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# Multi Element Wing Analysis

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***Abstract :*** *In This Paper An Effort Has Been Made To Address The Issue Of Space Junk, By Making Use Of The Unmanned Aerial Vehicles That Can Fly In The Stratosphere At High Altitude And Low Reynolds's Number. The Main Aim Of This Work Is To Suggest The Use* ***Multi Element Airfoil*** *In The Wings Of An UAV Over The Single Airfoil Of The Wing In Order To Increase Its Efficiency In The Work Environment Of The Stratosphere. After Addressing The Problem On Computational Tools I.E. ANSYS And CATIA, It Has Been Found That Multi Element Significantly Increases The Maximum Lift Coefficient ($Cl_{max}$).*
***Keywords:*** *Ansys, CATIA, Multi-Element Airfoil, UAV*

## I. Introduction

Man's Curiosity To Know About The Space Or Universe Has Been Leading To Increasing In The Number Of Space Vehicles, Thereby Increasing Unwanted Material In Space. This Results In Space Pollution, Popularly Known As Space Debris. This Has Become A Vital Issue To Focus On, Since Majority Of The Pollution Is Caused By Launch Of Satellite Rockets. The Number Of Such Rockets Can Decrease By Making Use Of Unmanned Aerial Vehicles (Uavs).To Replace Artificial Earth Satellites, High Altitude Low Speed Uavs Are Opted, Which Are Designed To Fly For Long Time In Earth's Stratosphere (Within The Range Of Altitudes From 25 To 30 Km). Thus The Uavs Will Be Able To Carry Out Similar Missions As Of Satellites Such As Telecommunications, Earth Surface Observation, Meteorological Service Etc.

The Performance Of These Stratospheric Uavs Is Majorly Affected By Their Aerodynamic Characteristics. These Characteristics Depend On The Properties Of The Airfoil Which Are Used In Wings Of The UAV. For Low-Speed High-Altitude Flight Regimes, Low Reynolds Number Are Considered Typically Ranging From 3*104 To 5*105. Thus For Proper Operation Of Stratospheric Uavs, It Is Important To Choose Appropriate UAV Wing Airfoil. It Is One Of The Important Parts In UAV Design Process. It Is Not Possible To Satisfy All The Numerous Requirements Of The UAV, Since Often They Will Contradict Each Other. Therefore It Will Become Difficult To Choose The Airfoil. Hence To Support This Choice Process A Comparative Analysis Of Characteristics Of Possible Versions Of UAV Wing Airfoil Was Carried Out Between Various Airfoils Such As S1223, FX63-137, NACA23015, SA7035, And S7075.As Per The Evaluation Of The Data From The Graphs Of Clvs Cd; Cl Vs Alpha; Cm Vs Alpha; Cd Vs Alpha. S1223 Was Found To Be More Efficient.

After Addressing The Problem Of Type Of Airfoil That Is Required To Be Used A Detailed Attempt Has Been Made To Find Out The Use Of Multi Elements In The Wings Of An UAV. For This Purpose A Computational Methodology Has Been Accepted. Since, In Aerodynamic Design, Computational Methods Are Slowly Superseding Empirical Methods And Design Engineers Are Spending More And More Time Applying Computational Tools Instead Of Conducting Physical Experiments To Design And Analyze Aircraft Including Their High-Lift Systems.

A Study Is Made To Validate Data On S1223 And Convert A Single Foil To Multi-Element. Multi-Element Is A Configuration Where A Flap Is Added At The Trailing Edge Of Main Airfoil. This Flap Increases The Angle Of Attack And Camber Of The Wing, Which In Turn Increase Cl Of The Wing Configuration. We Attempt To Investigate The Position And Number Of Flaps On S1223 And The Increase In Cl By Such A Modification.

## II. Methodology

**A Computational Methodology Is Being Accepted, Which Is Elaborated Stepwise As Follows:**
**STEP 1: Airfoil Selection:**

There Are A Number Of Airfoils Which Are Suitable For The High Lift And Low Reynolds's Number Requirements. However, As Per The Stratospheric Conditions Of The Earth's Surface The Velocity Of Wind Varies In The Range Of (16m/S - 20m/S), Thus Suggesting The Small Reynolds's Number($3*10^5$ – $5*10^5$).Thus, Airfoil Selection Criteria Is As Follows :

• Low Reynolds Number.
• Maximum Lift Coefficient.
• Low Drag Characteristics.

• High Lift At Maximum Angle Of Attack.
• Slow Stall Characteristics.
• Coefficient Of Pressure (Pressure Distribution).
• Calculated Reynolds Number At 60kmph Is 3.42376 X $10^5$

Hence After Studying The Performance Graphs Of Different Airfoils For Low Reynolds Number High Lift Selected 4 Airfoils And Their Performance Graphs Viz. Cl Vs Cd, Cl Vs Aoa, Cm Vs Aoa Were Plotted At Reynolds Number $3x10^5$. Graphs Were Plotted Using Online Tool On Www.Airfoiltools.Com. [5]
From The Above Graph Its Clear That S1223 Airfoil Is The Most Suitable Airfoil In This Case:
Step 2: Designing Process

### A. Modeling

Modeling Of Airfoil S1223 Was Done In CATIA V5R21 By Importing Co-Ordinates Of S1223 From The Above Site. For Multi-Element Airfoil, Geometry Was Developed From Co-Ordinates Which Were Imported And Scaled According To Our Requirements.

### B. Domain And Meshing

A C-Domain Is Used For 2D Analysis Of An Airfoil As It Reduces The Number Of Unnecessary Elements & Computing Time. A Tri-Tet Mesh Is Used To Reduce Mesh And Analysis Time With A Sizing Provided For Refinement Of Values Close To The Airfoils. Also Inflation Layers Are Provided In The Vicinity Of The Airfoil To Capture The Boundary Layer Phenomenon. The Meshed View Are As Follows:

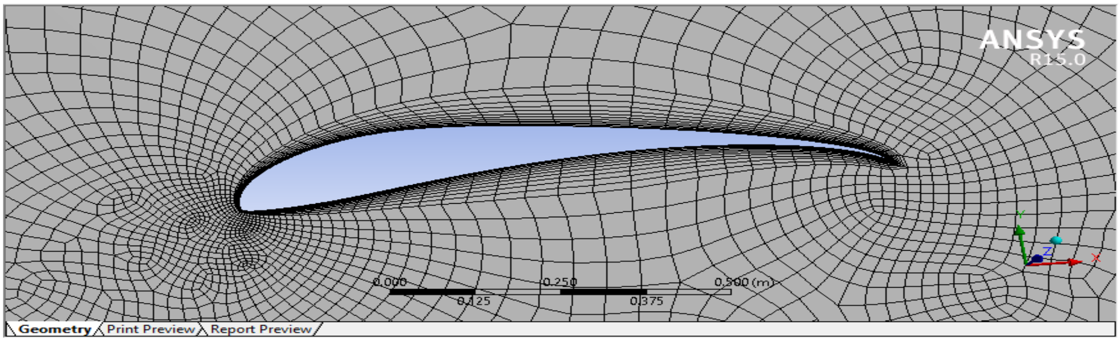



Fig 1 Airfoil S1223

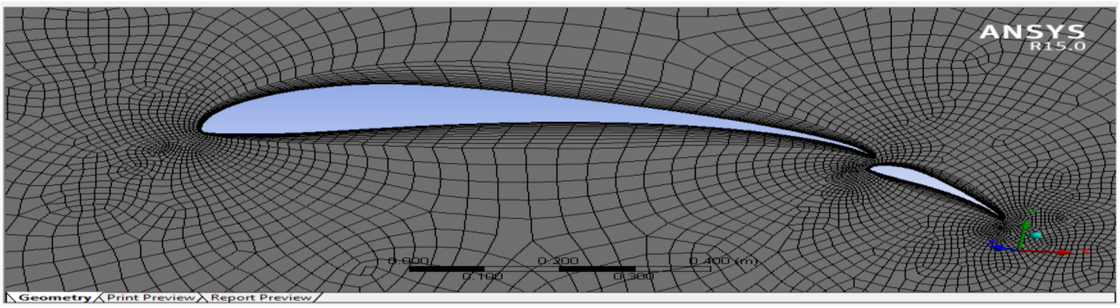



Fig 2 Airfoil S1223 With 1 Element

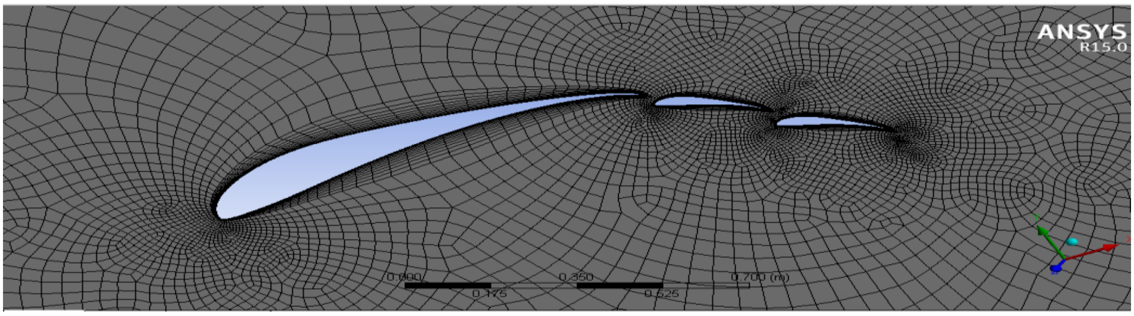



**Fig 3** Airfoil S1223 With 2 Elements

### C. Boundary Condition

The Flow Over The Airfoil Is Considered To Be Viscous Laminar In Nature. Suiting This Criteria A Pressure Based Solver Is Used

Table 1 Inlet Parameter

| | |
|---|---|
| Angle Of Attack | 0 Degree |
| Velocity Of Air At Inlet | 60 Kmph |
| Guage Pressure At Inlet | 0 Pa-S |

### Step 3: Results And Graphs

For Cl:

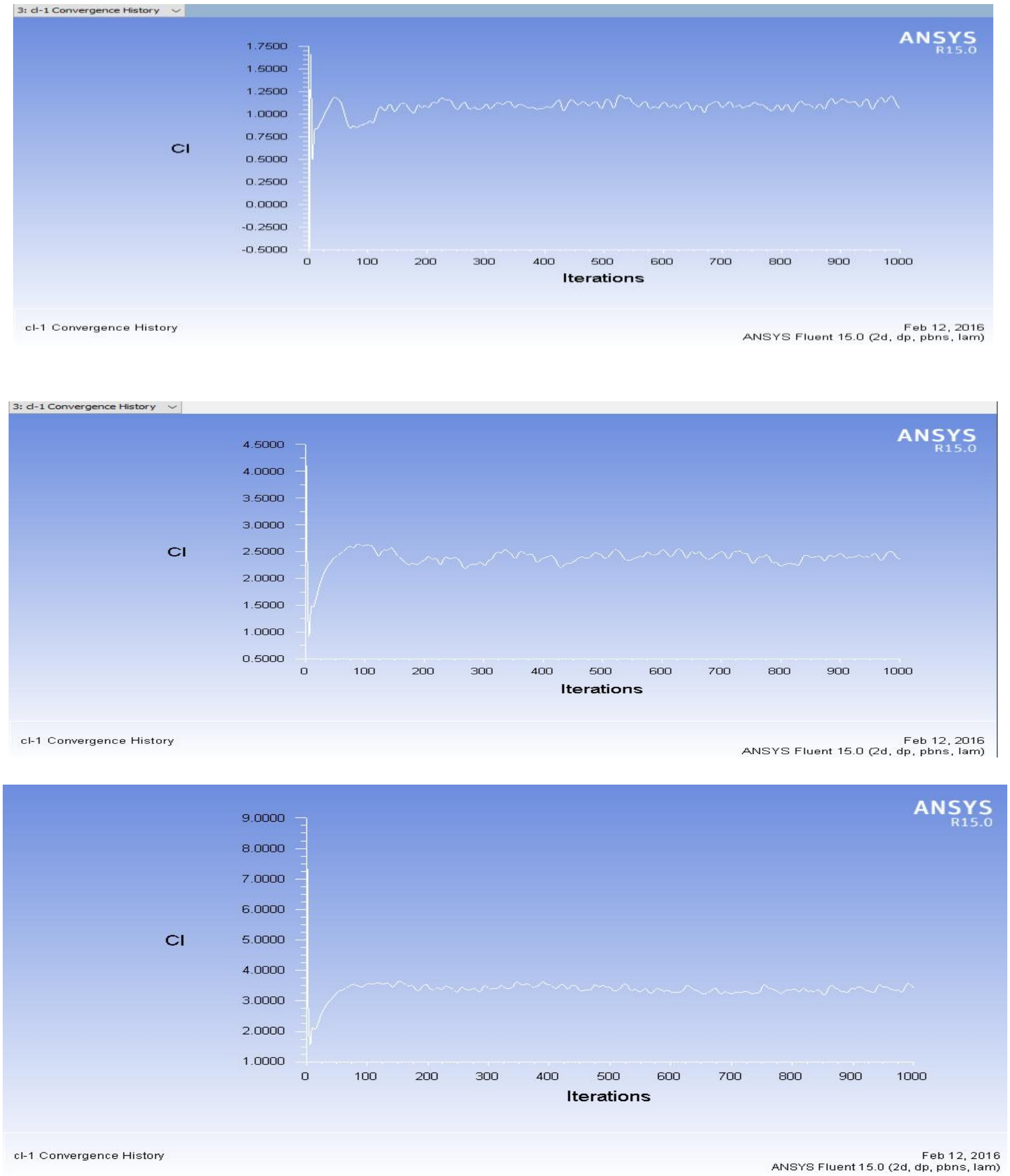



Fig 4 Graph For Cl

For Cd:

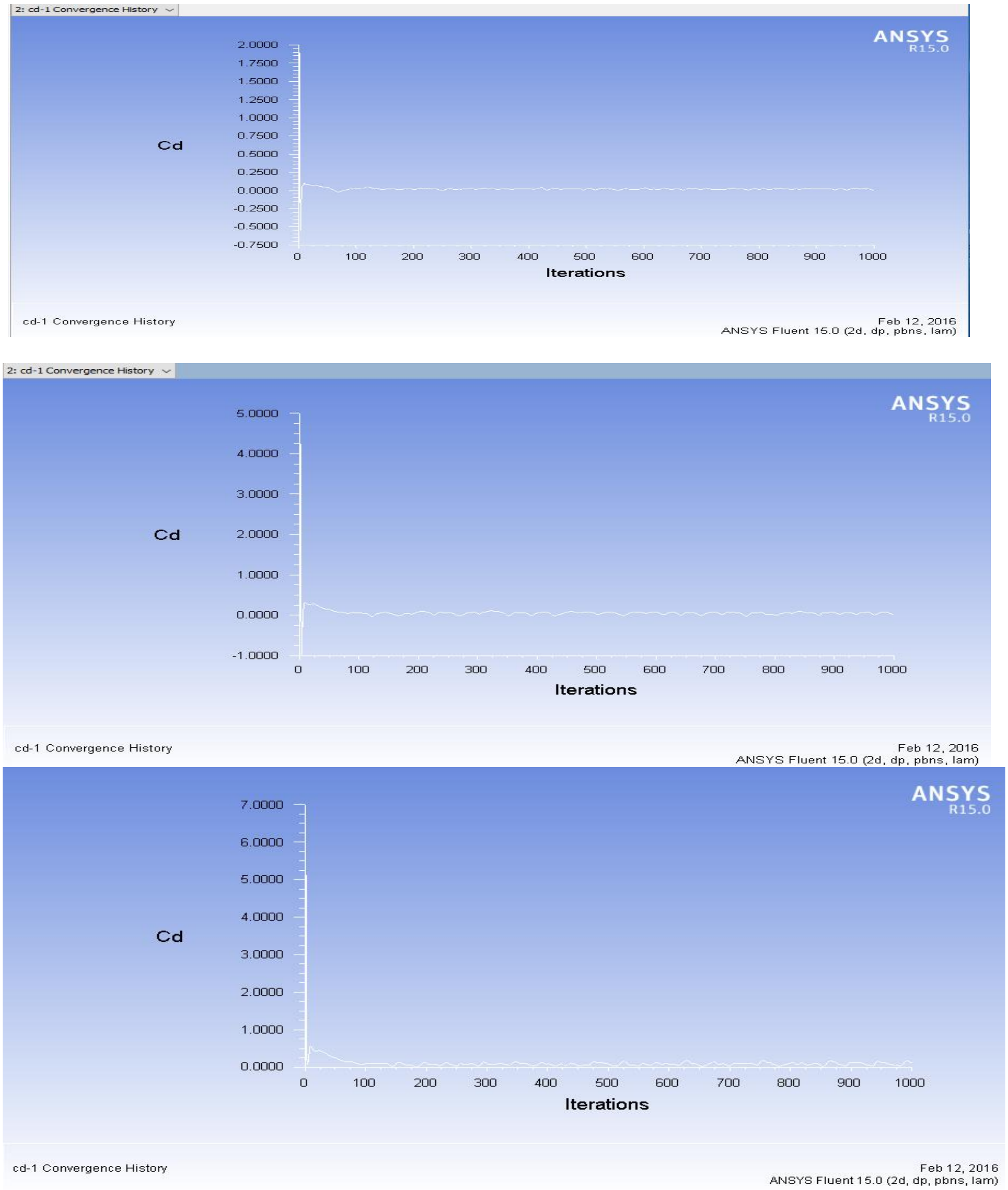
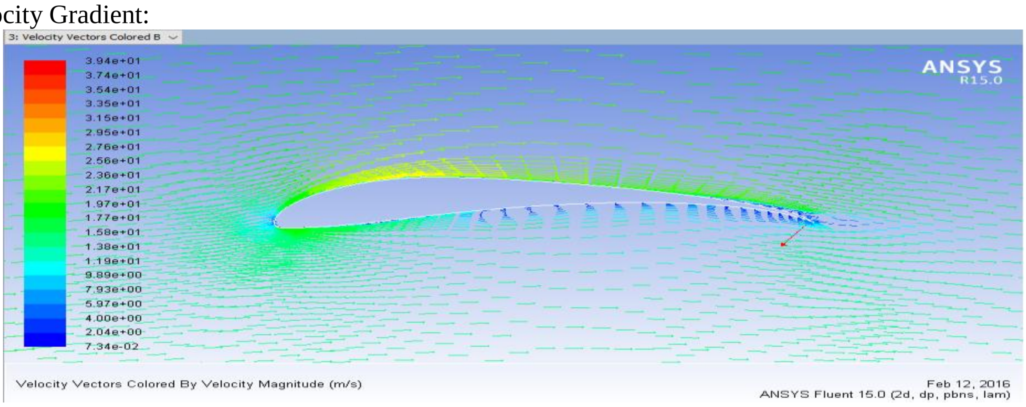



Fig 5 Graph For Cd

For Velocity Gradient:



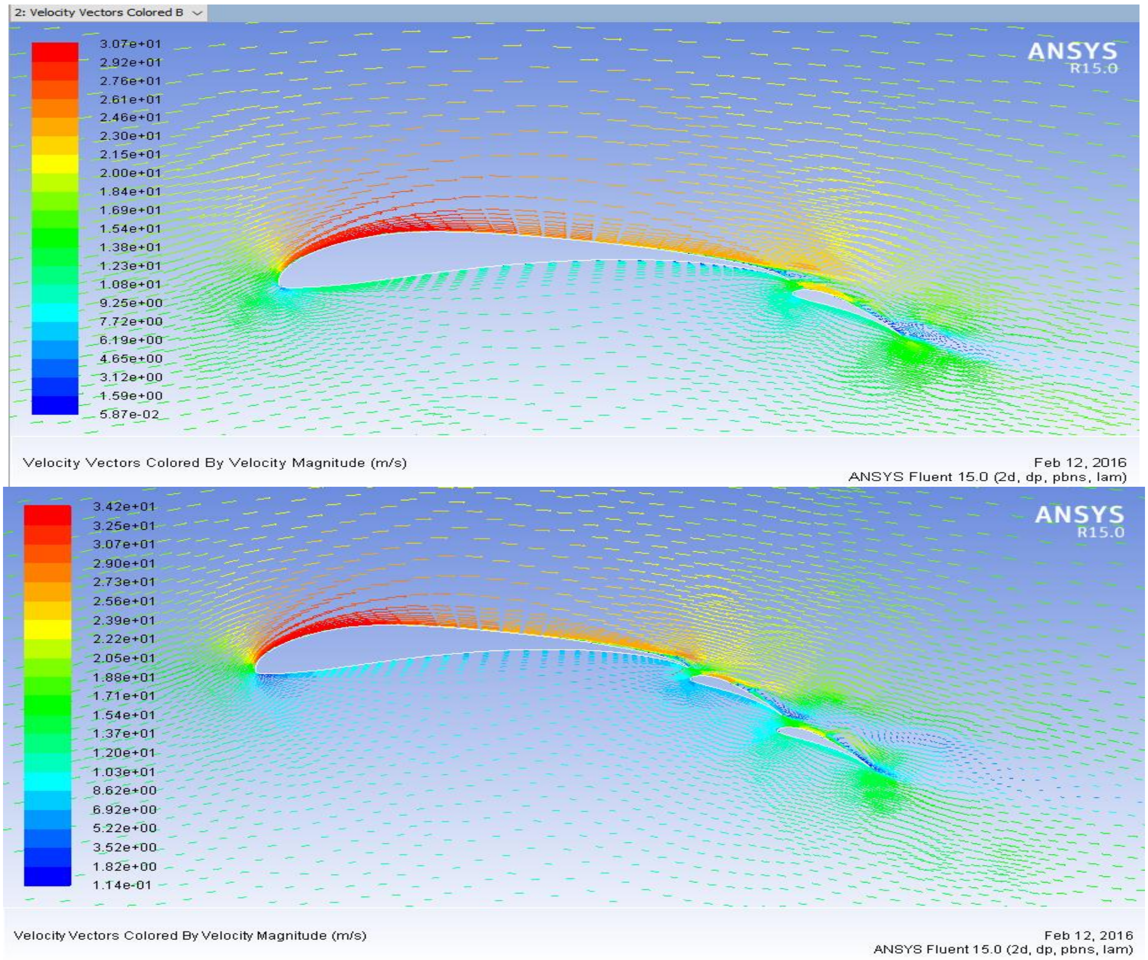
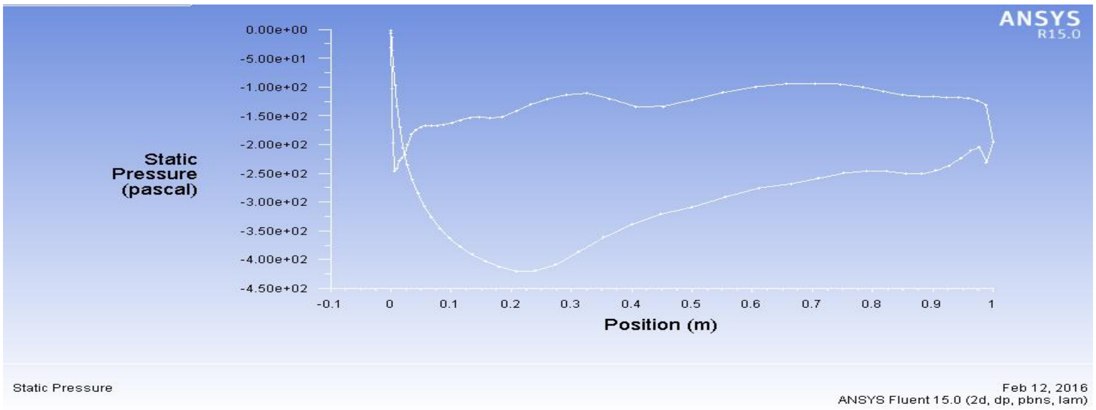
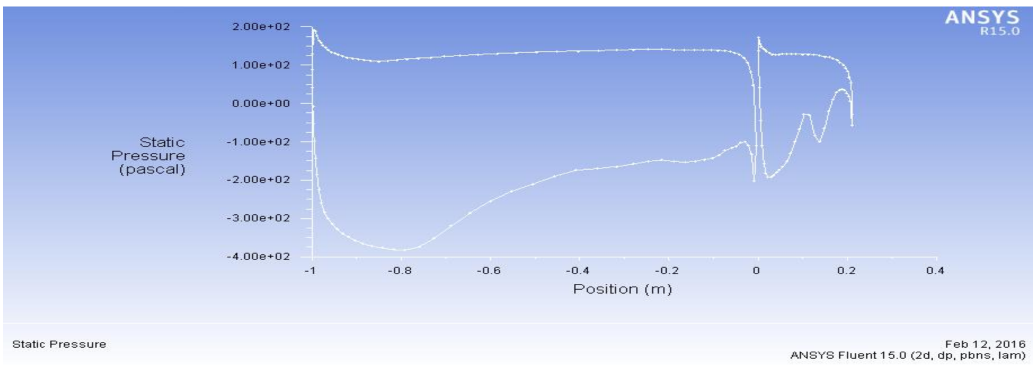



Fig 6 Velocity Gradient

For Static Pressure



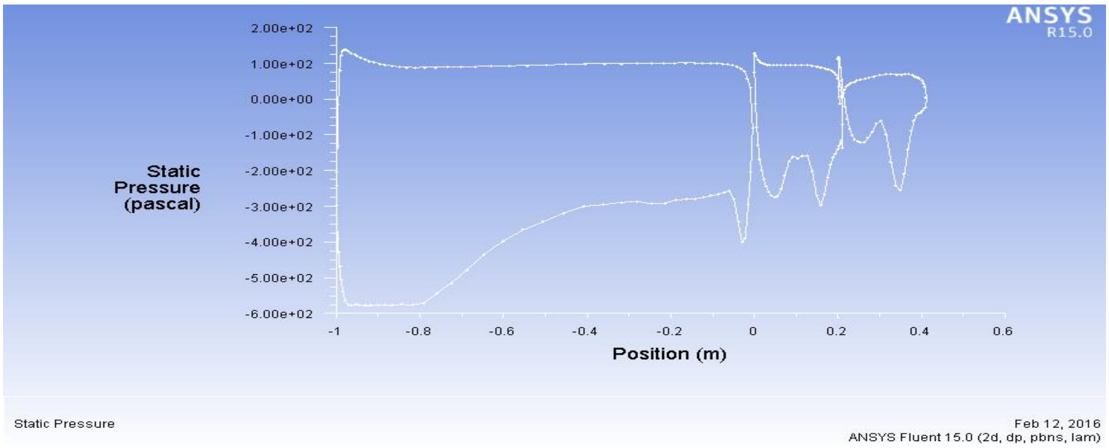



Fig 7 Statics Pressure

The Results And Graphs Are Summarized Below:

Table 2 Coefficient Of Lift And Drag

| | Airfoil S1223 | Airfoil S1223 With 1 Element | Airfoil S1223 With 2 Elements |
|---|---|---|---|
| Co-Efficient Of Lift | 1.2 | 2.5 | 3.5 |
| Co-Efficient Of Drag | 0.1 | 0.5 | 0.25 |

## III. Conclusions

By Increasing The Number Of Elements At The Trailing Edges Of The Airfoil, A Considerable Increment In The Co-Efficient Of Lift Was Observed. This Increases The Efficiency Of The UAV.

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