INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

ISSN (ONLINE): 2321-3051

Vol.4 Issue 4,

April 2016

Pgs: 76-84

EXPERIMENTAL INVESTIGATION OF CONCEPTUAL BOX WING AIRCRAFT

Balaji K[1], Rathnavel S[2], Vinoth J[3] and Siva V[4]

[1] *PG Scholar, jibala732@gmail.com*

[2] *PG Scholar, rathnavelaero@gmail.com*

[3] *PG Scholar, vinothsahayam@gmail.com*

[4] *PG Scholar, sivasivaraj.v@gmail.com*

Department of Aeronautical Engineering, Regional Centre of Anna University,
Tirunelveli-627007, India.

ABSTRACT

From different aerodynamic aspects of box-wing design i.e. an unconventional aircraft design configuration exhibiting the capability of reducing drag (induced drag). Being a non-planar concept, the basic aerodynamic features differ from conventional designs. Reducing in noise, fuel and cost in future can only be made by adopting novel concepts. Experimental testing is carried out for box wing and reference aircraft and the result shows there is a reduction in drag value for box wing aircraft compared to reference aircraft

KEYWORDS: box wing, induced drag, Experimental Aerodynamics, conceptual design

1. INTRODUCTION

Aircraft are generally built up from the basic components like wings, fuselages, tail units and control surfaces. Each component has one or more specific functions and must designed to ensure that it can carry out these functions safely. An aircraft configuration of interest is the box/joined wing aircraft configuration, which in recent times has attracted the attention of researchers due to its claimed merits of reduced structural weight and low induced drag [2].

A box wing aircraft is a biplane with oppositely swept wings, which tips are connected by winglet. The main advantages it offers are the low induced drag and alleged structural superiority.

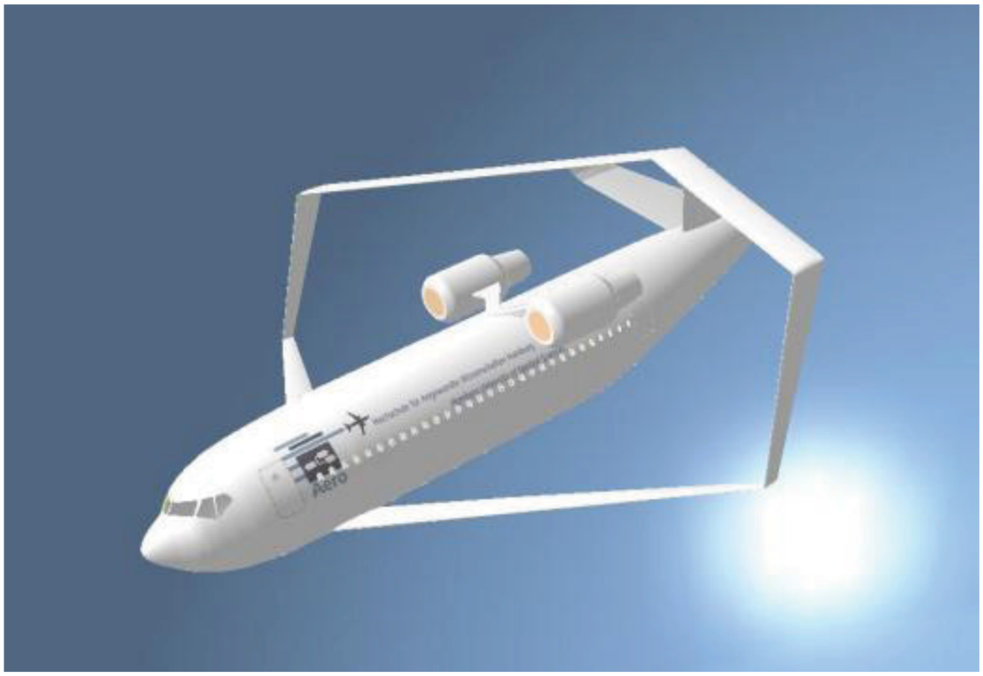

Figure 1. Conceptual design of Box Wing

One major advantage obtained from novel concepts like the non-planar box-wing design, is a reduction in drag compared with planer wings of same span and lift. Drag reduction result in a direct decrease in operation costs and in an in-direct decrease in noise and emissions levels Drag during the cruise phase of large transport aircraft consist of friction and induced drag. Drag during the cruise phase of large transport aircraft consist of friction and induced drag, where the induced drag is relatively lower than the friction drag [1].

Civil aviation transport is facing challenges like globalization, climate change and a cumulative scarcity of resources. To overcome with these challenges, aircraft have to become more efficient, especially concerning energy and fuel consumption. With the latest aircraft emerging on the market, the inherent saving potentials of conventional configurations is almost exhausted. With these configurations progress in achieving the goals of Flight path 2050 could only be made through better technologies and alternative fuels. This constitutes the need for new configurations having more inherent potential of reducing energy and fuel consumption compared to today's aircraft. One of these is the box wing configuration, a biplane with vertically and horizontally staggered wings whose tips are connected by extended winglets. The most recognized benefits of this configuration are its Low induced drag and alleged structural superiority. This thesis serves to investigate the advantages of the box wing aircraft in detail and to deduce a possible medium range box wing.

2. WIND TUNNEL

The wind tunnel is of suction type with an axial flow fan driven by a variable speed DC motor. This section is followed by a 6.25:1 contraction section, the test section, a diffuser and the duct containing the axial flow fan. The control of the DC motor is by a rectifier controlled variable speed drive. The wind tunnel can be used to study the pressure distribution and lift-drag characteristics of airfoils, cylinder, etc

Specifications

- The total length of the wind tunnel is about 6.0m. The axial flow fan and the duct is 1.2m long. The maximum height is about 2.0m.
- Test section of 30cm x 30cm cross section and 100cm length with thick Plexiglas window.
- Axial flow fan with aluminum cast airfoil shaped blades driven by a 7.5HP DC motor mounted outside the duct. The drive is through a belt pulley drive.
- The test section velocity is varied by changing the speed of the DC motor.

3. MEASURING INSTRUMENTS

There are various instruments used in the wind tunnel to measure the aerodynamic coefficients. They are:

Tachometer

A tachometer (revolution-counter, Tach, rev-counter, RPM gauge) is an instrument which is used to measure the rotation speed of a shaft or disc, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are increasingly common.

Manometer

Pressure measuring devices using liquid columns in vertical or inclined tubes are called manometers. One of the most common is the water filled u-tube manometer used to measure pressure difference in pitot or orifices located in the airflow in air handling or ventilation system.

Multi-Limbed Manometer

Multi-Limbed Manometer means more than one manometer accommodated in common casing to facilitate different processes pressure indication at one place. It can be U-tube type or Single Limb well type. Up to 10 Manometers can be accommodated in one Gang Manometer. Ranges as desired by user in required units can be manufactured.

Bevel Protractor

A bevel protractor is a graduated circular protractor with a pivoted arm; used for measuring or marking off angles. The bevel protractor is used to establish and test angles to very close tolerances. The bevel protractor consists of a beam, a graduated dial and a blade which is connected to a swivel plate (with Venire scale) by thumb nut and clamp. When the edges of the beam and blade are parallel, a small mark on the swivel plate coincides with the zero line on the graduated dial. To measure an angle between the beam and the blade of 90° or less, the reading may be obtained direct from the graduation number on the dial indicated by the mark on the swivel plate.

4. DESIGN OF BOX WING AIRCRAFT

Design is done by using modeling software. It consists of two designs, one is the Box wing Aircraft and the other is the Reference aircraft (Airbus A320). Specifications of the box wing aircraft and reference aircraft are collected [3]. Figure 2 and 3 shows the design of box wing and reference aircraft.

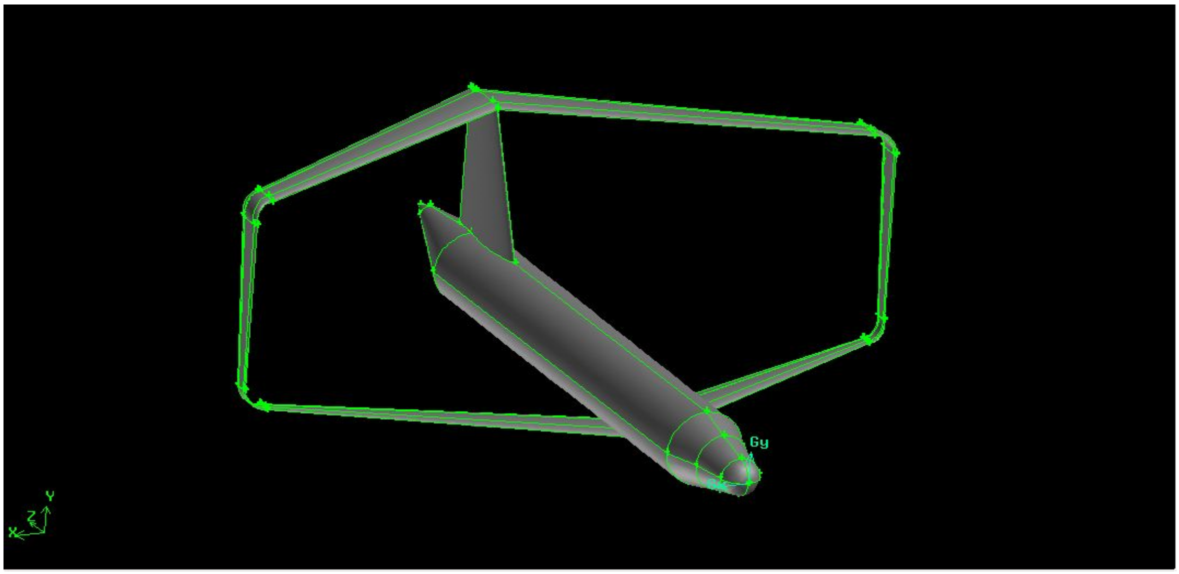

Figure 2. Design of Box Wing Aircraft

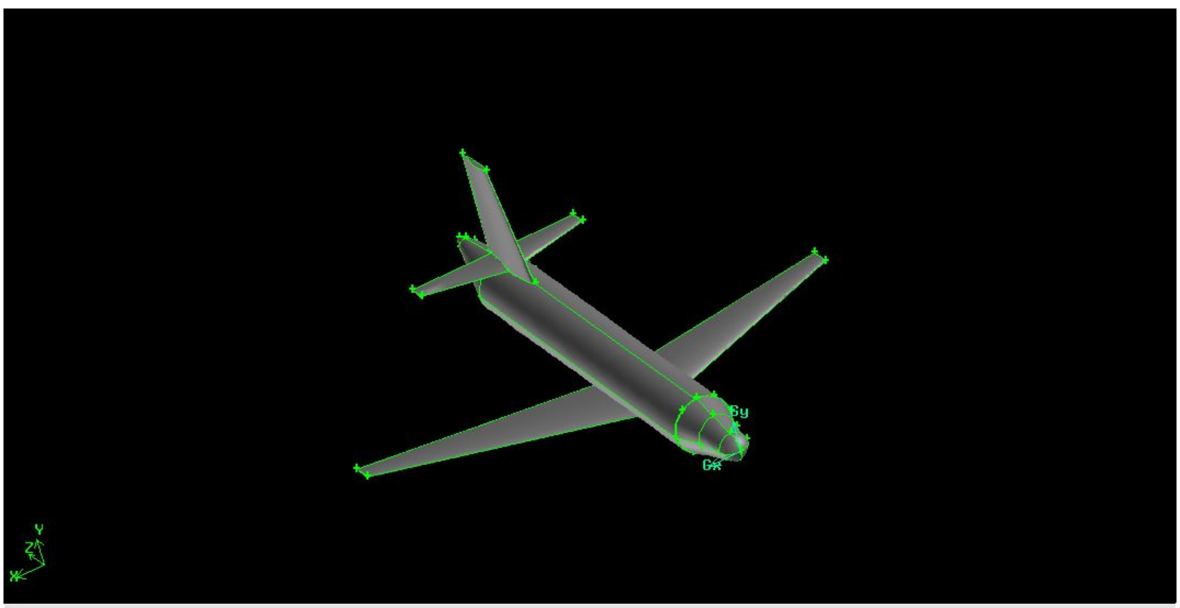

Figure 3. Design of Reference Aircraft

After the preliminary design, fabrication is made which are tested in wind tunnel setup.

MOUNTING OF BOX WING AIRCRAFT IN THE WIND TUNNEL

Before performing the experiment it is important that the aircraft model is to be mounted correctly according to the required position inside the wind tunnel test section. It is necessary that the mounting should withstand the air velocity inside the test section

Figure 4. Mounting of model in wind tunnel.

5. RESULTS AND DISCUSSION:

Wind tunnel testing is carried for both reference and box wing aircraft of the scaled down model as per the wind tunnel specification. Testing is done for 8.2 and 13 m/s corresponding C_L and C_D value is measured for the wind tunnel. Figure 5-8 is the Comparison graph plotted for angle of attack vs C_L and C_D for both the configurations at 8.2 and 13 m/s. From the results it is clear that there is increase in CL and decrease in CD value for box wing aircraft compared with reference aircraft at both 8.2 and 13 m/s.

		WITHOUT BOX WING		WITH BOX WING	
V (m/s)	AOA	C_L	C_D	C_L	C_D
8.2	-15	0.542	1.788	0.868	1.572
	-10	0.983	1.517	1.301	1.409
	-5	1.301	1.517	1.410	1.301
	0	0.488	0.217	0.542	0.108
	5	0.705	0.271	0.759	0.217

	10	1.03	0.596	1.030	0.379
	15	1.356	0.759	1.464	0.596
	20	1.518	0.975	1.627	0.704
	25	1.573	1.03	1.735	0.867
	30	2.169	1.246	2.223	1.030
	35	1.518	1.355	1.735	1.192

Table 1 C_L AND C_D VALUE FOR 8.2 m/s

		WITHOUT BOXWING		WITH BOX WING	
V (m/s)	**AOA**	**C_L**	**C_D**	**CL**	**CD**
13	-15	0.195	0.845	0.325	0.737
	-10	0.39	0.824	0.477	0.694
	-5	0.521	0.759	0.564	0.629
	0	0.239	0.087	0.304	0.065
	5	0.347	0.152	0.412	0.108
	10	0.499	0.195	0.542	0.173
	15	0.564	0.282	0.607	0.238
	20	0.607	0.325	0.716	0.303
	25	0.629	0.499	0.759	0.412
	30	0.868	0.607	0.998	0.477

Table 2 C_L AND C_D VALUE FOR 13 m/s

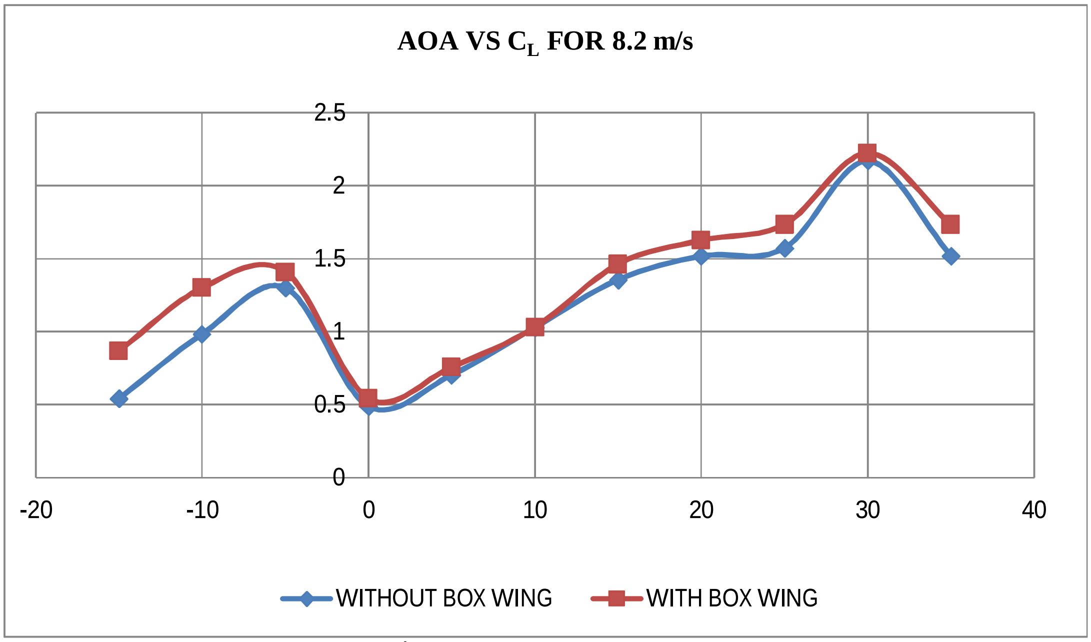

Figure 5. AOA VS C_L FOR 8.2 m/s

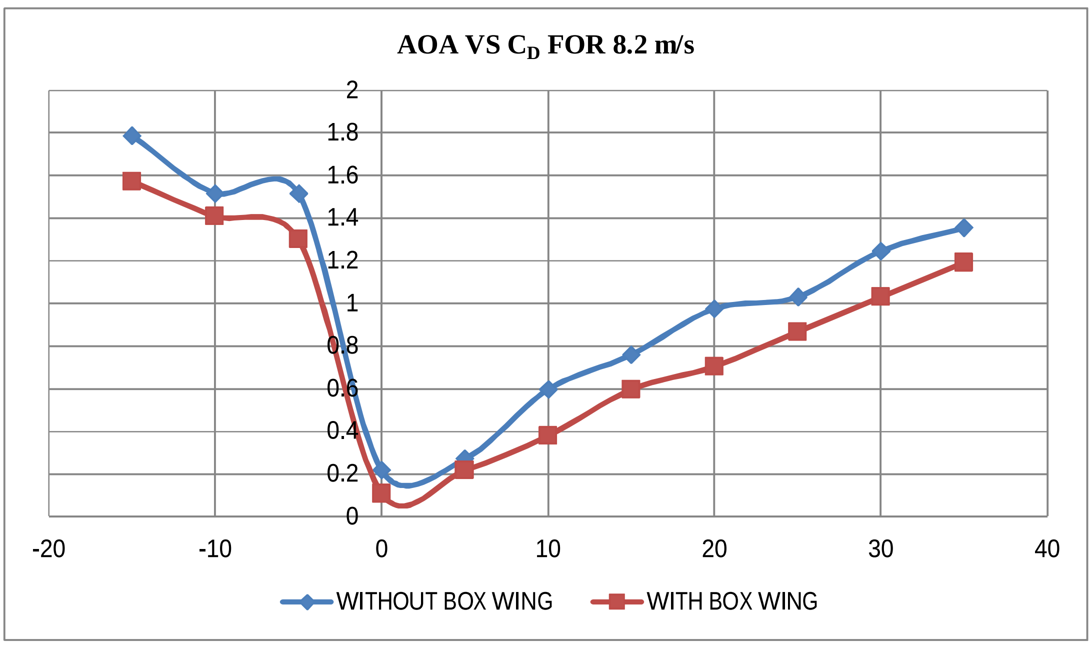

Figure 6. AOA VS C_D FOR 8.2 m/s

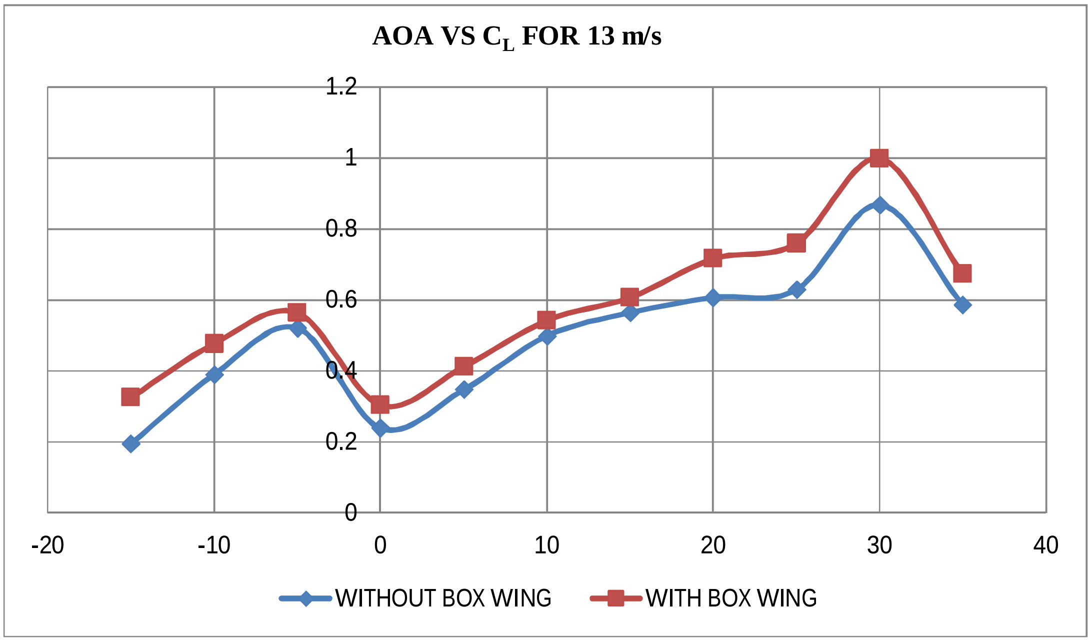

Figure 7. AOA VS C_L FOR 13 m/s

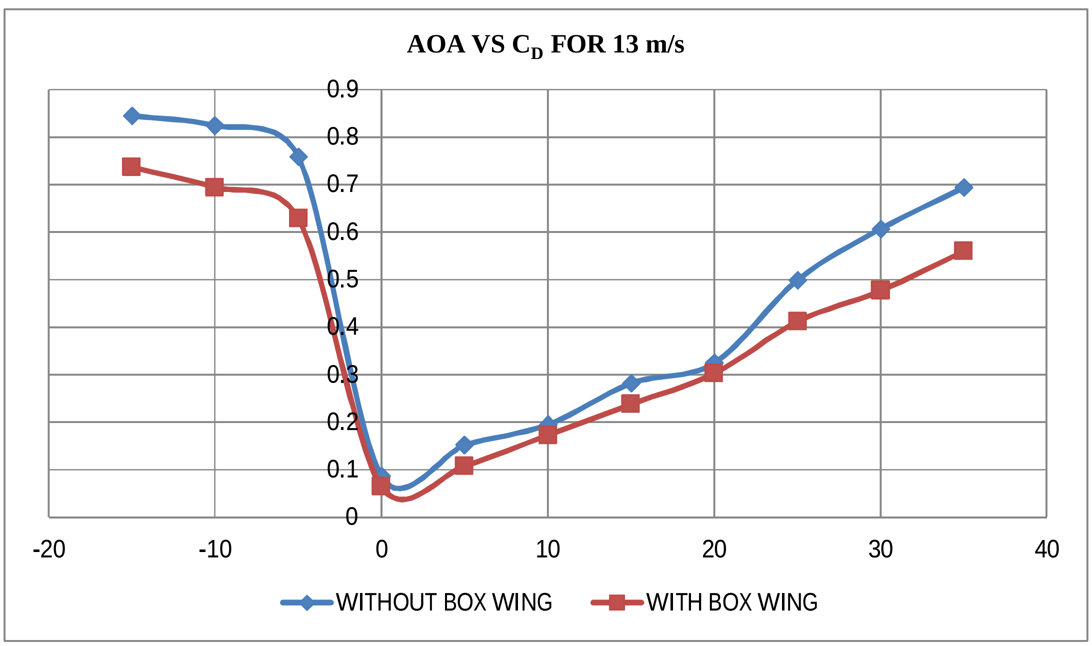

Figure 8. AOA VS C_D FOR 13 m/s

6. CONCLUSION

Non planar systems do possess the capabilities to reduce the induced drag significantly. It can be concluded that this reduction is mainly due to overall reduction in the downwash of the complete system. The increase in aspect ratio by dividing a surface into two or more similar span surfaces having same total wing area can considerably reduce the induced drag. In addition to this it is seen that by adding a winglet or an end plate to a lifting system further reduces the downwash and increases the overall span efficiency of the system.

Testing is done for box wing and reference wing aircraft in wind tunnel setup. From this it is concluded that the induced drag is reduced for box wing aircraft compared to reference aircraft.

REFERENCES

[1] M. Martínez, C. Cuerno, "Preliminary aerodynamic investigation of an unmanned box wing aircraft", Universidad Politecnica de Madrid

[2] Paul O Jemitola, John P Fielding, "Box wing aircraft conceptual design", Department of Aerospace Engineering, Cranfield University

[3] D.Schiktanz, D.Scholz, "Box wing fundamentals – an aircraft design perspective"

AUTHOR BIOGRAPHY

1. Balaji K is pursuing Master Degree in Aeronautical Engineering from Regional Centre of Anna University, Tirunelveli. He obtained Bachelor Degree in Aeronautical Engineering from Anna University; Chennai, India (2013).His area of interest is Aerodynamics and Aircraft Design.

2. Rathnavel S is pursuing Master Degree in Aeronautical Engineering from Regional Centre of Anna University, Tirunelveli. He obtained Bachelor Degree in Aeronautical Engineering from Anna University; Chennai, India (2013).His area of interest is Aerodynamics and Computational Fluid Dynamics

3. Vinoth J is pursuing Master Degree in Aeronautical Engineering from Regional Centre of Anna University, Tirunelveli. He obtained Bachelor Degree in Aeronautical Engineering from Anna University; Chennai, India (2014). Area of interest is Aerodynamics, Structures and Aeroelasticity.

4. Siva V is pursuing Master Degree in Aeronautical Engineering from Regional Centre of Anna University, Tirunelveli. He obtained Bachelor Degree in Aeronautical Engineering from Anna University; Chennai, India (2014). Area of interest is Aerodynamics and Aircraft Performance.