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Stability Characteristics of missile due to maneuvering in all six Degree of freedom using CFD simulations

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Abstract: This project aims at establishing the stability characteristics of the missile with respect to Angle of attack of the control surfaces, using Computational fluid dynamics Simulations. The drag, lift around the missile will be estimated for various AOA. Based on these simulations, the optimal range of angle of attack in all six Degrees of freedom will be decided

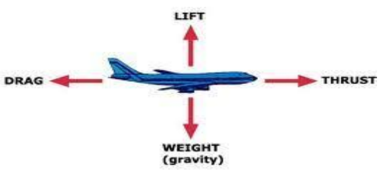
Keywords:Drag, Lift, Angle of attack (AOA), Computational fluid dynamics (CFD), star-ccm+

I.INTRODUCTION

Building an efficient rocket engine is only part of the problem in producing a successful rocket. The rocket must also be stable in flight. A stable rocket is one that flies in a smooth, uniform direction. An unstable rocket flies along an erratic path, sometimes tumbling or changing direction. Unstable rockets are dangerous because it is not possible to predict where they will go. The missile body contains the guidance and control system, warhead, and propulsion system. Some missiles may consist of only the body alone, but most have additional surfaces to generate lift and provide maneuverability. These are called as control surfaces. Control surfaces are used in missiles to maneuver the missile i.e. to change the flight-direction of the missile. The angle of attack (AOA) of the control surface is altered whenever there is a need for change of direction. Thus the control surfaces help in managing the trajectory of the missile in all the six DOFs. However the range of AOA is an important factor in deciding the stability of the missile. A high value of AOA will lead to huge turbulences around the missile resulting in instability because of which the missile may not be able to reach its target and thus crash in the midway. The flow around the missile is analyzed using the CFD tool STAR-CCM+. The CFD analysis will be conducted in the following stages:

- Geometry creation: Building of the 3D model of the missile.
- Meshing: The fluid (air) around the 3D model of the missile will be suitably discretized into polyhedral-elements.
- The physical conditions like Reynolds's number, air density, velocity etc. will be applied appropriately.
- Analysis run will be conducted to solve the large flow problems involved.
- The results of the analysis will be post-processed and documented.

The drag, lift around the missile are calculated using formulas for various angle of attack, based on these optimal range of angle of attack in all six degree of freedom estimated using CFD.In fluid dynamics drag (sometimes called air resistance or fluid resistance) refers to forces which act on a solid object in the direction of the relative fluid flow velocity and lift is perpendicular to fluid flow velocity.



The lift coefficient of afixed-wing aircraft varies uniquely with angle of attack. Increasing angle of attack is associated with increasing lift coefficient up to the maximum lift coefficient, after which lift coefficient decreases. As the angle of

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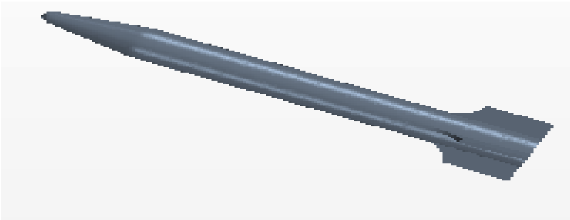
attack of a fixed-wing aircraft increases, separation of the airflow from the upper surface of the wing becomes more pronounced, leading to a reduction in the rate of increase of the lift coefficient

II. METHODOLOGY

II (A). Model description

To model this simulation we use missile basic model. This model is analyzed using Star-ccm+ and drag, lift arecalculated, forthis we take liquid in steady flow and turbulent condition is taken. For liquid we taken pressure as 1barand temperature 343K is taken. To design the model in star-ccm+ through geometric modeling technology.The lift coefficient of afixed-wing aircraft varies uniquely with angle of attack. Increasing angle of attack is associated with increasing lift coefficient up to the maximum lift coefficient, after which lift coefficient decreases. As the angle of attack of a fixed-wing aircraft increases, separation of the airflow from the upper surface of the wing becomes more pronounced, leading to a reduction in the rate of increase of the lift coefficient
Taken rectangular section and rotate it around 360^0 and the model section as follows



For 0-10 degrees we estimate drag and lift value, generally Angle of attack up to 10 degrees drag, lift values are estimated.

II (B). ANALYSIS

Mesh operation is generated in this process select polyhedral model and base size is 0.18mm and select surface mesh to generate surface and to select total volume chosen volume mesh option. In analysis taken AOA with respective contact angles

AOA	Angle between chord line and direction of force
0	178
1	176
3	172
4	170
5	169
6	167
7	164
8	162
9	156
10	152

Force analysis for 0-10degrees:

For 0 degree:The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is 53371 to 296661 Pa

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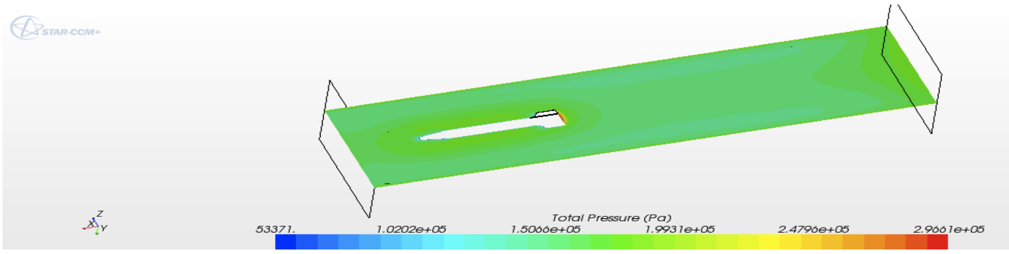
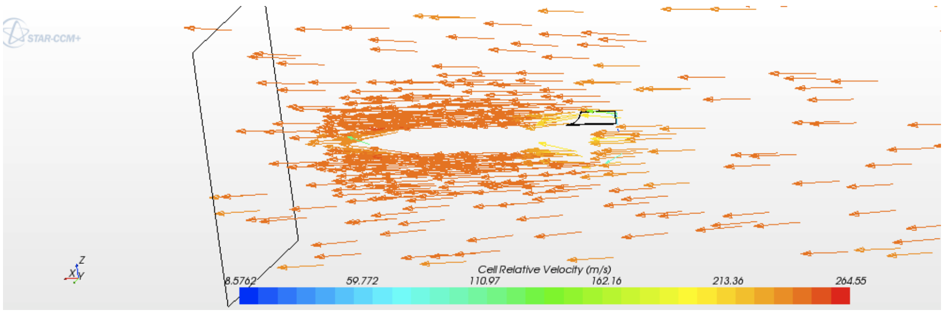
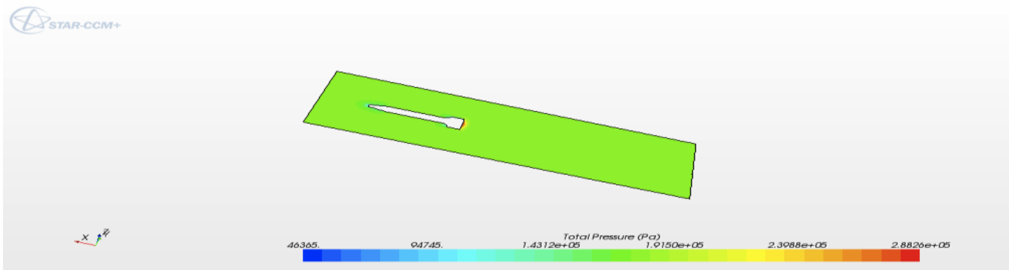


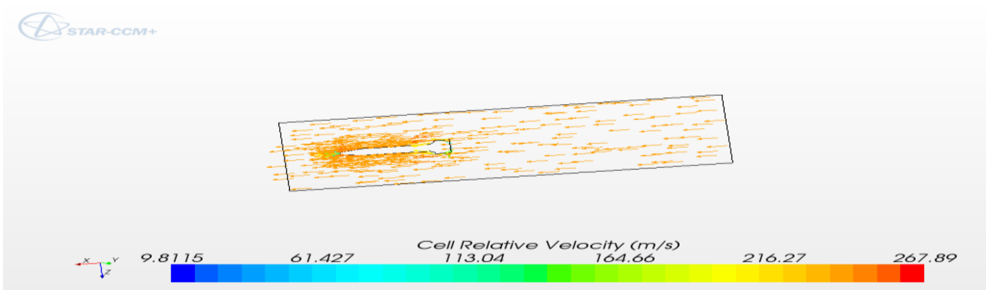
Vector analysis show velocity ranges



For 1^0: The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is 46365 to 288260 Pa



Vector analysis show velocity ranges



For 2^0: The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is -2581.1to 352420 Pa

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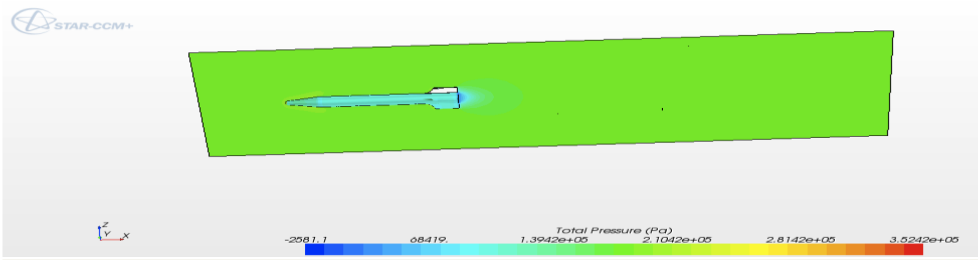
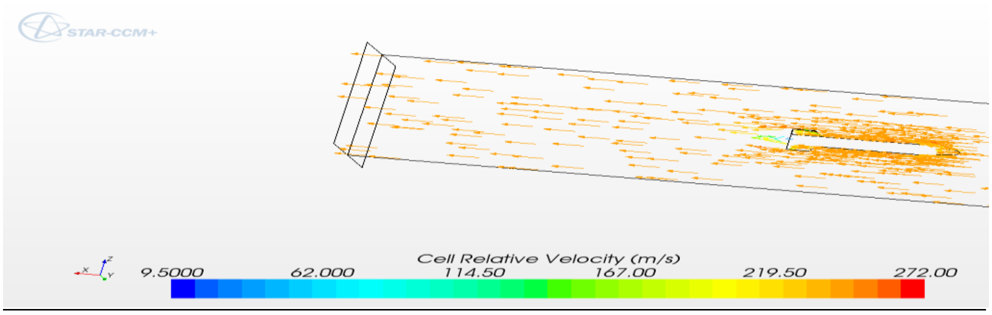
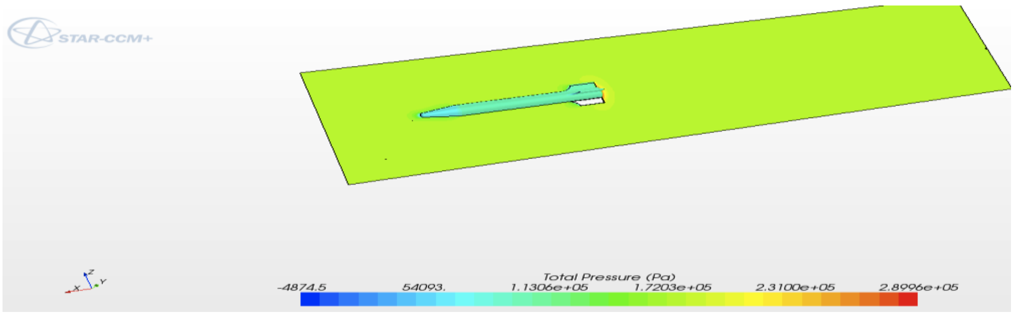


Vector analysis showvelocity ranges



For 3^0: The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is -4874.5 to 289960 Pa



Vector analysis shows velocity ranges

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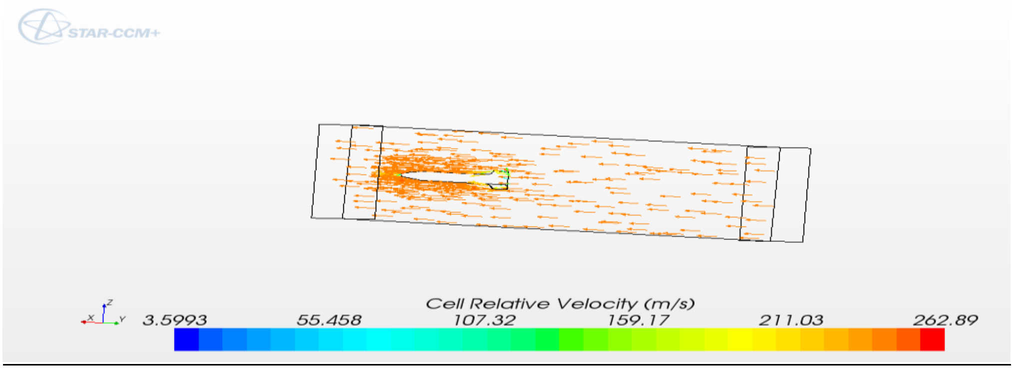
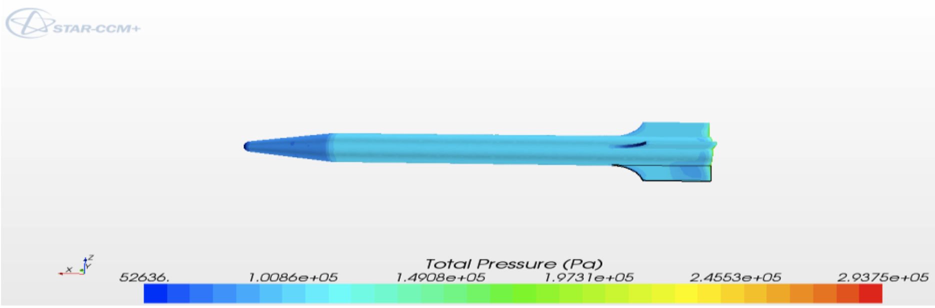
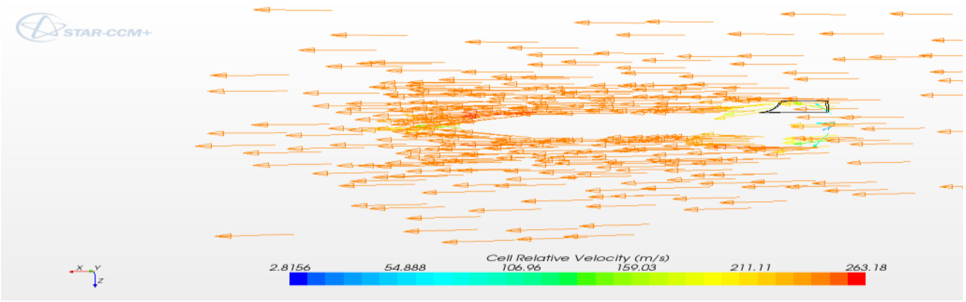


For 4^0: The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is 52636 to 293750 Pa



Vector analysis shows velocity ranges



For 5^0: The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is 8280.8 to 184920 Pa

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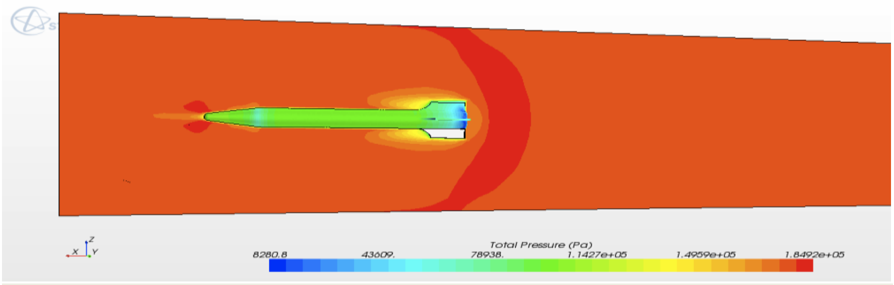
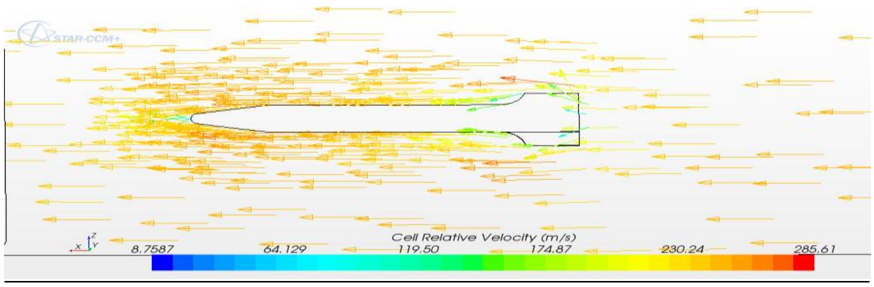
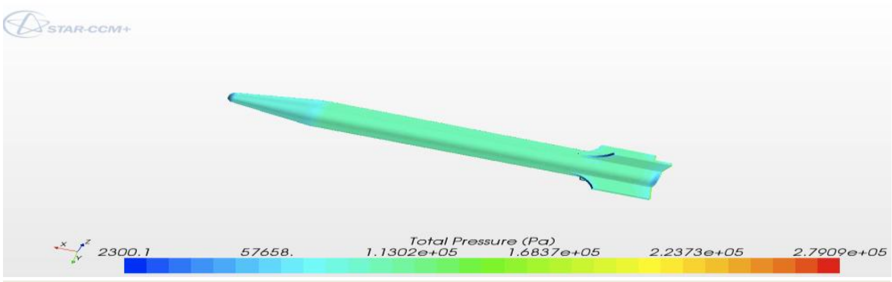


Vector analysis shows velocity ranges

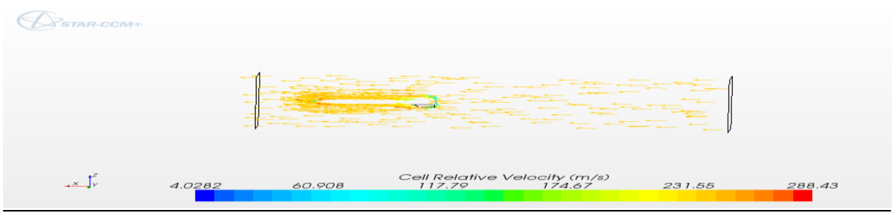


For 6^0: The scalar analysis is as shown below

In scalar analysis pressure value is calculated and range is 2300.1 to 279090 Pa



Vector analysis shows velocity ranges



For 7^0: The scalar analysis is as shown below

In scalar analysis pressure value is calculated and range is 6358.5 to 340410 Pa

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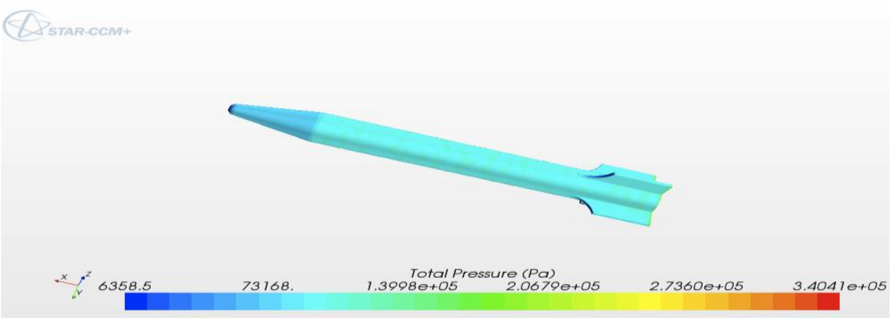

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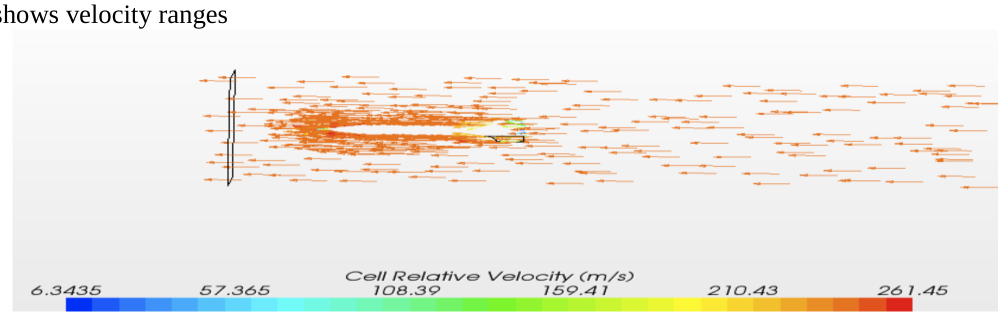
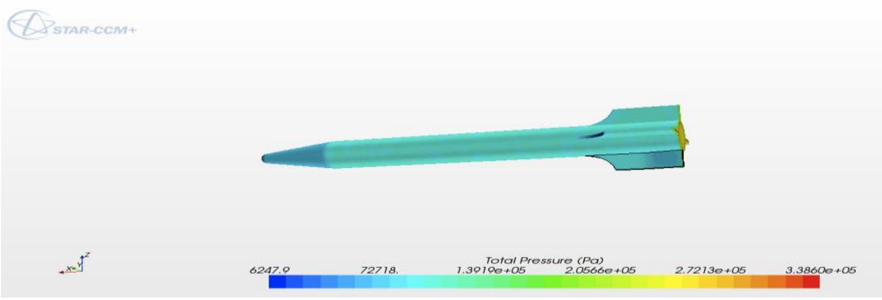
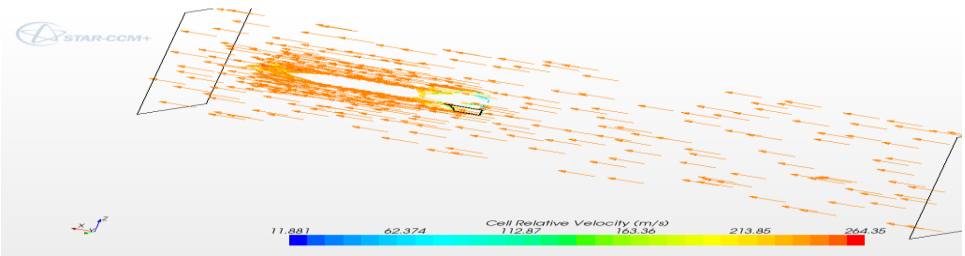


For 8^0: The scalar analysis is as shown below

In scalar analysis pressure value is calculated and range is 6347.9 to 338600 Pa



Vector analysis shows velocity ranges



For 9^0: The scalar analysis is as shown below

In scalar analysis pressure value is calculated and range is -3825.3 to 340450 Pa

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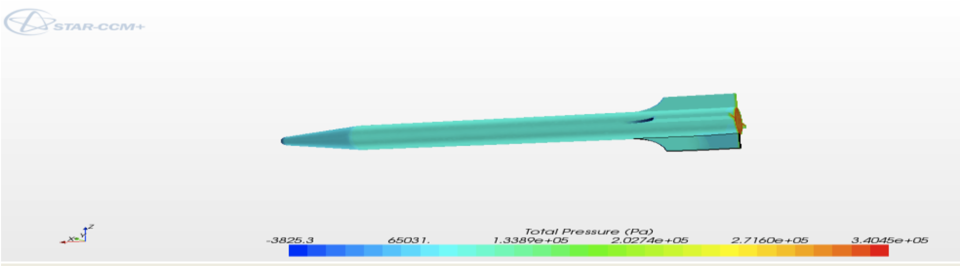
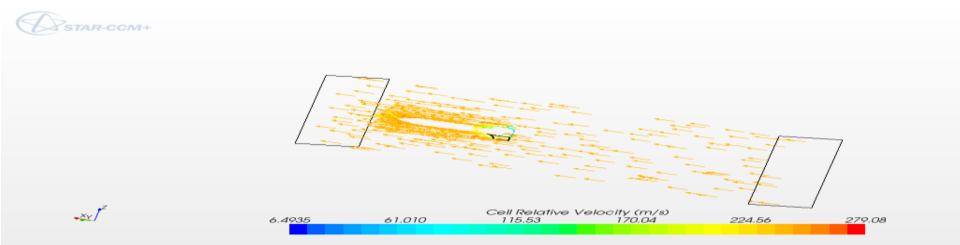
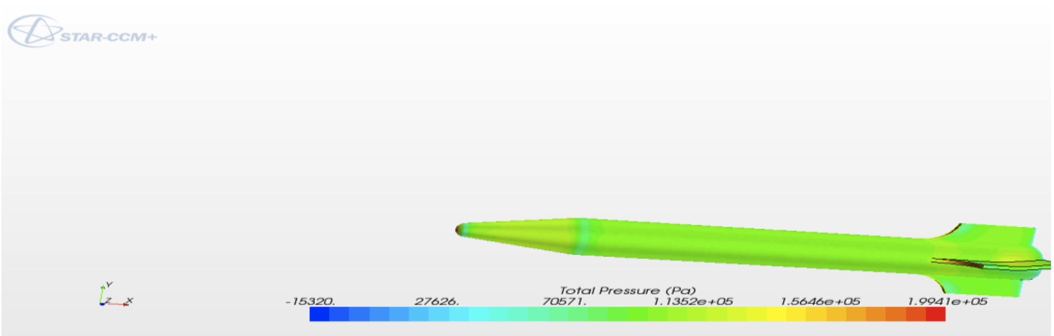


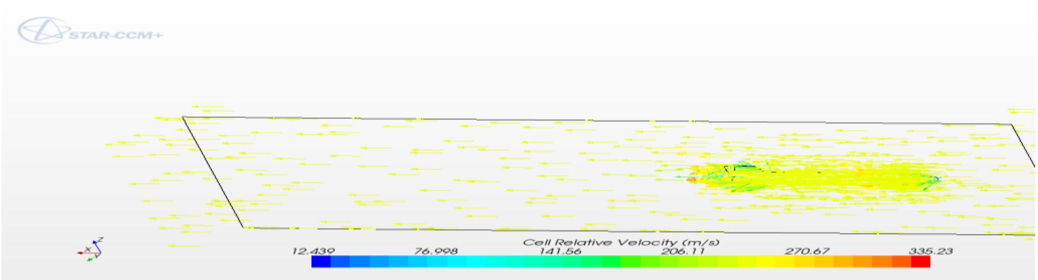
Vector analysis shows velocity ranges



For 10^0: The scalar analysis is as shown below
In scalar analysis pressure value is calculated and range is -15320 to 199410 Pa



Vector analysis shows velocity ranges



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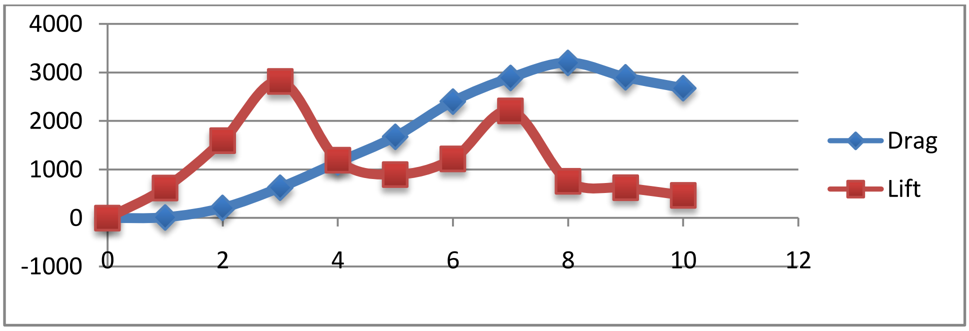
III RESULTS

The drag and lift values we get as below table:

Angle of Attack	0^0	1^0	2^0	3^0	4^0	5^0	6^0	7^0	8^0	9^0	10^0
Drag	1.297	16.24	210.02	629.34	1149.45	1678.22	2402.12	2890.15	3202.36	2900.03	2675.44
Lift	1.02	620.12	1598.07	2816.33	1192.64	898.03	1220.03	2210.01	758.21	624.02	468.25



Graph is drawn between Angle of contact and Drag, Lift the point at which drag force and lift force combines give perfect AOA, and the point is 1192.64.

IV CONCLUSION

Generally from the graph at AOA 4 degree the appropriate force analysis is done, the angle of attack increases with increase in drag and lift decreases and increases with slight variations. Mostly flight or missile accidents occur due to movement with respective force only, so that direction and stability characteristics are determined mainly on AOA.So depending on force AOA varies, the control angle from analysis using star-ccm+ is 4^0

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