International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Special Issue 41 (AVALON) (March 2016), PP. 22-25

SOLAR POWERED AIRCRAFT

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Abstract— The ability to produce power without damaging the Environment is a continuing challenge Fossils fuels like Gasoline natural gas and coal, all come from Non-renewable sources and when burned, increase the Level of air pollution and may harm the environment. Batteries, such as those found in flashlight and MP3 Players, have limited lifetimes and often end up being disposed of in landfills. There are many environmental friendly alternative available today such as wind energy, geothermal, hydroelectric power plant and finally solar energy. The Sun emits a tremendous amount of energy every second of every day. Only a very small fraction of the Sun's energy ever makes it to the Earth, but it's still an incredibly large amount. A lot of that energy is already used in the form of heat, or by plants needing the light for photosynthesis, converting carbon dioxide into sugars and eventually releasing breathable oxygen, but it still leaves a large portion un-used and ready for capture. 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, working, advantages, and disadvantage of solar aircraft and concludes by stating the need to utilize free solar energy for aviation.

Keywords— Solar powered aircraft, new aerial vehicle technology, solar energy in aerospace, renewable energy, green technology.

I. 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**.**

II. HISTORY OF SOLAR AIRCRAFT

The aircraft's first flight was a short hop that occurred at Lasham Airfield, Hampshire, United Kingdom on 19 December 1978. Fred To was not present when this occurred, and the pitch of the propeller was found to be incorrectly set, which was why it was a short hop. Subsequent flights occurred in 1979, and those are often mistakenly taken as the first flights of the aircraft, as confirmed by Barry Jacobson (a member of the Solar ONE team). The 1979 flight took place on 13 June and covered just under 0.75 mi (1.2 km). The pilot was Ken Stewart and the aircraft lifted off at 18 to 20 kn (33 to 37 km/h) and reached 35 kn (65 km/h) and 80 ft (24 m) in height. A second flight on the same day by Bill Maidment achieved a speed of 42 kn (78 km/h). All flights were made on battery power that had been recharged on the ground from the installed solar cells. An intended flight across the English Channel was abandoned when the aircraft did not reach intended endurance targets.

The Conjunction of two Pioneer Fields, Electric Flight and Solar Cells. The use of electric power for flight vehicles propulsion is not new. The first one was the hydrogen-filled dirigible France in year 1884 that won a 10 km race around Villacoulbay and Medon. At this time, the electric system was superior to its only rival, the steam engine, but then with the arrival of gasoline engines, work on electrical propulsion for air vehicles was abandoned and the field lay dormant for almost a century. On the 30th of June 1957, Colonel H. J. Taplin of the United Kingdom made the first officially recorded electric powered radio controlled flight with his model "Radio Queen", which used a permanent-magnet motor and a silver-zinc battery. Unfortunately, he didn't carry on these experiments. Further developments in the field came from the great German pioneer, Fred Militkywho first achieved a successful flight with an uncontrolled model in October 1957. Since then, electric flight continuously evolved

with constant improvements in the fields of motors and batteries.

Three years before Taplin and Militky's experiments, in 1954, photovoltaic technology was born at Bell Telephone Laboratories. Daryl Chapin, Calvin Fuller, and Gerald Pearson developed the first silicon photovoltaic cell capable of converting enough of the sun's energy into power to run every day electrical equipment. First at 4 %, the efficiency improved rapidly to 11 %. Two more decades will be necessary to see the solar technology used for the propulsion of electric model airplanes.

1. Early Stages of Solar Aviation with Model Airplane

On the 4th of November 1974, the first flight of a solar powered aircraft took place on the dry lake at Camp Irwin, California. Sunrise I, designed by R.J.Boucher from Astro Flight Inc. under a contract with ARPA, flew 20 minutes at an altitude of around 100 m during its inaugural flight. It had a wingspan of 9.76 m, weighed 12.25 kg and the power output of the 4096 solar cells was 450W. Scores of flight for three to four hours were made during the winter, but Sunrise I was seriously damaged when caught flying in a sand storm. Thus, an improved version, Sunrise II, was built and tested on the 12th of September 1975. With the same wingspan, its weight was reduced to 10.21 kg and the 4480 solar cells were able this time to deliver 600W thanks to their 14 % efficiency. After many weeks of testing, this second version was also damaged due to a failure in the command and control system. Despite all, the history of solar flight was engaged and its first demonstration was done.

Fig.1: Sunrise II, 1975

2. The Dream of Manned Solar Flight

After having flown solar model airplanes and proved it was feasible with sufficient illumination conditions, the new challenge that fascinated the pioneers at the end of the 70's was manned flights powered solely by the sun. On the 19th of December 1978, Britons David Williams and Fred To launched Solar One on its maiden flight at Lasham Airfield, Hampshire. On April 29, 1979, Larry Mauro flew for the first time the Solar Riser, a solar version of his Easy Riser hang glider, at Flabob Airport, California. The 30 m wingspan and 254 kg aircraft became a part of NASA's Environmental Research Aircraft Sensor Technology (ERAST) program that started in 1994.

Fig.2: Gossamer Penguin, 1980

From 1994 to 2003, this program led to the construction of Helios, 1999-2003 series of three successive solar aircrafts, Pathfinder Plus, Centurion and Helios. The latter was intended to be the ultimate "eternal airplane", incorporating energy storage for night- time flight. In 2001, Helios set an unofficial world record altitude of 29'524 m (96'863 ft) but unfortunately, it never proved sustainable flight as it was destroyed when it fell into the Pacific Ocean on June 26, 2003 due to structural failures. QinetiQ, a British company, is also very active in the field of solar HALE platforms with Zephyr, an airplane which flew in July 2006 for 18 hours, including 7 hours of flying in the dark. It has recently been selected as the base platform for the Flemish HALE UAV remote sensing system Mercator in the framework of the Pegasus project.

Fig.3: Helios, 1999-2003

The platform should fulfill missions like forest fire monitoring, urban mapping, coastal monitoring, etc. But the objective of Helios to prove the feasibility of eternal flight for an unmanned airplane was reached on the 22nd of April 2005. Alan Cocconi, president and founder of AcPropulsion, flew his Solong during 24 hours and 11 minutes using only solar energy coming from its solar panels and also thermals, currents of warm air rising from the desert floor. The 4.75 m wingspan and 11.5 kg airplane confirmed its capabilities two months later on the 3rd of June with a flight lasting 48 hours and 16 minutes. The next dream to prove continuous flight with a pilot on board will perhaps come true with Solar-Impulse, an 80 m wingspan lightweight solar airplane built in Switzerland. After the manufacturing of a 60 m prototype in 2007-2008 and the final airplane in 2009-2010, a round-the-world flight should happen in May 2011 with a stopover on each continent.

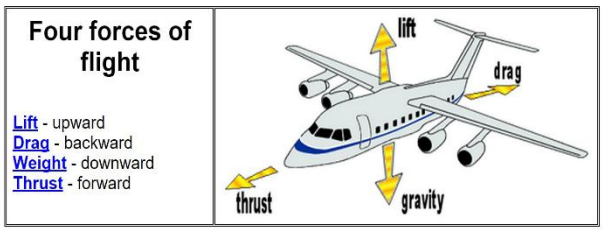
III. AERODYNAMIC PROPERTIES OF AIRCRAFT

A. The Bernoulli Principle

Airplanes fly when the movement of air across their wings creates an upward force on the wings (and thus the rest of the plane) that is greater than the force of gravity pulling the plane toward the earth.

The physics behind this phenomenon was first described by Daniel Bernoulli, an 18th century Swiss mathematician and scientist who studied the movement of fluids. Bernoulli discovered that the pressure exerted by a moving fluid is inversely proportional to the speed of the fluid. In other words, fluid pressure decreases as fluid speed increases, and vice versa.

The same principle applies to moving air. The faster that air moves through a space, the lower the air pressure; the slower it moves, the higher the pressure. Aircraft wings are designed to take advantage of that fact and create the lift force necessary to overcome the weight of the aircraft, and get airplanes off the ground. The undersides of wings are more or less flat, while their tops are curved. In addition, wings are slanted slightly downward from front to back, so air moving around a wing has a longer way to travel over the top than it does underneath. The air going over the top moves faster than the air going underneath, and the air pressure above the wing thus is lower than it is under the wing, where slower moving i r mo ecules bunch oge her The pressure d fferent a crea es l f and he faster he w ng moves hrough he a r he grea er he f becomes, eventua y overcom ng he force of gravi y upon he a rcraf



Fig,4 forces acting on an aircraft

B. Concept of lift

Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. Lift is generated by every part of the airplane, but most of the lift on a normal airliner is generated by the wings. Lift is a mechanical aerodynamic force produced by the motion of the airplane through the air. Because lift is a force, it is a vector quantity, having both a magnitude and a direction associated with it. Lift acts through the centre of pressure of the object and is directed perpendicular to the flow direction.

Lift is a mechanical force. It is generated by the interaction and contact of a solid body with a fluid (liquid or gas). It is not generated by a force field, in the sense of a gravitational field, or an electromagnetic field, where one object can affect another object without being in physical contact. For lift to be generated, the solid body must be in contact with the fluid: no fluid, no lift. The Space Shuttle does not stay in space because of lift from its wings but because of orbital mechanics related to its speed. Space is nearly a vacuum. Without air, there is no lift generated by the wings. In plane wings are shaped to make air move faster over the top of the wing. When air moves faster, the pressure of the air decreases. So the pressure on the top of the wing is less than the pressure on the bottom of the wing. The difference in pressure creates a force on the wing that lifts the wing up into the air.

Fig.5: lift in an aerofoil

IV. WORKING OF SOLAR AIR CRAFT

A. Brief description of the principle

Solar panels, composed by solar cells connected in a certain configuration, cover a certain surface of wing or other part of the airplane (tail, fuselage etc.). During the day, depending on the sun irradiance and the inclination of the rays, the convert light into electrical energy. A converter, called Maximum Power Point Tracker, ensures that the maximum amount of power is obtained from the solar panels. This power is used firstly to power the propulsion group and the onboard electronics, and secondly to charge the battery with surplus of energy. During the night, as no more power comes from the solar panels, only the battery supplies the various elements. This is schematically represented on the figure below.

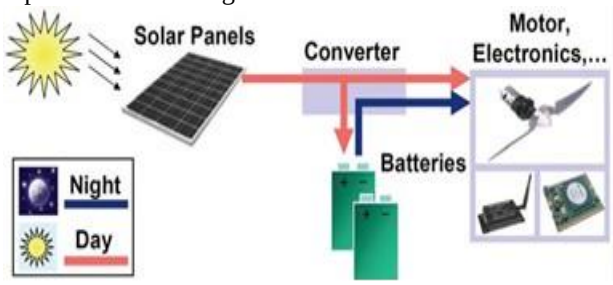


Fig.6 Schematic representation of power transfer

B. Maximum Power Point Tracker

MPPT method is the method of tracking the incoming sun rays on the solar panel of aircraft wings. AS everyone know that solar output greatly depends upon the solar irradiance angle. The MPPT is required to adapt the voltage of the solar panels so that they provide the highest power possible. With the growth of the photovoltaic market, there are a lot of commercially available MPPTs, but as they are used mainly for fixed applications (garden house, etc.). Currently the research is going to implement the tracking of sun rays in solar aircraft sector.

C. Energy storage

When the energy production is not constant and continuous, a good energy storage method is necessary. We can list many different ways to store energy like energy Chemical(hydrogen,biofuels),Electrochemical(batteries,fuelcells),Electrical(capacitor,supercapacitor,superconductingmagneticenergy storage or SMES), Mechanical (compressed air, flywheel) and Thermal.

These different technologies coexist because their characteristics make them attractive to different applications. From a user point of view the main selection criteria are the energy and power density, the response time, the efficiency and of course the costs. The volume or energy density, of course, have an influence on the fuselage size but this volume plays a minor role on the power required compared to the weight. A look at figure 2.11 shows that in the present case electrochemical batteries and fuel cells are the two best candidates. In fact they have the highest gravimetric energy density from all the solutions that are reversible

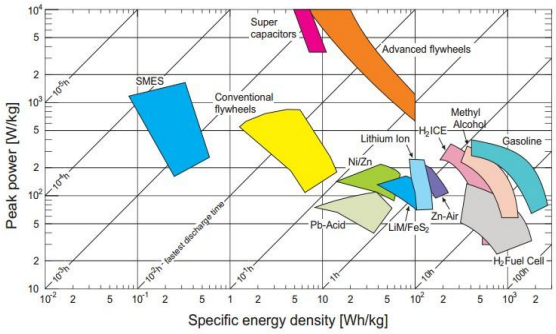


Fig.7: The Ragone Plot - Peak power and specific energy density of various energy storage methods (Source:Forschungsverbund Energie Niedersachsen withdata from Lawrence Livermore Labs)

D. Working principle of Electrochemical Batteries

Electrochemical batteries are energy storage devices, which are able to convert chemically stored energy into electrical energy during discharging. They are composed of a cathode and an anode, made of two dissimilar metals that are in contact with an electrolyte. When all elements are in contact with each other, a flow of electron is produced. If the process is reversible so that they can be recharged, they are referred to as secondary batteries, in the other case they are primary batteries [5]. Concerning a solar airplane, rechargeable batteries will of course be used.

V. APPLICATIONS

The solar aircraft acts as a transport vehicle with reduced cost and increased overall profit because of reduction of fuel. In this kind of vehicles, the energy is derived from free, clean and environment friendly solar radiation on the earth surface with the help of solar panel which converts the solar energy to electrical energy. Small solar aircrafts can be easily used for solving the aircraft traffic problems due to its compactness. The concept of solar aircraft is used for satellites which are continuously orbiting around the earth since solar energy can pass through the vacuum easily and it can be converted into the electrical energy in the vacuum.

VI. CONCLUSION

A normal aircraft consumes 5 gallons of fuel per mile, thus with such rapid consumption the global fuel crisis is certain. Thus the solar powered aircraft helps in fuel conservation and also causes no pollution to environment. Hence with rapid development in research and technology the solar aircraft can be a boon to the future.

VII. REFERENCES

[1] Noth, R. Siegwart, W. Engel, Version 1.1, December 2007,"Design of Solar Powered Airplanes for Continuous Flight".

[2] Bruss H (1991) Solar Modellflug Grundlagen, Enwicklung, Praxis, Verlag für Technik und handwerk, Baden-Baden.

[3] Tozer TC, Grace D, Thompson J and Baynham P (2000) UAVs and HAPs - Potential Convergence for Military Communications, IEE Colloquium on "Military Satellite Communications", 6th June 2000

[4] Overview of Energy Storage Methods. http:// www.moraassociates.com/.

[5] P. H. L. Notten. Rechargeable Batteries: Efficient Energy Storage Devices for Wireless Electronics. In S. Mukherjee and et al., editors, AmIware Hardware Technology Drivers of Ambient Intelligence, Philips Research, part 5, pages 315–345. Springer Netherlands, 2006.

[6] http://www.altrnativeenergy.com/10 Best Solar Airplane Concept.

[7] John D. Anderson, Jr, third edition, "Fundamentals of aerodynamics", chap 4.

[8] Prof. Alpesh Mehta, Shreekant Yadav, Kuldeepsinh Solanki, Chirag Joshi, "SOLAR AIRCRAFT: FUTURE NEED", International Journal of Advanced Engineering Technology T/Vol.III/ Issue IV/Oct.-Dec., 2012.

[9] William H. Phillips, "Solar aircraft", U.S. Patent