COMPUTATIONAL FLUID DYNAMICS AND STRUCTURAL ANALYSIS OF QUADCOPTER FRAME SS-1 AND COMPARISON WITH X-FRAME

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Abstract

A quad copter is a Multirotor which contains four rotors. Higher the number of rotors in an UAV (Unmanned Aerial Vehicle), more the stability. Quadcopter is a multi-rotor with a combination of maximum stability with minimum rotors. These are used for many purposes, but nowadays, commonly used for defence and local surveillance. In this paper, we have designed a new frame named as "SS-1" and it is compared with conventional "X-frame". Modelling is done on Solid Works 2014, and Computational Fluid Dynamics and Structural Analysis on ANSYS workbench 15.0.

Keywords *– Computational Fluid Dynamics, Quadcopter, Ansys, Ss-1 Frame, X-Frame, Solid Works, Structural Analysis, Ansys Fluent*

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1. INTRODUCTION

1.1 Quadcopter

Quad copter is a multirotor which is lifted and propelled by four rotors. It performs three type of movement apart from lifting i.e. yaw, pitch, and roll. By adjusting the RPM of rotors simultaneously it can manoeuvre about its position. It can be used for transporting things, aerial filmography, defence and local surveillance etc.

1.2 X-Frame

X-Frame is the most commonly used frame for quad copter. In this frame, arms of quad copter are placed diagonally inside two surface plate. This frame is also called conventional frame.

Fig. 1.2 X-Frame

1.3 SS-1 Frame

SS-1 is a modification done in the X-frame by altering the arrangement of arms. The arms are fixed on the sides of surface plate. Fastening is done by nuts and bolts.

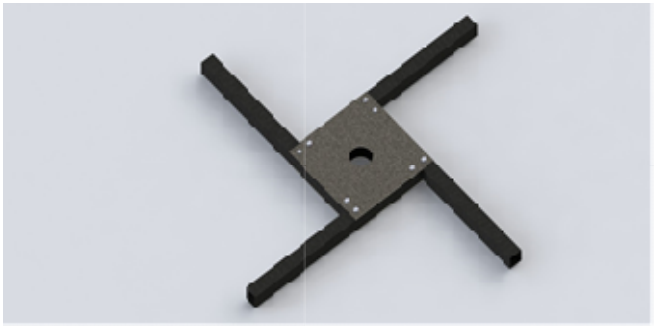


Fig 1.3 SS-1 Frame

2. ANSYS RESULTS

2.1 Analysis of X-Frame

The analysis carried out is Structural Analysis. Load applied is 50N i.e. the general payload lifted by quadcopter including its own weight.

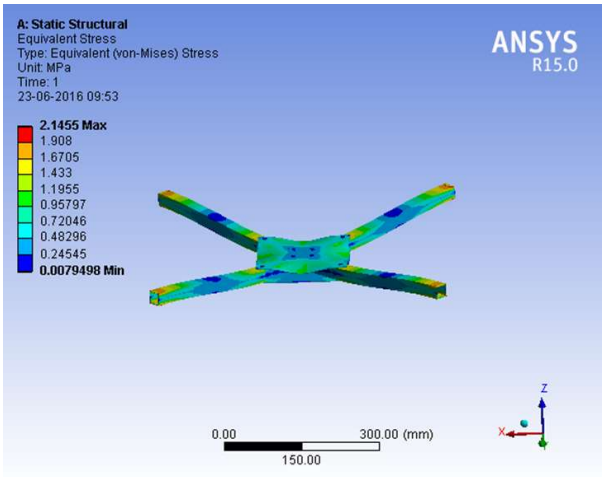


Fig 2.1.1 Equivalent Stress of Carbon Fibre (X-Frame)

The ultimate tensile strength of carbon fibre is 300MPa.the maximum equivalent stress that is obtained is 2.1455 MPa. Hence the frame is safe.

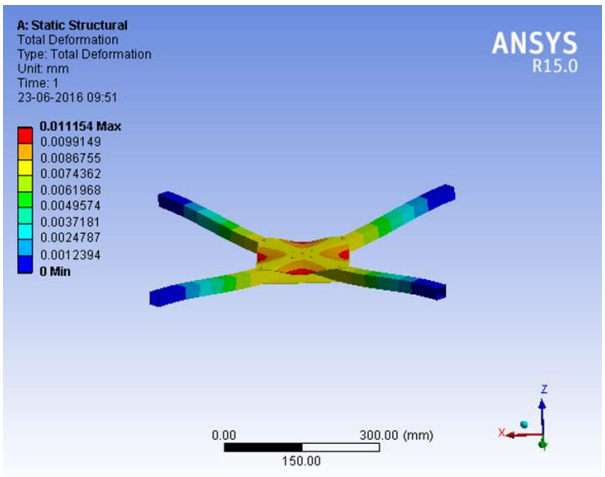


Fig 2.1.2 Total Deformation of Carbon Fibre (X-Frame)

2.2 Analysis of SS-1 Frame

The analysis carried out is Structural Analysis. Load applied is 50N i.e. the general payload lifted by quad copter including its own weight.

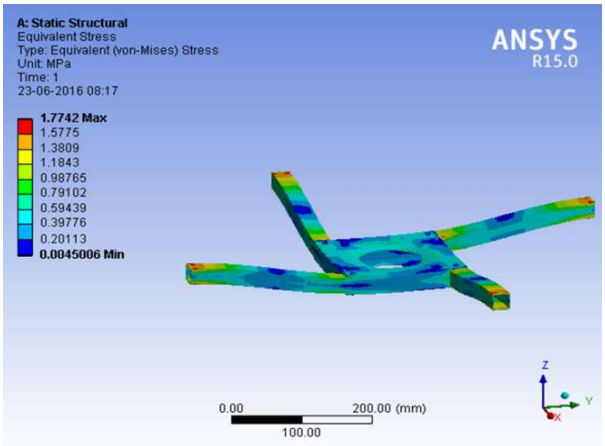


Fig 2.2.1 Equivalent Stress of Carbon Fibre (SS-1 Frame)

The ultimate tensile strength of carbon fibre is 300MPa.the maximum equivalent stress that is obtained is 1.7742 MPa. Hence the frame is safe.

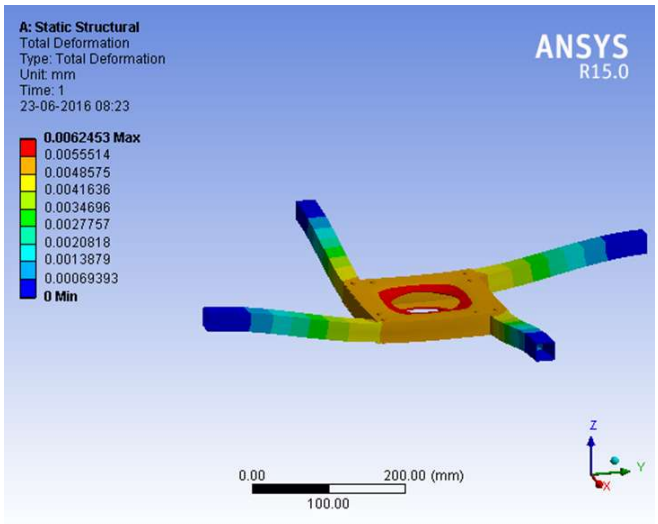
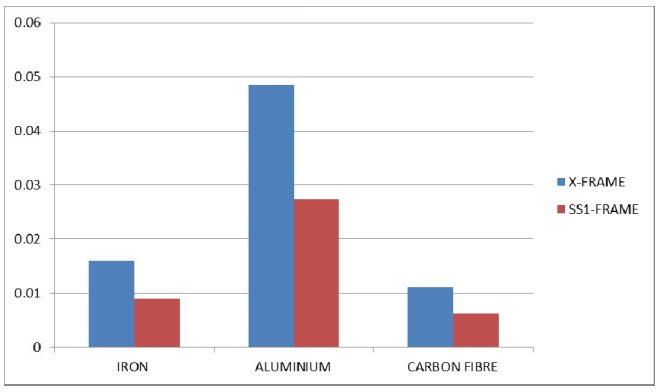


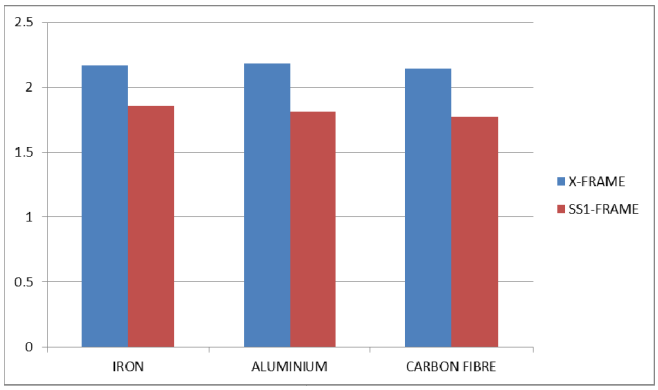
Fig 2.2.2 Total Deformation of Carbon Fibre (SS-1 Frame)

3. COMPARISION BETWEEN SS-1 FRAME AND X-FRAME

Both frames were tested on different materials for optimality. The materials used for comparison are IRON, ALUMINIUM, and CARBON FIBRE.



TOTAL DEFORMATION (mm)



MAXIMUM EQUIVALENT STRESS (MPa)

4. DIMENSIONS

Table 4.1

S. No.	Components	Dimensions (cm) (L*B*H)
1.	Box Sectional Hollow Tube	(38.1*2.54*2.54)
2.	Plate	(17.78 * 17.78*0.16)
3.	Bolts	(0 .25 * 3 * 0.05) (D * L * P)

5. PERCENTAGE REDUCTION IN SS-1 OVER X-FRAME

Table 5.1

Percentage Reduction In Total Deformation	44%
Percentage Reduction In Equivalent Stress	17%
Percentage Reduction In Equivalent Strain	17%

6. COMPUTATIONAL FLUID DYNAMICS ANALYSIS RESULTS.

Computational fluid dynamics has been done on ANSYS FLUENT. The parameters are given below which are used for the comparison between mentioned frames. Number of iterations taken for calculation are 500, and meshing resolution used is fine so to get accurate results.

6.1 CFD Results of X-Frame

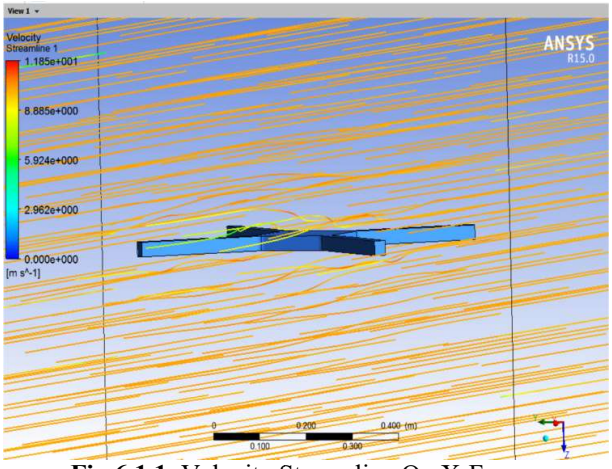


Fig 6.1.1 Velocity Streamline On X-Frame

Inlet velocity of air is taken as 10 m\sec. The maximum velocity of air around the frame is found to be 11.85 m/sec.

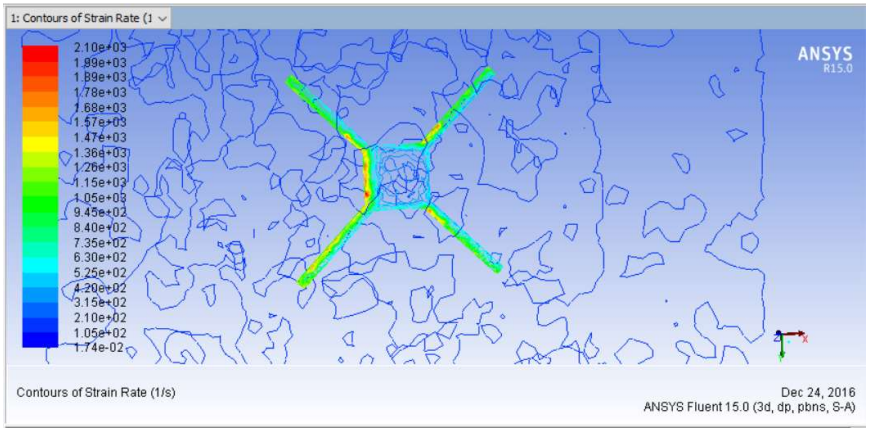


Fig 6.1.2 Contour Of Strain Rate In X-Frame

Maximum strain rate is found to be 2100/second and average strain rate all over the X-frame is found to be 1050/second.

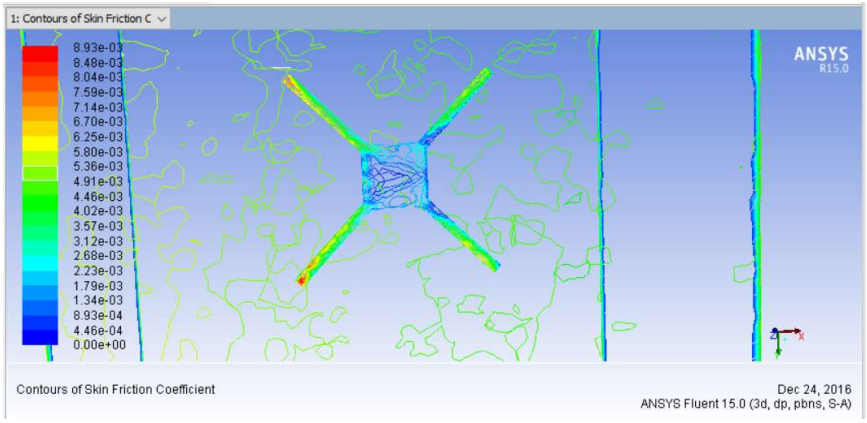


Fig 6.1.3 Contours Of Skin Friction Coefficient In X-Frame

Maximum skin friction coefficient on the X-frame is 0.00893 and the average value is 0.0046.

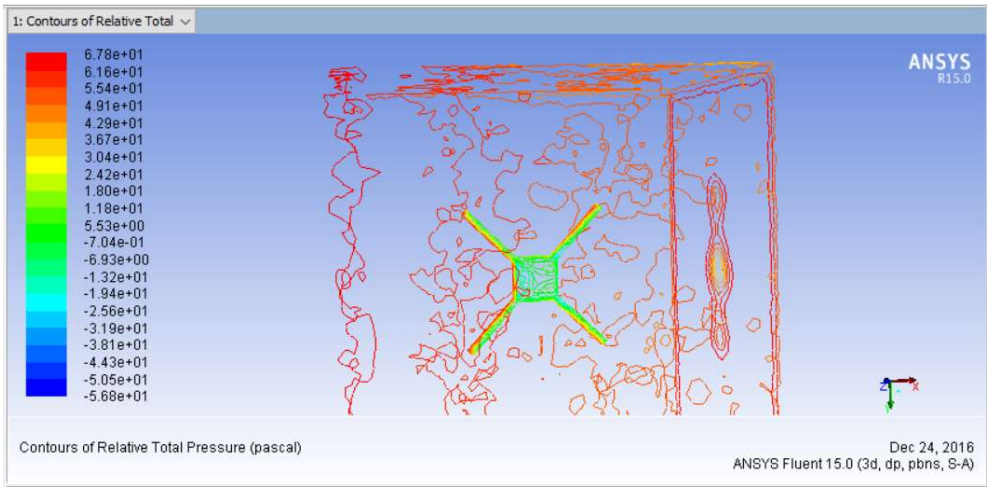


Fig 6.1.4 Contour Of Relative Total Pressure In X-Frame

Maximum relative total pressure is 67.8 pascal and average value is 5.53 pascal.

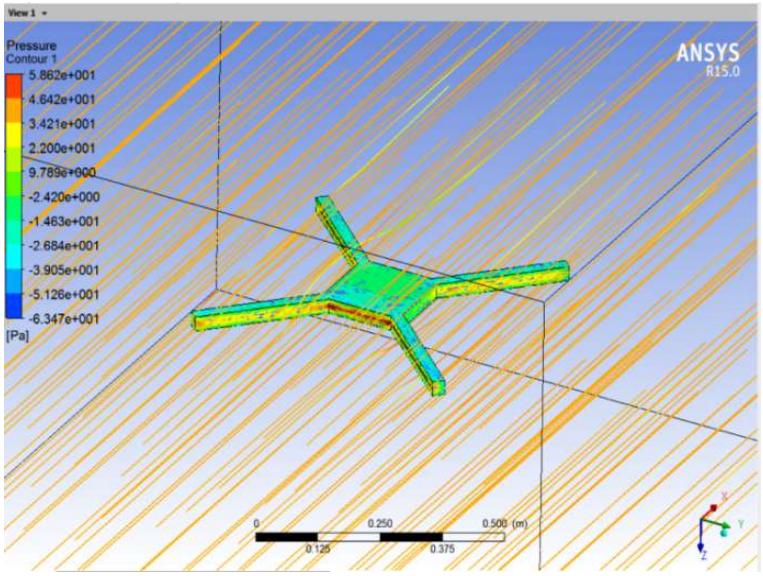


Fig 6.1.5 Pressure Contour In X-Frame

Maximum pressure on the X-frame is 58.62 Pascal.

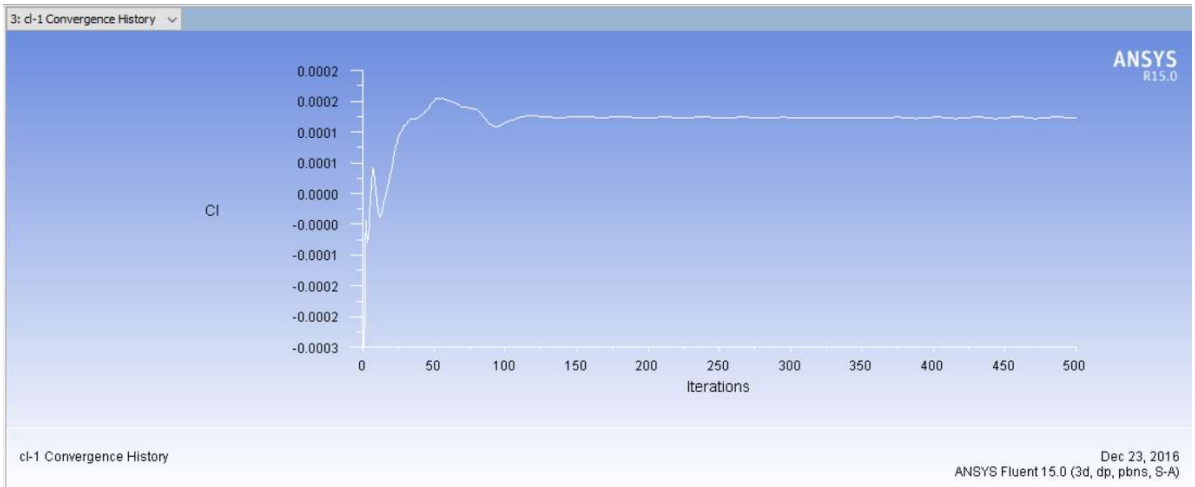


Fig 6.1.6 Coefficient Of Lift In X-Frame

Coefficient of lift in X-frame is 0.0002.

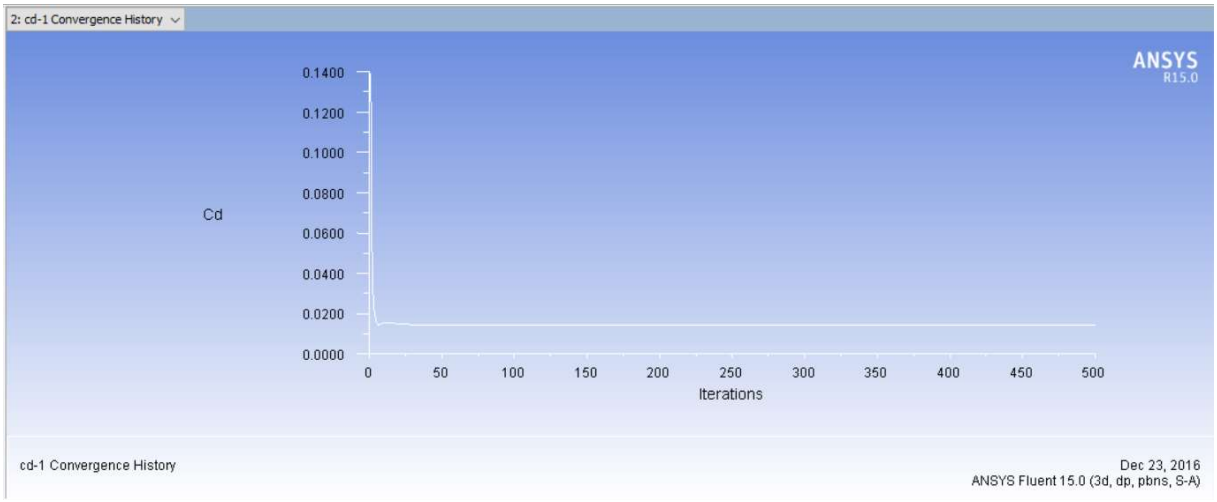


Fig 6.1.7 Coefficient Of Drag In X-Frame

Coefficient of drag in X-frame is 0.02.

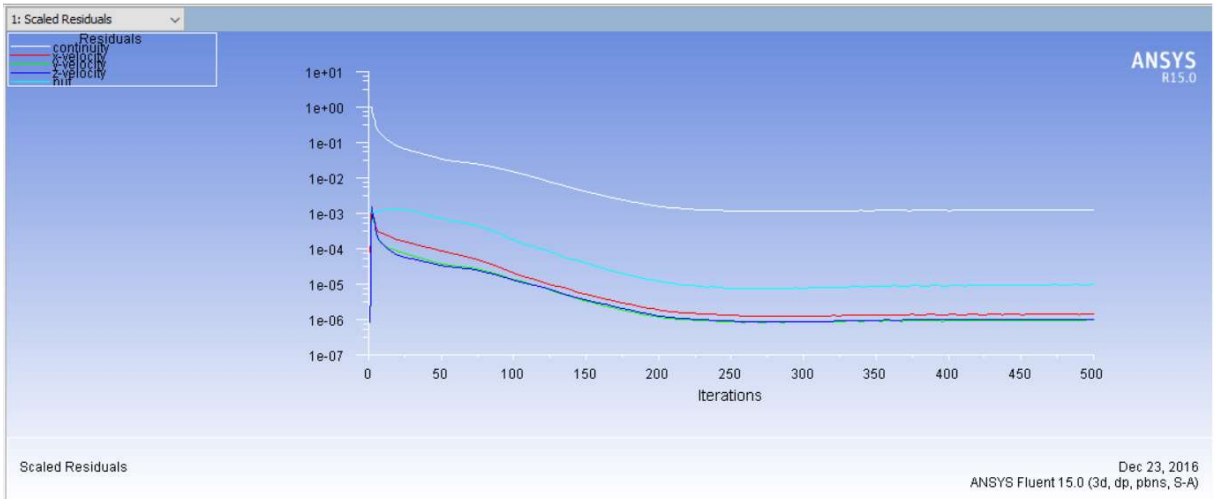


Fig 6.1.8 Scale Residuals In X-Frame

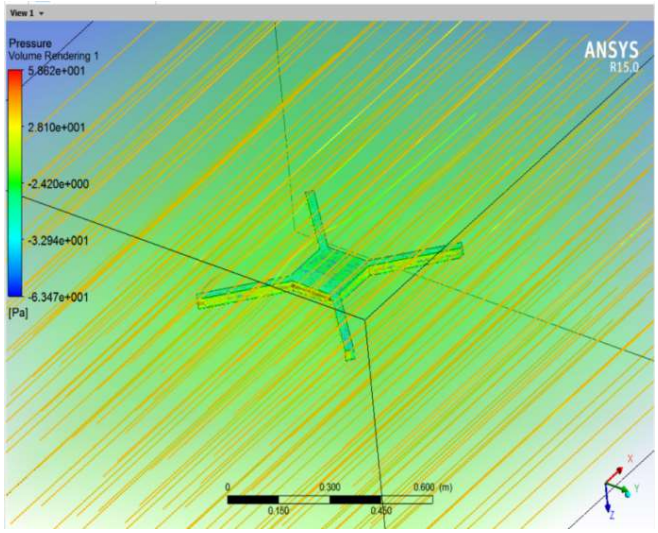


Fig 6.1.9: PRESSURE-VOLUME RENDERING IN X-FRAME

Maximum pressure-volume rendering is 58.62 pascals.

6.2 CFD Results of SS-1 Frame

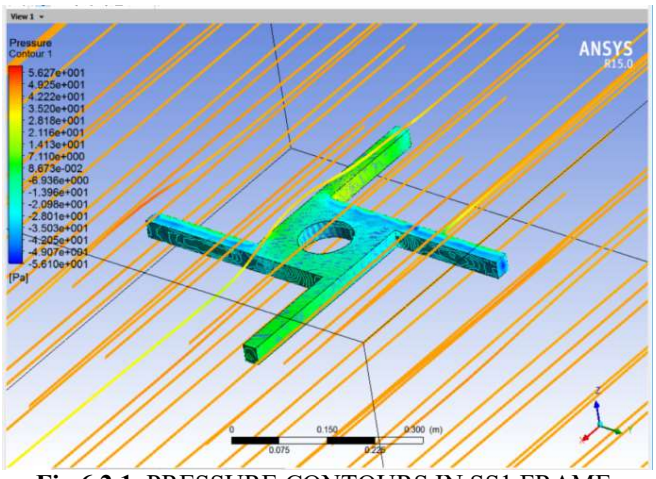


Fig 6.2.1 PRESSURE CONTOURS IN SS1 FRAME

Maximum pressure on the SS-1 frame is 56.27 pascals.

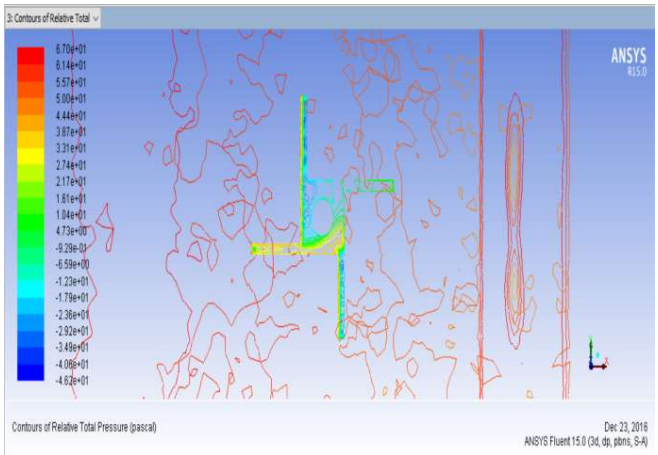


Fig 6.2.2 Contours of Relative Total Pressure In Ss-1 Frame

Maximum relative total pressure is 67 pascals and average value is 4.73 pascals.

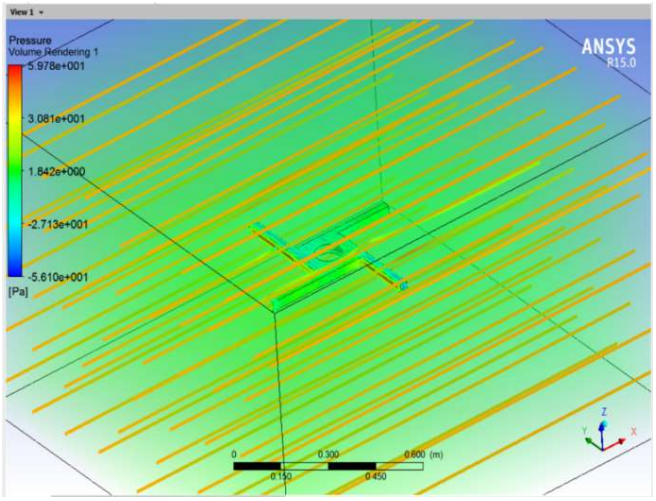


Fig 6.2.3 Pressure-Volume Rendering of Ss-1 Frame

Maximum pressure volume rendering is 59.78 pascals.

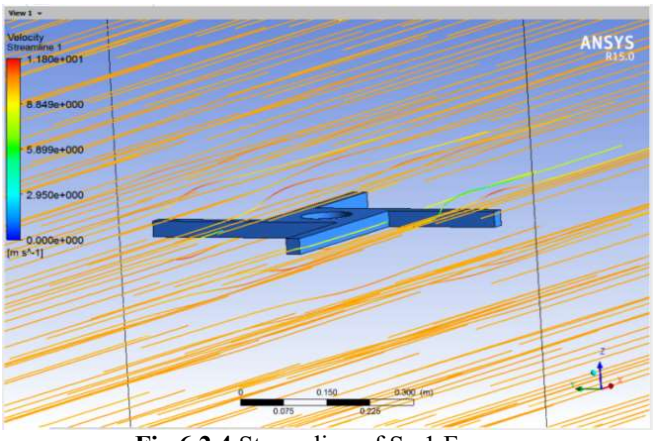


Fig 6.2.4 Streamline of Ss-1 Frame

Inlet velocity of air is taken as 10 m\sec. The maximum velocity of air around the frame is found to be 11.80 m/sec

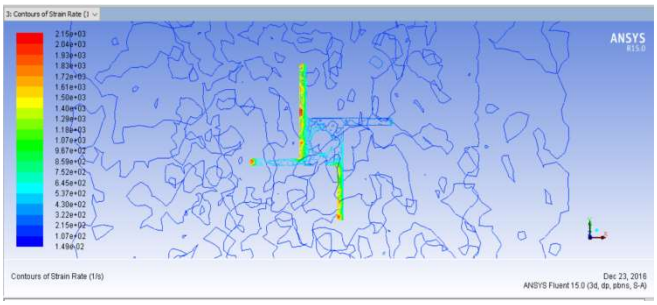


Fig 6.2.5 Contours of Strain Rate In Ss-1 Frame

Maximum strain rate is found to be 2150/second and average strain rate all over the SS-1 frame is found to be 1070/second.

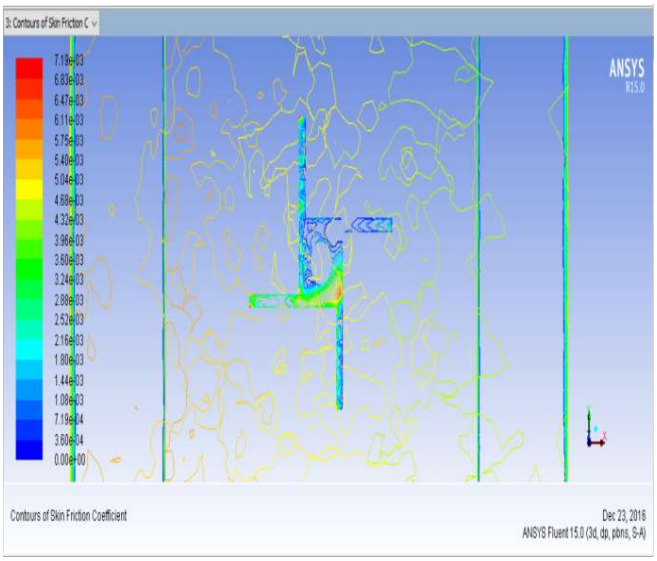


Fig 6.2.6 Contours of Skin Friction Coefficient In Ss-1 Frame

Maximum skin friction coefficient in the SS-1 frame is 0.00719 and the average value is 0.0036.This value islesser than X-frame which means that SS-1 frame has lesser resistance in air than X-frame.

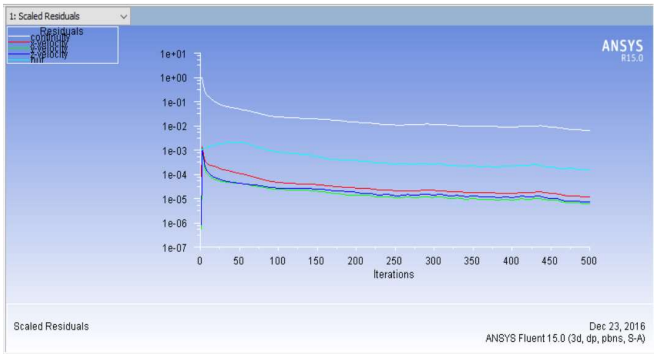


Fig 6.2.7 Scale Residuals In Ss-1 Frame

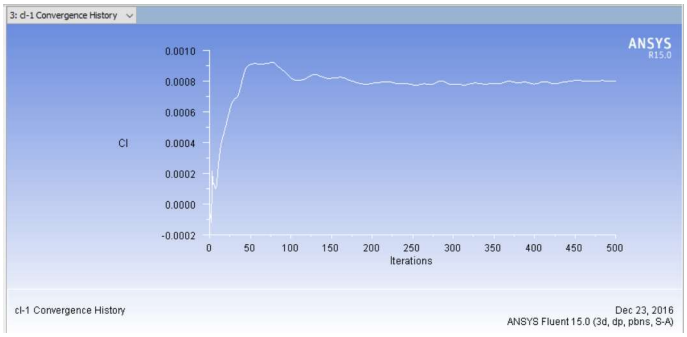


Fig 6.2.8 Coefficient of Lift In Ss-1 Frame

Coefficient of lift in SS-1 frame is 0.0008. This value is greater than X-frame which means that lifting of SS-1 frame in air is easier than X-frame.

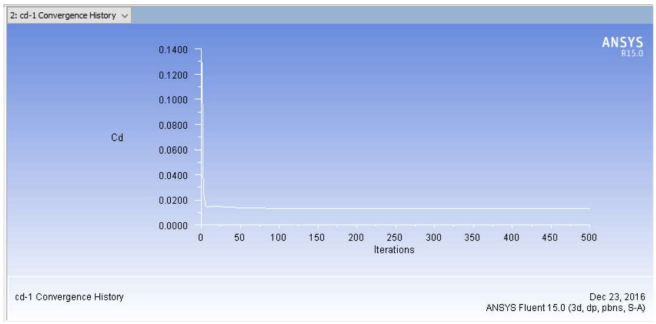


Fig 6.2.9 Coefficient of Drag In Ss-1 Frame

Coefficient of drag in SS-1 is 0.02.

7. CONCLUSION

The above results show that the SS-1 Frame is better than X-Frame. The result also shows that the percentage reduction in parameters is nearly same for all materials used. Mass reduction in SS-1Frame is about 7% over X-Frame which makes it lighter in weight and material cost is also reduced. Computational Fluid Dynamics analysis shows that the SS-1 frame is better than conventional X-frame and it can be used in place of X-frame.

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BIOGRAPHIES

VIJAY KUMAR PATHAK completed his graduation in Mechanical engineering in July 2016, from Institute of Information Technology and Management, Gwalior, affiliated to Rajiv Gandhi Prodyogiki Vishwavidyalaya, Bhopal. He is proficient in AutoCAD 2016 and as a part of his major project, he has modeled and analyzed a Quadcopter frame using Solid Works14 and ANSYS 15.He is currently an employee in TSS solutions pvt. Ltd, Agra.He wishes to pursue MS from a prestigious institute, where he can enrich his skills and interest in research field. Apart from studies, he likes to sing, write,cook and play sports.

SHIVAM TIWARI completed his graduation in Mechanical engineering in July 2016, from Institute of Information Technology and Management,Gwalior, affiliated to Rajiv Gandhi Prodyogiki Vishwavidyalaya,Bhopal. He is proficient in AutoCAD 2016 and as a part of his major project, he has modeled and analyzed a Quadcopter frame using Solid Works 14 and ANSYS 15.He is currently an employee in TSS solutions pvt. Ltd, Agra.He wishes to pursue MS from a prestigious institute, where he can nurture his skills and interest indesigning and developing products. Apart from studies, he likes to sing and sketch