Review Article

SOLAR AIRCRAFT: FUTURE NEED

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ABSTRACT

Generally domain Aircraft uses conventional fuel. These fuel having limited life, high cost and pollutant. Also nowadays price of petrol and other fuels are going to be higher, because of scarcity of those fuels. So there is great demand of use of non-exhaustible unlimited source of energy like solar energy. Solar aircraft is one of the ways to utilize solar energy. Solar aircraft uses solar panel to collect the solar radiation for immediate use but it also store the remaining part for the night flight. This paper intended to stimulate research on renewable energy sources for aviation. In future solar powered airplanes could be used for different types of aerial monitoring and unmanned flights.

This review paper briefly shows history, application and use of solar aircraft. We are focusing on design and fabrication of solar aircraft which is unmanned prototype.

KEY WORDS: Solar energy, Reynolds number, Bernoulli's principle

1. INTRODUCTION

Energy comes in different forms. Light is a form of energy. Sun is source of energy called "sunlight". Sunshine is free and never gets used up. Also, there is a lot of it. The sunlight that heats the Earth in an hour has more energy than the people of the world use in a year. A little device called a solar cell can make electricity right from sunlight. The dream of flight powered only by the sun's energy or sunlight has long motivated scientists and hobbyists. A solar aircraft is one which collects energy from the sun by means of photovoltaic solar cells. The energy may be used to drive electric motor to power the aircraft. Such airplanes store excess solar energy in batteries for night use.

Also there are rapidly increasing traffic problems in world and in our country also, so it is required to go for such small solar aircrafts which can be used for transporting goods or materials between places at short distance.

Using solar panels there is more space due to escape of engines and turbines. Quite a few manned and unmanned solar aircraft have been developed and flown.

1.1 Brief history

1. [4]The Helios Prototype solar-electric airplane was an uninhabited aerial vehicle (UAV), were developed as technology demonstrators under Environmental Research Aircraft and Sensor Technology (ERAST) project. Prior to its loss during flight in June 2003, the Helios Prototype set a world altitude record for propeller-driven aircraft of almost 97,000 feet.

2. [4]Pathfinder was developed for government program in the early 1980's to develop a high-altitude, long-endurance aircraft for surveillance purposes. It is also known as the HALSOL (for High-Altitude Solar) aircraft. It has eight electric motors which is later reduced to six and first powered by batteries. After that project was cancelled, the aircraft was placed in storage for 10 years before being resurrected for a brief program under the auspices of the Ballistic Missile Defence Organization (BMDO) in 1993. There were five low-altitude checkout flights were flown under the BMDO program at NASA Dryden in 1993 and early 1994 on a combination of solar and battery power with the addition of small solar arrays,

3. [4]The Centurion is a lightweight, solar-powered, unmanned aircraft which used technology of applying solar power for long-duration and high-altitude flight. It is considered to be a prototype technology demonstrator for a future need of solar-powered aircraft that can be flown for weeks or months on scientific testing and missions or while serving as telecommunications relay platforms. The Centurion has a wingspan of 206 feet and 70% longer than the Pathfinder-Plus 121-feet span.

4. [4]The "Hy-Bird" project with a 100% clean electric airplane powered only by solar energy and hydrogen. The goal is to design an airplane, which will use only renewable energies with no greenhouse gas emission and also to decrease noise pollution. There were photovoltaic cells affixed on the wing and on the horizontal tail supply power for the take off and for on-board electric supply. An electric engine which is more silent than heat engines, will propel Hy-Bird.

5. [4]SOLAR RISER which is an ultra light glider demonstrated by Larry Mauro driven by solar power. Eric began construction of his design in late 1986. Progress was slow until 1988. Then with the help of Sanyo and several other corporations the SUNSEEKER was test flown at the end on 1989 as a glider. An ac brushless motor and a folding prop were installed. During August of 1990, The SUNSEEKER crossed the country in 21 flights, with 121 hours in the air.

6. [4]The Sky-Sailor was developed as a vehicle. It is in a small Aeroshell that would be attached to a carrier spacecraft. Upon reaching the red planet, the Aeroshell would be released for direct entry into the Martian atmosphere. It has a distance of 1700 km during a 12-hour period. This allows the airplane to reach many different areas of interest. The exploration mission will end when the airplane crashes normally due to the batteries life cycle and dust deposition on solar panels.

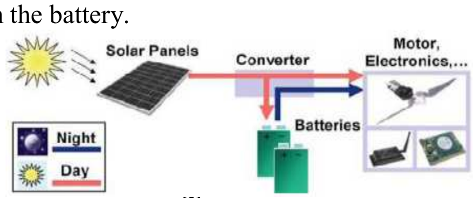
7. [4]The SoLong is an electric-powered UAV (unmanned aerial vehicle) that collects solar energy from photo-voltaic arrays laminated into its wings. It is possible to fly for one night just by discharging the batteries, but for two or more nights, the plane has to fully recoup and store the energy used at night while flying in the sunlight the following day. Once that is achieved, the cycle can repeat continually, and keep the plane airborne indefinitely.

8. [4]The Zephyr is an aircraft that can fly continuously using solar power and "low drag aerodynamics". Zephyr can be flown for many weeks and even months with the combination of solar panels on the upper wing surface and rechargeable batteries. The first trial of the Zephyr for flying was conducted recently by QinetiQ in White Sands Missile Range, New Mexico. Two aircraft were flown for four and a half and six hours respectively, the maximum flight times permitted under range restrictions.
9. [4] At the NASA Glenn Research Centre, a Venus exploration aircraft of size to fit in a small aeroshell for a scientific mission, has been designed and analyzed. It must have flight at or above the wind speed, about 95 m/sec to remain continually illuminated by sunlight. The analysis showed that, at typical flight altitudes of 65 to 75 km above the surface, a small aircraft powered by solar energy could fly continuously in the atmosphere of Venus. At this altitude, the atmospheric pressure is similar to pressure at terrestrial flight altitudes.
10. [4]The Solar Impulse project with the construction of an initial prototype with a 61-metre wingspan, referred to by its registration number "HB-SIA". It is the research of four years and studies, calculations and simulations. Its mission is to verify the working hypotheses in practice and to validate the selected construction technologies and procedures. On 24 July, 2012, it has taken-off at 05:01am with flight duration of 13hours 29mins and average speed of 34 kts. It has an average altitude of 3596 meters without any fuel.

1.2 Principle of operation

Our basic principle is to use solar power by means of aircraft. And this thing can be done by solar panels which cover the whole surface of wing. This panels converts radiative energy into electric energy. This electric energy is used to charge battery which drives electric motor. Propeller which is mounted on motor shaft produces thrust continuously. Because of this, aircraft is moved and force is produced on wing by dynamic effect of air which opposes the downward force of weight.

During the night, the only energy available comes from the battery.



[2]**Figure 1**

1.3 Aerofoil used for wing

Shape of aerofoil provides lift of aircraft. Also it should have better surface area for its smooth functioning. All airfoils are worked on same principle i.e., Bernoulli's principle. It shows the relationship between velocity and pressure in a moving gas:

$P+\frac{1}{2}\rho v^2+g\rho h=k$

where,
P=Pressure(Pa)
ρ=Density(kg/m^3)
v=Velocity(m/s)
g=Acceleration(m/s^2)
h=Distance from reference, measured in opposite direction of the gravitational force(m)
k=constant(kg/m^2)

The formula shows that if g, ρ and h remain unchanged, pressure will drop when flow velocity increases. It means area under high velocity will have lower pressure and vice versa. Air which is moving over the wing moves faster than the air below. As shown in fig 2.

Faster-moving air above exerts less pressure on the wing than the slower-moving air below. The result is an upward push on the wing. This is called lift.

This is the reason why wings are shaped in such a way that air above the upper surface moves fast. And this can be done by moving air above the wing through longer distances than the air below the wing in same time. That's why upper surface of wing is more curved than its lower surface. Till now many airfoils have been developed for different purposes, like low or high speeds, or stability.

We have used symmetrical aerofoil because the wings will be hand fabricated and developing a cambered airfoil will be difficult. That means there will be no camber. We have selected NACA aerofoil of 4 digit i.e., NACA 0015. The 'NACA' aerofoils are shapes for aircraft wing developed by the National Advisory Committee for Aeronautics (NACA).

Figure 2

1.3.1 Four-digit series

[3]The NACA four-digit wing sections define the profile by:

1. First digit describing maximum camber as percentage of the chord.
2. Second digit describing the distance of maximum camber from the airfoil leading edge in tens of percent's of the chord.
3. Last two digits describing maximum thickness of the airfoil as percent of the chord.[5]

The NACA 0015 airfoil is symmetrical, the 00 indicating that it has no camber. The 15 indicates that the airfoil has a 15% thickness to chord length ratio: it is 15% as thick as it is long.

[6]The formula for the shape of a NACA 00xx foil, with "xx" being replaced by the percentage of thickness to chord, is:

$$y_t = \frac{t}{0.2}c\left[0.2969\sqrt{\frac{x}{c}} - 0.1260\left(\frac{x}{c}\right) - 0.3516\left(\frac{x}{c}\right)^2 + 0.2843\left(\frac{x}{c}\right)^3 - 0.1015\left(\frac{x}{c}\right)^4\right]$$

[7][8]Where:

- *c* is the chord length,
- *x* is the position along the chord from 0 to *c*,
- *y* is the half thickness at a given value of *x* (centreline to surface), and
- *t* is the maximum thickness as a fraction of the chord (so 100 *t* gives the last two digits in the NACA 4-digit denomination).

Note that in this equation, at (x/c) = 1 (the trailing edge of the airfoil), the thickness is not quite zero. If a zero-thickness trailing edge is required, for example for computational work, one of the coefficients

should be modified such that they sum to zero. Modifying the last coefficient (i.e. to -0.1036) will result in the smallest change to the overall shape of the airfoil. The leading edge approximates a cylinder with a radius of:
$r = 1.1019t^2$.

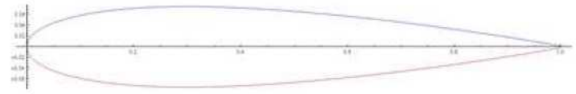


Figure 3

1.3.2 Inclination effect on lift

For small angles, lift is related to angle.

Greater angle = greater lift.

For large angles, the lift relation is complex.

Included in lift coefficient.

Stall is a “SEPARATION OF AIRFLOW” from the upper wing surface = rapid decrease in lift.

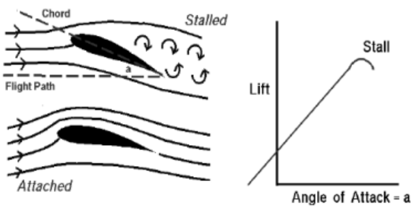


Figure 4

1.3.3 Angle of attack

It is the angle between the wing chord and the relative wind.

We have used software to create airfoil. By putting proper angles of attack related values of other parameters like coefficient off lift, coefficient of drag, Reynolds number etc can be generated. For our aircraft we have chosen angle of attack of 4.5 because the aircraft generally trimmed at 3 to 5 degrees angle of attack. This range values keep the aircraft away from the stall angle providing a safer flight.

From the fig 8 of topic no. 3, we have,

Coefficient of lift (C_L) = 0.549

Pitch moment (C_m) = -0.002

Coefficient of drag (C_D) = 0.0082

L/D ratio = 67

Reynolds no. = $3*10^6$

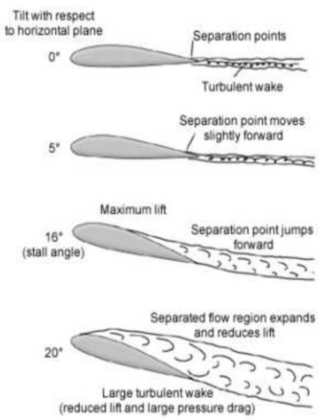


Figure 5

1.4 Mechanical structure

Our aircraft will be lightweight aircraft with 1 kg of total weight including motors, servos, battery, cells etc. The wingspan of it will be about 1m. It can produce thrust with brushless outrunner motor of 1000 rpm/v. It will basically worked through battery of 1500mah 3S. This battery will charged through monocrystalline silicon cells attached to wing. This can be done with the help of charging circuit. To move elevator and rudder required torque is about 1.6 kg-cm. Also, 2.3 kg torque is required to move aileron.

1.4.1 Aircraft parts

The airframe of a fixed-wing aircraft consists of the following four major units:

- Fuselage
- Wings
- Stabilizers
- Flight controls surface (elevators, rudders, ailerons)

Key idea:-

- Elevators are used to make a plane climb or dive.
- Ailerons are used to make a plane roll left or right.
- Rudders are used to make a plane turn left or right.
- Throttles are used to make a plane go faster or slower.

1.4.2 Calculation

Weight Estimation:

[1]Wing Design:

Needed Wing Area, Swing

Choose Aspect Ratio (AR)

Wing span (bw) = $\sqrt{(AR * \text{Swing})}$

Wing chord (cw) = $\frac{\text{Swing}}{bw}$

The coefficient of lift is determined from equating the lift obtained from the wing to the aircraft weight.

L = W.

$0.5*v^2*\rho*C_{L_{\alpha_{3D}}}$ *Swing = M*g

Where ρ is the density of air = 1.225kg/m^3 , g is acceleration due to gravity, g = 9.81m/s^2, v is the cruise speed.

Angle of attack, α

We can use the software for a design of symmetric airfoil and we can get the related value,

$C_{L_{\alpha_{3D}}} = C_{L_{\alpha_{3D}}}*\alpha$ (y = mx kind equation calculate $C_{L_{3D}}$ which is like m)

In practical cases, the flow over the wing is 3 dimensional whereas the flow over an airfoil during study is 2 dimensional. To accommodate this difference the following correction is applied.

The relation between the 2 dimensional lift and the 3 dimensional lift:

$$C_{L_{\alpha_{3D}}} = \frac{C_{L_{\alpha_{2D}}}}{1+\frac{C_{L_{\alpha_{2D}}}}{\pi * AR_W}} \qquad \text{………………. (1)}$$

Calculate, $C_{L\alpha 2D}$(/radian) from equation (1)

For the symmetric airfoil,

$C_{L\alpha 2D} = C_{L\alpha 2D}*1^0 = C_{L\alpha 2D}$

(At angle of attack = 1 degree)

Value of $C_{L\alpha 2D}$ = value of at angle of attack for a symmetric airfoil.

[1]Tail design:

Choose the tail area (s_t) to be around 15-16 % of the wing area. (For better stability of the aircraft)

The aspect ratio of tail is chosen to be less than that of the stall in tail is delayed w.r.t. that of wing.

Aspect ratio of tail, AR_t

Tail span = (b_t) = $\sqrt{AR_t * s_t}$

Tail root chord $C_{root} = \frac{2S_t}{(1+\lambda_t)b_t}$

Tail tip chord $C_{tip} = \lambda_t*C_{root}$

Choose the tail setting angle (i_t) to be $1^0 - 1.5^0$ less than α. the tail setting angle is provided to achieve a positive C_{mo} value which leads to a stable airplane. The tail is always given a negative tail setting angle for the reason mentioned above

The tail moment arm (L_t) is calculated from the longitudinal moment equation:

$0.5*v^2*\rho*C_{L_{3D}}*Swing*x=0.5*v^2*\rho*C_{L_{\alpha t}}*(\alpha-i_t)*s_t*L_t$ ………………. (2)

$C_{L_{\alpha_t}} = 2\pi \quad rad^{-1}$

'x' is the distance of your centre of gravity from the aerodynamic centre of your wing.

Calculate, x_{CG}(from the leading edge of your wing)

[1]Volume ratio, V_h of the tail is defined as

$V_h = (L_t*s_t) / (Swing*C_W)$

[1]Longitudinal Stability Checks:

(1) The value of the pitching moment at 0^0 angle of attack should be positive (nose up)

C_{mo} = coefficient of moment at zero angle of attack,

$C_{mo} = C_{l\alpha t}*i_t*V_h$

(2) The slope of the C_m vs $C_{m\alpha}$ should be negative for stability.

$C_{m\alpha} = C_{L_{\alpha_{3D}}} \; (x_{CG}-x_{ac})/C_W-V_h*C_{l\alpha t}(1-d€/d\alpha)$

1.5 Solar and solar cells

1.5.1 How solar cells make electricity

[9]The cells are made of a type of material known as a semiconductor. Often, they are made of silicon. The process of making electricity begins when the silicon atoms absorb some light. The light's energy knocks some electrons out of the atoms. The electrons flow between the two layers. The flow makes an electric current. The current can leave the cell through the metal contacts and be used. When light hits a solar cell, much of its energy is wasted. Some light bounces off or passes through the cell. Some is turned into heat. Only light with the right wavelengths or colours, is absorbed and then turned into electricity. Single simple solar cell makes only a little electricity. For most purposes more is needed. For this reason, cells are often linked together in groups known as solar modules. A solar module has a frame that holds the cells. Some modules are several feet long and wide. They usually can produce up to a few hundred watts of electricity. If more power is needed, modules can be joined together to form a large solar array. Modules are sometimes called solar panels. Arrays are also sometimes called solar panels. Whatever you call a group of solar cells, the fact remains: the more cells you link together, the more electricity you make. With enough modules, huge amounts of power are possible. A good example is a new power plant being built at Moura in Portugal. The first phase of the project has 262,080 solar modules, each with 48 cells. They will produce up to 46 megawatts of electricity.

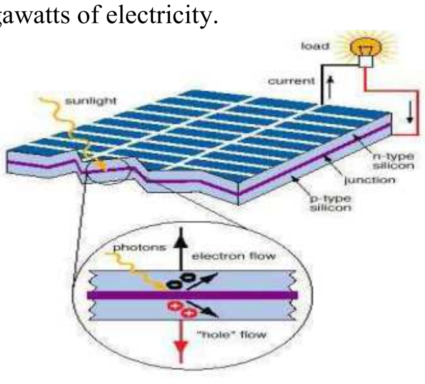


Figure 6

1.5.2 Solar cells we are going to use

Solar cells:

Crystalline silicon cells: By far, the most prevalent bulk material for solar cells is crystalline silicon (abbreviated as a group as c-Si), also known as "solar grade silicon". Bulk silicon is separated into multiple categories according to crystallinity and crystal size in the resulting ingot, ribbon, or wafer. E.g., monocrystalline silicon (c-Si) polycrystalline silicon, or multicrystalline (poly-Si or mc-Si). Crystalline solar cells are wired in series to produce solar panels. As each cell produces a voltage of between 0.5 and 0.6 Volts, 36 cells are needed to produce an open-circuit voltage of about 20 Volts. This is sufficient to charge a 12 Volt battery under most conditions.

Monocrystalline – made from a single large crystal, cut from ingots. Most efficient, but also the most expensive. Somewhat better in low light conditions

Polycrystalline – basically cast blocks of silicon which may contain many small crystals. This is probably the most common type right now. Slightly less efficient than single crystal, but once set into a frame with 36 or so other cells, the actual difference in watts per square foot is not much.

Other types of solar cells are:

Thin films cells, Copper indium gallium selenide cells, Gallium arsenide multijunction, Light-absorbing dyes (DSSC), Quantum Dot Solar Cells (QDSCs), Organic/polymer solar cells, Silicon thin films.

However we are going to use solar monocrystalline silicon cells, each 150 microns thick and chosen for their lightness, flexibility and efficiency.

monocrystalline polocrysralline

Figure 7

1.6 Applications

1. As a transport vehicle to reduce cost and to increase overall profit to reduce fuel cost.
2. Use of free energy means nothing to invest in transportation of materials and get free transportation after investing in small aircraft.
3. One main reason of traffic is due to the big and bulky transporting vehicles so by using small lighter aircraft traffic problem can be reduce.
4. Fast transportation of materials so some expensive material can also transport in less time.
5. One kind of solar aircraft is in astrology industries as a transporting vehicle used to go in space or on neighbour planets.
6. Use of solar aircraft worldwide can make fast development of countries.
7. Use of Solar Energy as source of energy will increase as conventional fuels are reducing drastically.
8. Future of aviation field.
9. Future utility to solve traffic problems.
10. Device used for Astronomical field.
11. Utility of solar aircraft in transporting

which can be helpful to reduce cost of transportation.

12. Lower cost of transportation than conventional vehicles.
13. Lighter in weight and not bulky

2. LITERATURE REVIEW RELATED TO SOLAR AIRCRAFT

[10]There is a cruciform wing structure for solar powered aircraft on which 28 cells are mounted on horizontal wing surfaces. For maintaining normal to the sun rays wing surfaces with span wise axis perpendicular to horizontal surfaces. The solar airplane may of conventional design with respect to fuselage, propeller and tail or may construct around core with propeller mechanism near the tips of airfoils. [11]Solar powered aircraft is capable of continuous flight nowadays. The research activities carried out till now have been mainly focused on flying wings or conventional aircraft configurations, with a great emphasis on the technological aspects. The paper deals with the current state of art of empower the aviation industry with solar power and the shortcoming and the future aspect. [12]The Autonomous Systems Lab of EPFL3 has developed, with ESA program, an ultra-lightweight solar autonomous model airplane called Sky-Sailor. The main goal of this project is to research on navigation, control of the plane. The airplane will be capable of continuous flight over days and nights, which makes it suitable for a wide range of applications. [13]Energy-optimal path planning and perpetual endurance for unmanned aerial vehicles equipped with solar cells on the wings, which collect energy used to drive a propeller. Perpetual endurance is the ability to collect more energy than is lost during a day. This paper shows two unmanned aerial vehicle missions: (1) to travel between given positions within an allowed duration while maximizing the final value of energy and (2) to loiter perpetually from a given position, which requires perpetual endurance. For the first one, the problem is of energy-optimal path planning features the coupling of the aircraft kinematics and energetic models through the bank angle. The problem is then formulated as an optimal control problem, with the bank angle and speed as inputs. The power ratio is used to predict the qualitative features of the optimal paths. If the power ratio exceeds a certain threshold, perpetual endurance is possible. [14]There are the solar airplanes which have a facility to sustain energy for flight during day-night cycles. Close to the Earth surface they are useful for transportation and at high altitudes, they are useful for monitoring and measurement applications, therefore they are targeted by several research groups and institutions. Also it indicates that how to choose the essential design parameters of the airplane for a specific mission, minding the current state-of-the-art technologies involved. Solar airplanes using both batteries as energy storage devices as well as their capability of flying performance-optimizing altitude profiles can be sized and evaluated in terms of various performance measures. [15]There is the concept of the exploration of neighbour planets around the earth. The ground robots are used but they have limitations. So, an aircraft which uses sun energy for flying continuously is approach of interests in this way. The step in this direction was a project of sky-sailor started in 2004. The aim was to study the possibility of solar powered aircrafts in the atmosphere of those planets. There is the result of two years of work on this project. [16] Mr. Hannes Ross has shown an overview of the historic solar powered aircraft is provided and the basic challenges which have to be solved for a solar powered aircraft. The goal of this is to “Fly with Solar Energy” to civil or military surveillance and reconnaissance missions. However, none of those aircraft was able to demonstrate a continuous day and night operation until 2005. [17]There is an analysis and development of the prototype with the aim of sending an aircraft to Mars (which imposes size limitations) has been done by Andr´eNoth, Stefan Leutenegger, Walter Engel, and Roland Siegwart. They showed the actual concepts for designing solar airplanes for different scales and mission. Because of this consideration the design of Sky-Sailor, a small prototype unmanned aircraft that used for continuous flight at low altitude. The conceptual design tool, in particular the airframe weight model will allow optimizing and downscaling solar airplanes towards a 1m wingspan nearer in future. These planes could be used as completely autonomous remote sensors, for example, spending lots of time constantly airborne in disasters. [18]There is also a solar powered air craft which uses solar energy to electrolyze on board water to produce hydrogen. All this hydrogen is stored in various on board tanks making the aircraft lighter than air. The hydrogen also used to operate fuel cells which supply power for electrical parts including motor of a propeller. Further water comes as waste from fuel cells is used to produce hydrogen. This type of aircraft do not emit any harmful substance and also flies for indefinitely time. There is a only problem of leakage of hydrogen and water. [19]The design features of fuel-less air vehicles and their sensitivity to several key performance metrics for this class of aircraft are discussed by Adam M. Wickenheiser and EphrahimGarcia in their paper. They studied aircraft with wingspans in the range of 3 to 5 m and Reynolds no in range of $5*10^5$ to $5*10^6$ is considered. New metrics are showed that are unique to a microwave-powered aircraft and are also useful in the development of its missions. These metrics are related to the design of the aircraft, the energy transmitter to the duration and range of the vehicle’s missions. In addition an examination of the strong coupling among the aircraft’s flight performance, power harvesting abilities, and its mission capabilities is also analyzed. Different wing shapes are showed for coupling. Also tradeoffs between flight performance and power harvesting performance are shown. [20]Mr. Derek L. Lisoski and Mr. Mark B. Tischler has shown an overview of Pathfinder- solar aircraft and its flight test program, with some of the analysis techniques used, and their results. On the day of 7th July, 1997, the NASA Pathfinder solar-powered aircraft flew to altitude of 71,500 feet which is the new world altitude record for aircraft powered by electric energy and driven by propeller. The Pathfinder platform which is developed by AeroVironment for NASA’s Environmental Research Aircraft and Sensor Technology (ERAST) program is an unmanned solar-powered airplane which was the first of a series of

technology demonstrators which are slated to include the 100,000 ft altitude Centurion and Helios solar aircraft. The Pathfinder flew a total of six times at the Pacified Missile Range Facility, Kauai, Hawaii in 1997 establishing the application of a solar powered aircraft for scientific and commercial payload missions. To ensure flight safty during flight test series the use of the CIFERB2 frequency response analysis code for initial simulation verification, in-flight real-time stability determination, and post-flight system identification.

Based on the above review, we would like to make an aircraft which is operated on solar power. In this literature we have analyzed designs of different solar airplanes invented. Now we will design modified aircraft which will take very short runway for takeoff.

3. ABOUT PROJECT WORK

Our project is based on solar power utilization. We will design solar aircraft and will try to make the same. All the measurements required for the parts of aircraft will be calculated using formulas shown in calculations. There are many materials like aluminium, magnesium, titanium, steel, and their alloys; also some plastic is used in conventional aircraft. We will use suitable material for our prototype which is Balsa wood, Bio-foam or Styrofoam. The equipment of solar aircraft may be solar cells, motor, servo motors, propeller, battery and other required equipments. Fig 8 is showing the aerofoil we have design through the software.

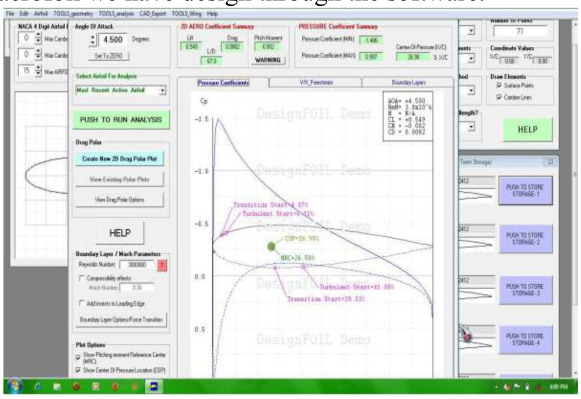


Figure 8

4. RESULT AND ANALYSIS

We will design suitable wing using appropriate software. Then we will measure parameters related to solar cells and thereafter we will apply those cells on wings. We will study and again calculate different parameters i.e., lift force, drag force, thrust, weight, gravity etc using appropriate formulas, to design solar aircraft. We will apply different tests like lift test, drive test, flight test etc.

5. CONCLUSION

Based on knowledge we get from literature review we are going to design and develop a Solar Aircraft by using proper methods and proper software for it.

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