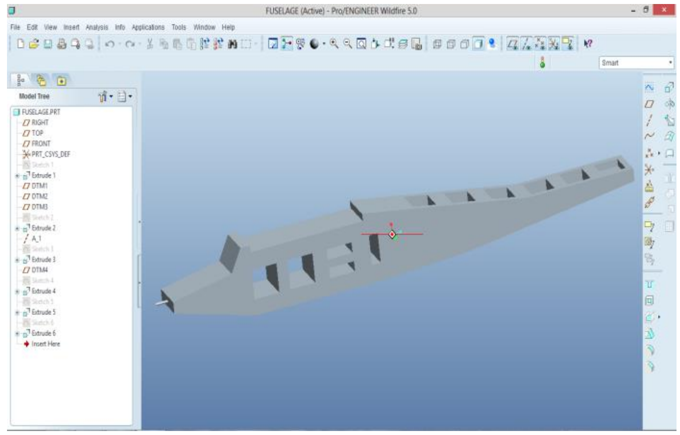

FIG. 4 FUSELAGE

III. SOLAR CELLS INTEGRATION

Battery used for propulsion system was of 11.1 volts, 2.2 ampere. Total 24 cells each on 0.5 volts connected in series to make 12 volts total.

FIG. 5 SOLAR RC AIRCRAFT

IV. SOLAR CHARGE CONTROLLER DESIGN

The charge controller used for charging a battery via solar cells was PWM charge controller. In our case we set the voltage 14.5V, when battery voltage less 14.5V then PWM generate 95% duty cycle. If greater than 14.5V then PWM generate 10%.The working of circuit is MOSFET 75NF75 is driven by transistor A1020 and another transistor A1020 is driven by another KSP13.KSP13 is connected with microcontroller 16F684. Below circuit shown in Fig. 6 designed using Proteus ISIS Professional.

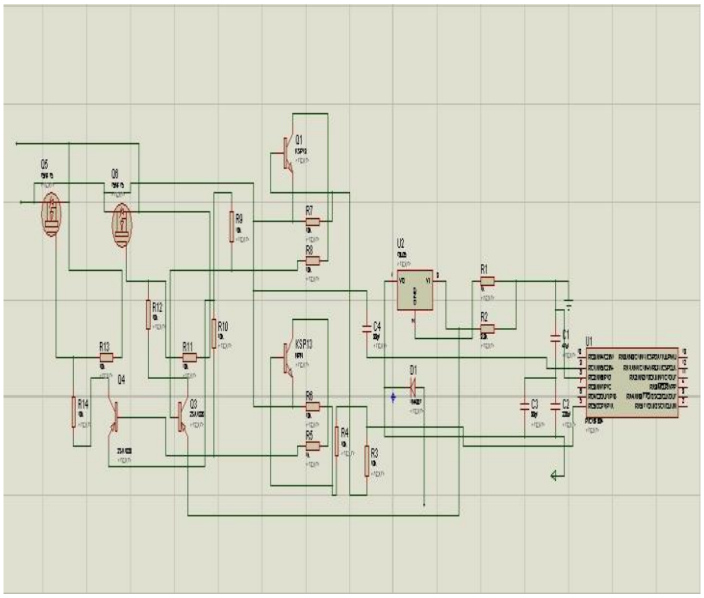

FIG. 6 CHARGE CONTROLLER

V. EQUATIONS AND CALCULATIONS

A. *Power:*

ω = rpm x $2\pi/60$

ω = 9546 x $2\pi/60$
ω = 100 approx.

T x ω = I x V x E
T = (21 amp x 11.1 V x 0.15)/100
T= 0.349

P= T x ω
P= 0.349 x 100
P = 34.965 W

B. *Reynolds No :*

C = Wing Length

$R_e = \rho vC/\mu_o$ [7]
R_e= (1.225 kg/m^3) x (22 m/sec) x (1.1811 m) / 0.000179
R_e= 0.177 x 10^6 approx.

C. *Propeller:*

Speed of propeller = load x RPM
Velocity = m/revolution x revolution/sec

D. *Aspect Ratio:*

Aspect ratio = span of wing / chord of wing [8]
= 46.5"/9.5" = 1.1811m/0.2413m = 4.89

E. *Drag:*

C_d = Drag Co-efficient
V = airplane speed

$D = \frac{1}{2} \rho V^2 C_d$
D = ½ (1.225 kg/m^3) $(22)^2$ (0.2849 m^2) (7x10^{-3})
D = 0.5 N

F. *Lift:*

C_l = Lift Co-efficient
V = airplane speed

$L = \frac{1}{2} \rho V^2 C_l$
L = ½(1.225 kg/m^3) $(22)^2$(0.2849 m^2) x0.6
L = 50.67 N

G. *Taper Ratio:*

Λ= chord length at tip / chord length at root
Λ= 9.5 in. / 9.5 in.
Λ= 1.0

H. *Mach Number:*

V = airplane speed
a = speed of sound

M = V / a
M= 0.06465

According to Mach number $M < 0.5$, our aircraft lie in subsonic flow.

I. *Charging & discharging of battery:*

Time of charging = Power of battery in hours / Power of solar

If battery power is 24W and solar power is 33W then time of charging = 24W / 33W = 0.727 hours = 43.62 minutes.

20% battery discharge then 20% of 24W is 4.8W so charging time is = 4 / 33= 0.1212 hours.

J. *Size of Solar Panel:*

Total Energy/day = incident solar energy per day per unit area x area x efficiency

Area= Total energy per day / incident solar energy per day per unit area x efficiency

Area= (34.965 W x 3600 sec x 24 hr.) / ((6000 W.hr/m^2 day) x 3600 sec/hr. x 0.16)

Area = 0.874 m^2

TABLE I. DETAIL DESIGN TABLE

PARTS	DIMENSIONS
FUSELAGE	39”
WING CHORD	9.5”
WING SPAN	46.5”
WING AREA	441.75 SQ.INCHES
HORIZONTAL STABILIZER	20.5”
VERTICAL STABILIZER	5.5”
LANDING GEAR	TAIL WHEEL TYPE
PROPELLERS	TWIN BLADES 10X5

TABLE II. DETAIL ONBOARD COMPONENT TABLE

LI-PO BATTERY 3S	**11.1 V , 2200 MH**
DC BRUSHLESS MOTOR	1200KV, 233W, 21 A, 9546 RPM
SERVO MOTOR	6 V
ESC(ELECTRONIC SPEED CONTROLLER)	25A

VI- CONCLUSION

We have designed and fabricated an energy harnessing solar aircraft. Onboard charging circuit is designed to increase time of flight up to 30% using solar cells. A maximum of 33W solar power is being supplied to battery of 24W. The total weight of aircraft is equal to electric motor installed capable to lift itself making it stand alone. The test flights showed our aircraft performed good within limits and has an overall enhanced time flight duration of approximate 45 minutes.

VII- FUTURE WORK:

Using this solar powered RC modeled Plane as multipurpose stand alone aircraft. Installing wireless digital camera with image processing techniques it can be used as surveillance aircraft. In the field of solar power, MPPT technique is being used for the smart solar battery charging, thus increasing efficiency of solar power for the continuous flight of aircraft. Auto self-stabilization can be done on this aircraft to reduce the chances of accidents or crash on the auto-pilot and fail safe landing.

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