International Journal of Research in Engineering and Applied Sciences(IJREAS)
Available online at http://euroasiapub.org/journals.php
Vol. x Issue x, August 2016, pp. 26~34
ISSN(O): 2249-3905, ISSN(P) : 2349-6525 | Impact Factor: 6.573 | Thomson Reuters ID: L-5236-2015

AUTONOMOUS VTOL AGRO-DRONE

Swetha S *
Alvina A Nirmalraj **
Girish R Shanbough ***

Keywords:

UAV ,
TILT ROTOR ,
VTOL,
AGRO-DRONE

Abstract

Agriculture is considered as a back bone of Indian economy with over 60% of the population engaged in agricultural activities in some form or the other. However due to primitive agricultural practices, lack of labor and urbanization the agricultural output is below par when compared to those countries whose main occupation is not agriculture. And in today's scenario the main problem India is facing is shortage of agricultural labor. So this situation calls for incorporation of automation in agriculture and one such effort has been undertaken in this project to pool in agriculture with aeronautics using AUTONOMOUS VTOL AGRO-DRONE. Due to agricultural pesticides exposure around 2.2million people located in developing nations are at a risk. Pesticides may enter the human body easily through inhalation, ingestion, or by dermal penetration through the skin. Now a day the people who work with agricultural pesticides are the most at risk if they are not properly dressed or if there are broken and leaking equipment. Hence the approach of this project is to develop a prototype model of Autonomous AGRO-DRONE to facilitate the farmers wherein a click of a button would spray the pesticides. The farmer need not dirty his hands to spray pesticides but instead can sit comfortably in his farm and monitor the entire process with the help of the surveillance system installed in the model. The Tilt-Rotor mechanism incorporated in this model enables it to perform both conventional take off and VTOL (Vertical Take-Off and Landing). By this feature the AGRO-DRONE is empowered to operate in congested farm fields and remote areas where conventional take off cannot be achieved. The autonomous control fitted to the model facilitates auto piloting, path finding, path calculation, area& distance calculation. The pressurized tank system provided at the under carriage initiates the spraying of pesticides through the nozzle provided. Thus the complete automation of the AGRO-DRONE helps the farmer to carry out pesticide spraying and virtual crop monitoring in the real time, thereby reducing time, effort and cost. AGRO-DRONE is operated by using a 16000 mAh Li-Po battery. First the current from the battery flows to the 4 motors through ESCs. Then the motor drives the propellers to provide the required forward thrust / lift. The fuselage carries the pesticide tank, compressor & sprinkler to spray the pesticide by drawing the power from the same battery. Camera is fitted at the nose for crop monitoring and surveillance.

Author Correspondence
First Author
Asst Prof, Department of Aeronautical Engineering,
Acharya Institute of Technology, Bangalore 560107.

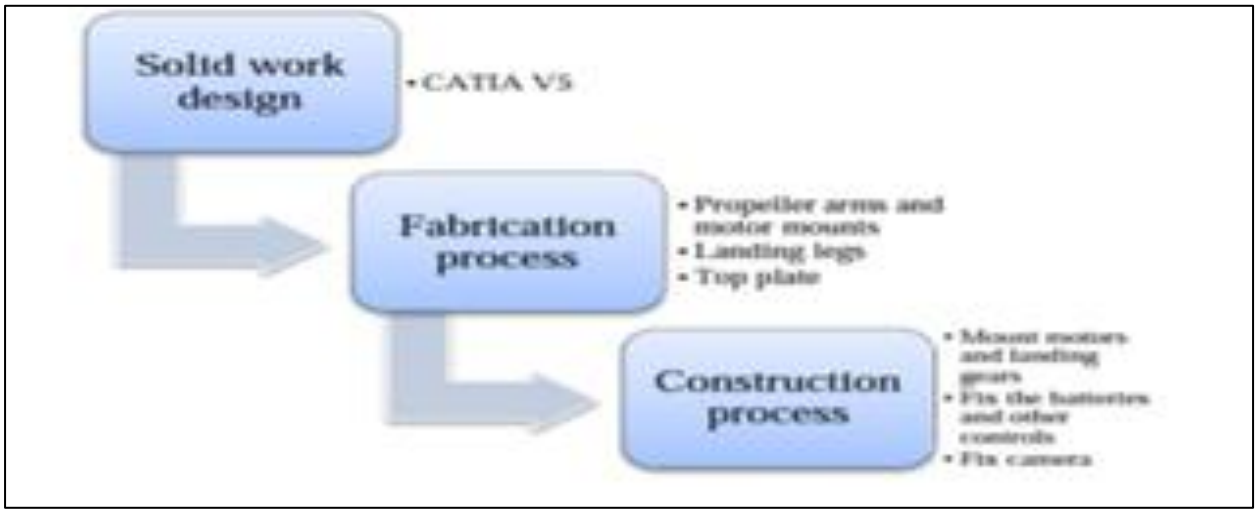
INTRODUCTION

The green Revolution in the early 1960s witnessed an increase in the agricultural yield due to improved agronomic activities. It was during this period that modern technology was incorporated in Indian agriculture to make India imbibe self-sufficiency. Some of the problems like low irrigation, lack of mechanization, inaccessibility to quality seeds, inadequate storage facilities etc. were addressed by adopting various measures. The rates at which production increased in the early years of the green revolution program, however, could not continue indefinitely, which questions the "sustainability" of the new style. The crop yield increased rapidly during the first few years of the program but later the rise was very meager. Also the measures adopted in addressing the problems associated with the Indian agriculture in itself posed new challenges. For example, the use of Pesticides to increase the crop yield brought about detrimental effects on the humans when they came in direct contact with the pesticides. Thus the overriding challenge of the Indian agriculture is the sustainability, safe and profitable growth. Although there are benefits to the use of pesticides, there have also been many problems associated with their use. The cause of using pesticides depends on the specific species they often kill or harm organisms other than pests, including humans. The World Health Organization estimates that there are 3 million cases of pesticide poisoning each year and up to 220,000 deaths, primarily in developing countries. Pesticides can enter the human body through inhalation, ingestion, or by dermal penetration through the skin. In order to overcome these adverse side effects brought about by the use of pesticides on humans an Autonomous VTOL Agro-Drone was designed and developed in this project. This drone brings automation in the field of agriculture by automating pesticide spraying. The direct human contact with the pesticides is avoided by carrying out the entire spraying process using the autonomous drone.The Autonomous VTOL Agro-Drone is a hybrid between helicopters and fixed wing aircrafts. The drone makes use of the Tilt rotor mechanism for its operation. The drone is primarily an agricultural aid that is capable of spraying pesticides autonomously. This agro drone is a convertiplane, an aircraft which uses rotor power for vertical take-off and landing (VTOL) and converts to fixed-wing lift in normal flight. The tilt-rotor mechanism empowers the drone to perform both conventional take off and VTOL (Vertical Take-Off and Landing), which makes it an ideal machine for operation in congested Indian farm lands.

METHODOLOGY

Discussion about the detailed methodology practiced to realize the envisioned prototype model is established in this section. Details about the design of our model, the tools &software's used and construction phase of our prototype model along with its specification are furnished.
These are the fundamental requirements to start with our project.

- Our model will have an ability to hover, by generating enough thrust & also it has enough control.
- Maneuverability in all directions of a three-dimensional plane
- Sufficient endurance of not less than 10-15 minutes
- Comparatively the body of the model is light-weight, including a battery with the highest power to weight ratio.

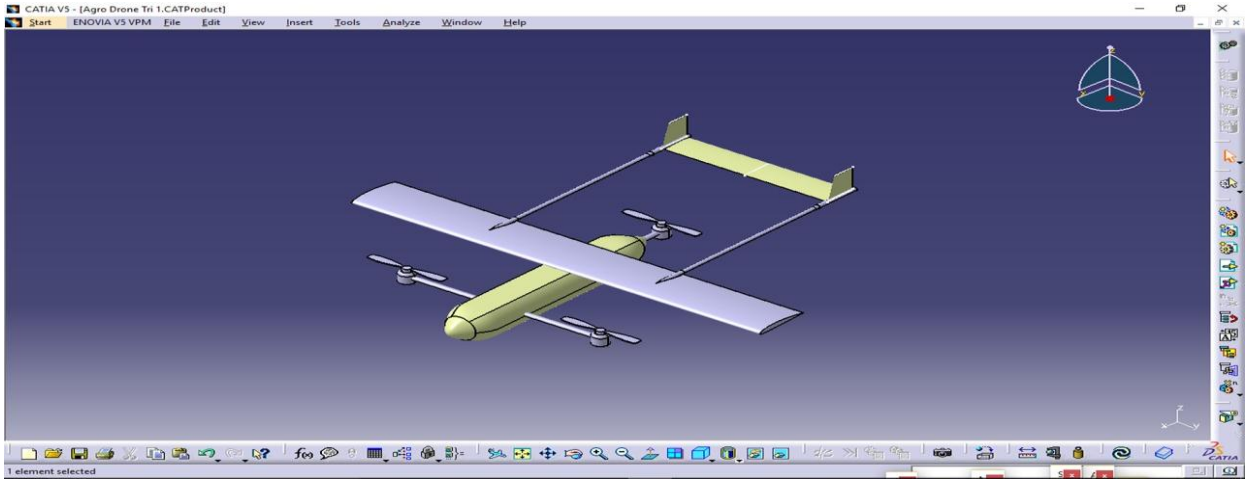


Construction phases adopted for Autonomous VTOL Agro-Drone

DESIGN REQUIREMENTS OF UAV MODEL

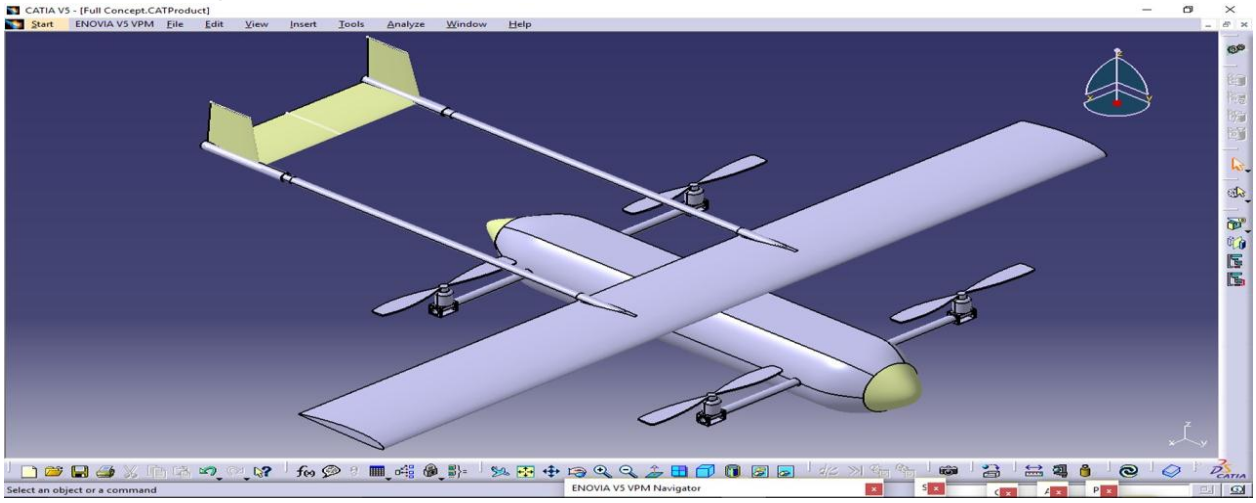
Initially the conceptual design of the model is made by either drawings or by solid models. The conceptual design phase gives a detailed description of the proposed model in terms of a set of integrated ideas and concepts about what it should do, behave, and look like, that will be understandable by the users in the manner intended. The conceptual design phase of the Autonomous VTOL Agro-Drone went through a series of design alterations like every other design process. The evolution of the right fitting rotor configuration ranged from the initial bi rotor configuration to the final quad rotor configuration to achieve the required mission.

The modeling of the design concepts were realized using CATIA V5 R20, design tool by Dassault systems.
Some of the initial concept designs adopted for the drone are shown in the following figures:
Tri rotor configuration:



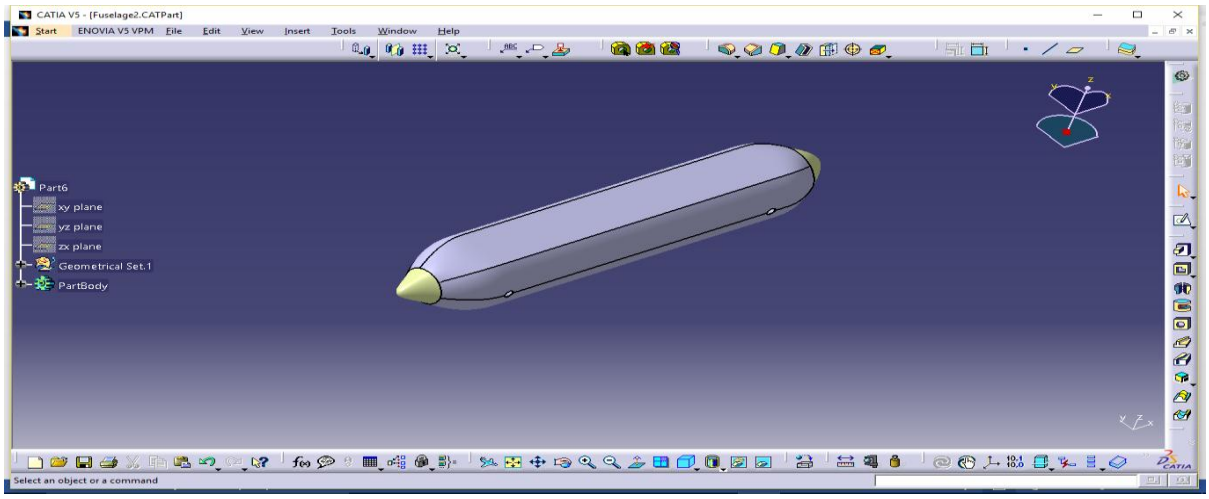
In order to achieve the VTOL (Vertical Take Off and Landing) a tri rotor configuration concept was instilled into the design. Though the tri rotor configuration gave better stability than the bi rotor configuration, it however is limited by the excessive loads exerted on the power system during operation. The excessive loads on the power system is due to the imbalance of power distribution during operation. Thus this design configuration was discarded as it was prone to reduce performance when tilt rotor concept is applied to it.

Quad rotor configuration:



The quad configuration shows greater stability than both the bi and tri rotor configurations to achieve tilt rotor mechanism. Increasing the no of rotors directly increases the stability of the aircraft. However the quad configuration gives the desired stability and performance for the required weight considerations.

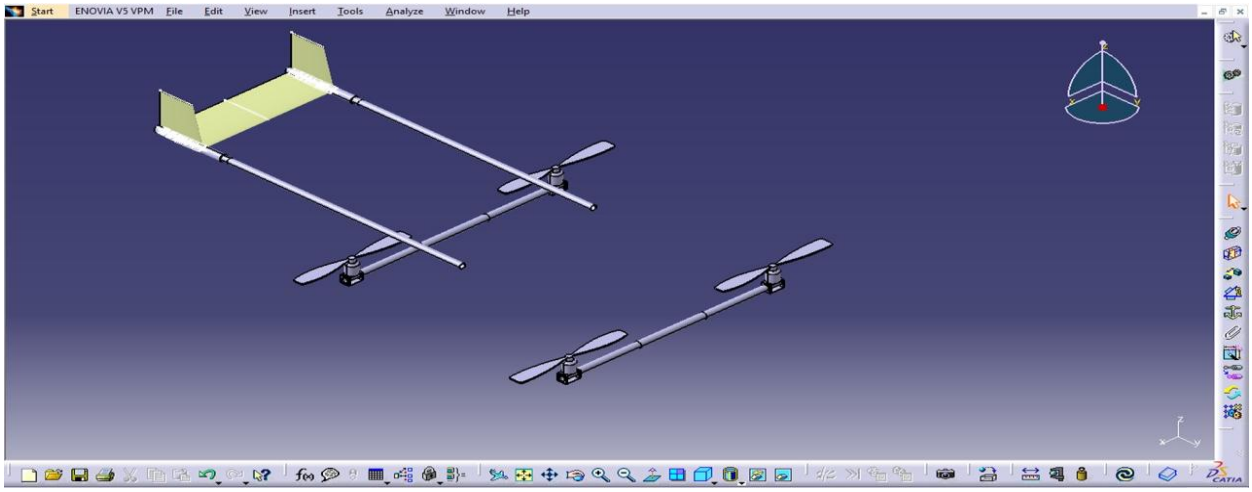
The fuselage is the main body which holds the crew & passengers.The fuselage also used for position control and stabilization surfaces in specific relationships to lifting surfaces, required for aircraft stability and maneuverability.The fuselage for the Autonomous VTOL Agro-drone is a monocoque construction. Monocoque a structural approach where the loads are supported through an object's external skin which is similar to an egg shell. This technique may also be called as the structural skin.



To mount the motor on the tube, clamps and motor mount plate are designed. With the help of this clamp and motor mount plate, motor can be firmly fixed to the tube. Same arrangement is made at the rare end of the fuselage which is placed at a distance of 1000mm from the front motor tube arrangement. The clamp was designed for the 25mm Dia and provided with 3mm through hole for bolting.

Conforming to the calculations made earlier for the power requirement to achieve both VTOL as well as the conventional take-off and landing, the required size of the propeller is fitted. To get the desired requirements the propeller shape were designed specifically.

In order to achieve more stability for the given weight the H-tail configuration was incorporated in the design of the drone. A twin boom structure was employed into the drone structure to support the H-tail.



The drone is powered by a 22V, 16000 mAh, 6-cell Li-Po battery. The battery powers four brushless DC motors having 330kV torque through specially designed ESCs (Electronic Speed Controllers). The motors are in turn fitted with propellers having a diameter of 17inches and a pitch of 5.5 inches. All the electronic equipment's are connected to a power distribution board, which controls the distribution of power from the battery to various electronic devices connected to it.

RESULT EVALUATION AND ANALYSIS

The desired proto type model was constructed as per the conceptual design phase and the same has been validated theoretically and tested practically. Different type of FEM analysis can be carried out on the design, of which two important analyses were carried out on the Autonomous VTOL Agro-Drone. They are:

1. **Structural analysis**
2. **Flow analysis**

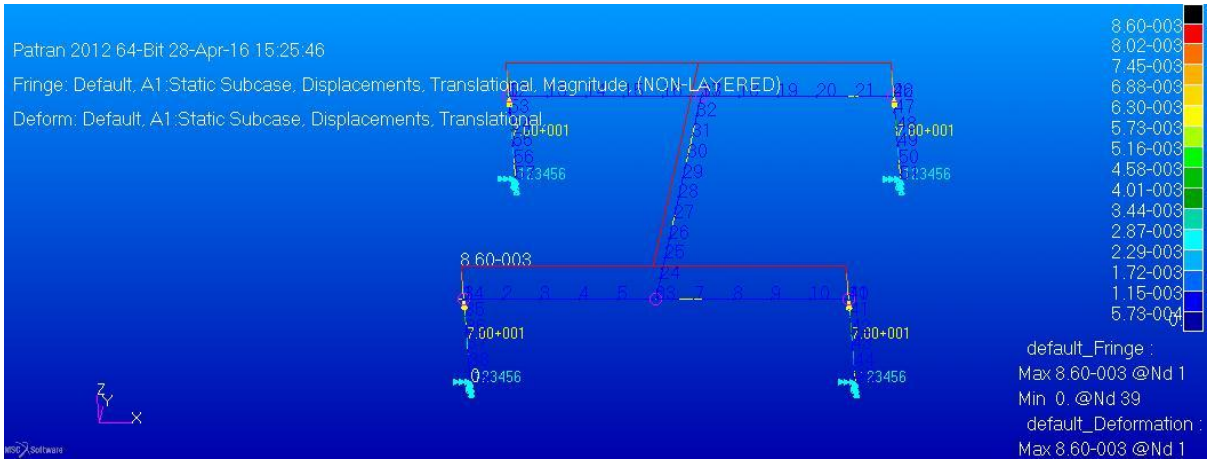
Structural Analysis

A structural analysis can be carried out in two ways,

- Experimental analysis
- Software analysis

Experimental analysis requires making a prototype of the design and involves long and laborious process which are time consuming and expensive. Thus to overcome this problem the software base analysis were developed and used.

Software analysis can be carried out using a wide no of structural analysis software packages available in the market such as Abacus, ANSYS- Structural, and PATRAN etc. However the structural analysis of this drone was accomplished using MSC Patran.

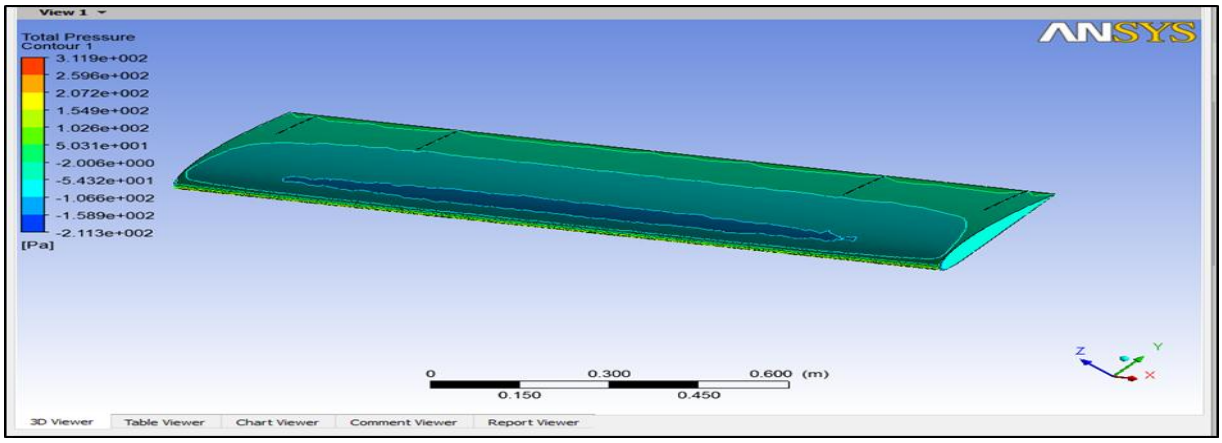


Flow analysis: Fluid flow analysis is carried out using computational fluid dynamics techniques. Numerical analysis & algorithms are used to solve and analyze these problems.The boundary conditions were applied over the surface for simulation.

The fluid flow analysis can be carried out using various approaches, such as,

1. Finite volume method
2. Finite difference method
3. Finite element method
4. Finite boundary method and
5. Spectral element method

Pressure distribution over the main wing



PHOTOGRAPH OF MODEL

CONCLUSION& FUTURE SCOPE OF WORK

- This project gave us a deep insight and better understanding of the construction and mechanism of an Autonomous VTOL Agro-drone.
- The performance of our model met the objectives that the team had initially set out.
- The time consuming task of pesticide spraying can also be confronted and reduced to almost 5 times the original time.
- The tilt rotor mechanism incorporated in the drone empowers it to operate it even in congested farm fields and virtually in any terrain.
- It is clearly evident that the AGRO-DRONE would most likely aid the farmers wherein a click of a button would spray the pesticides.
- Thus this drone would surely facilitate the reduction in time, effort and cost expended on agriculture.

- The drone can be of more use to the society at large with improvements made to the payload carrying capacity and diversified operational purposes.
- When a universal mount is used the drone has a scope of being used in a large no of field apart from agriculture.

ACKNOWLEDGEMENT

We thank Dr S K Maharana, Head of the Department, Mr. Mahantayya K Hiremath & all the faculties of Aeronautical Department, Acharya Institute of Technology who have been a constant source of inspiration for us and helped us in every aspect, guiding and motivating us.

REFERENCE

FaridKendoul, Isabelle Fantoni, Rogelio Lozano, (2005) "Modeling and control of a small autonomous aircraft having two tilting rotors", Proceedings of the 44th IEEE Conference on Decision and Control, and the European Control Conference Seville, Spain.

Prof. Swati D Kale, Swati V Khandagale, (2015) "Agriculture Drone for Spraying Fertilizer and Pesticides", International Journal of Advanced Research in Computer Science and Software Engineering,Volume 5, Issue 12.

UbairEjaz Butt, IzharHussainKazmi (2014) "Design and Modeling of Control System of Tilt Rotor Mechanism of a VTOL UAV", Student Research Paper Conference Vol-1, No-9.

J. Primicerio, S. F. Di Gennaro, E. Fiorillo, L. Genesio, E. Lugato, A. Matese, F. P. Vaccari (2012) "A flexible unmanned aerial vehicle for precision agriculture", Springer.

Ertu˘grul C¸ET˙INSOY, Efe SIRIMO˘GLU, (2011) "Design and development of a tilt- wing UAV", Turkish Journal of Electrical Engineering and Computer Sciences, Vol.19, No.5.

Biography of Authors (10pt)

Swetha S is a Assistant Professor, Department of Aeronautical Engineering, Acharya Institute of Technology, Bangalore-107.

Publications: 1. Aquadrone for multipurpose

2. Effect of injection pressure on the performance and emission characteristics of CI engine using jatropha curcus as bio-diesel with SC5D additive

3. Solar operated automatic seed sowing machine

4. The effect of ceramic reinforcement on the Microstructure, Mechanical properties and Dry sliding wear behavior of hypo-eutectic Al-Si-Mg alloy.

Membership:ISTE

Achievements: 1. Under her guidance one project team has selected for SPP - 39th SERIES: 2015 - 16 & received the fund from KSCST.

2. Under her guidance one of the project team selected for top 10 slots in this prestigious pan-India innovation competition "Ingenium 2015". Out of about 6000 team s from 25 states and 3 UT.

Alvina A Nirmalraj bearing USN 1AY12AE006 is a undergraduate student of B.E (Aeronautical Engineering), Acharya Institute of Technology affiliated to Visvesvaraya Technological University & completed course in CATIA V5 R20 at EDS Technologies Bangalore, completed internship of 25 days in Design and Structural analysis at Bangalore Aircraft Industries Pvt. Ltd, worked on aircraft tooling at Alpha-Tocal. Received the fund from KSCST for the same project, Received price for bladeless turbine concept at Shristi-2015 organized by ABVP.

Publication: Design of a Bladeless Wind Turbine.

Girish R Shanbough bearing University seat number: 1AY12AE019 is a undergraduate student of B.E (Aeronautical Engineering), Acharya Institute of Technology affiliated to Visvesvaraya Technological University & completed course in CATIA V5 R20 at EDS Technologies Bangalore, completed internship of 25 days in Design and Structural analysis at Bangalore Aircraft Industries Pvt. Ltd, worked on aircraft tooling at Alpha-Tocal. Received the fund from KSCST for the same project, Received price for bladeless turbine concept at Shristi-2015 organized by ABVP.

Publication: Design of a Bladeless Wind Turbine.