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Design and Analytical Investigations of Windshield Used In Aircraft-FSI Technique

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ABSTRACT: The windshield or windscreen of an aircraft, car, bus, motorbike or tram is the front window. Windshield is an important assembly of an aircraft and some master features are depended on its quality. The important quality characteristics of windshield are visibility through the canopy, structure rigidity, impact resistance, reliability of the internal mechanisms, and the lightness of construction.

The most widely used material for light trainer aircraft windshield is Glass. In the present work, it is proposed to replace the existing glass for a light trainer. In the present work two different materials were considered namely polymethyl-methacrylate and poly vinyl butyl for windshield. Windshield modeling was done in 3D using Pro/Engineer software.

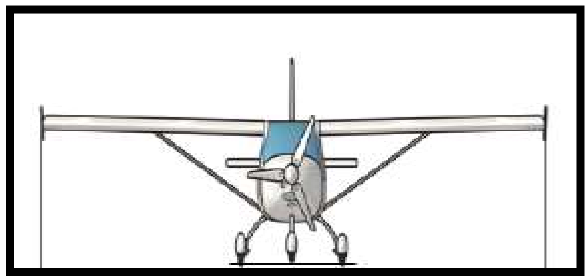
Dynamic analysis was carried out by Computational Fluid Dynamics (CFD), Fluid-Structure-Interaction (FSI) approach and ANSYS in order to evaluate fluid pressure, stress distribution and deformation in windshield with different air speeds. The analysis is carried out for all the three different materials at various air speeds of 900,800,600 and 400km/hr.

In this thesis, the FSI analysis to determine the pressure, velocity, stress and deformation at different speeds and materials.

I.INTRODUCTION

WINDSHIELD

The windshield (North America) or windscreen (Commonwealth countries) of an aircraft, car, bus, motorbike or tram is the front window. Modern windshields are generally made of laminated safety glass, a type of treated glass, which consists of two (typically) curved sheets of glass with a plastic layer laminated between them for safety, and are bonded into the window frame. Motorbike windshields are often made of high-impact acrylic plastic.

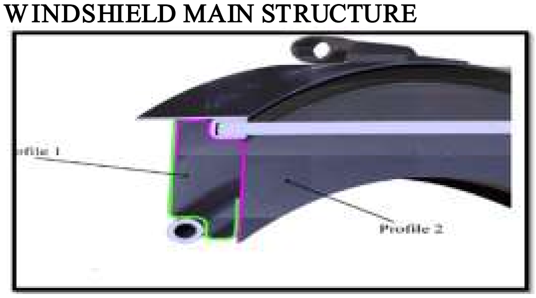


WINDSHIELD LOCATION AND INITIAL CONSIDERATION

(a) Size and depth
Repair of cracks up to 61 cm (24 in) is within permissible limits; auto glass with more severe damage needs to be replaced.

(b) Type
Circular Bull's-eyes, linear cracks, crack chips, dings, pits, and star-shaped breaks can be repaired without removing the glass, eliminating the risk of leaking or bonding problems sometimes associated with replacement.

WINDSHIELD MAIN STRUCTURE



Windshield frame sheet metal profiles

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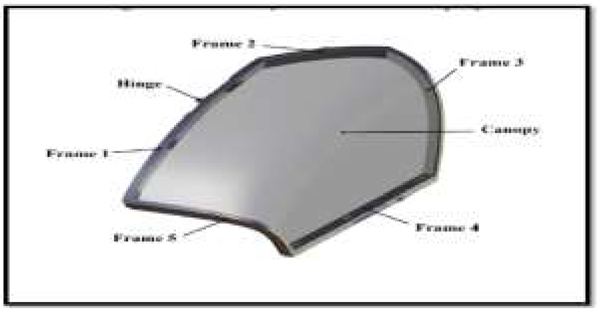


Speed (km/hr)	Velocity (m/s)	materials
900	250	Glass, polymethyl methacrylate & Poly vinyl butyl
800	222.22	
600	166.66	
400	111.11	

II. LITERATURE REVIEW

Ahmed MUKHTAR et.al [1] describes complete design process of windshield installation for the light trainer aircraft was described. Entire process was done using computer aided design (CAD) software. Passing through developing stages of the aircraft design, some influence factors directly have been causing change of windshield shape and structure design until the whole structure of aircraft had been frozen. One of the flight-technical requirements is efficient and rapid separation of the windshield in critical situations. Very thoughtfully design of the mechanisms that are consisted by windshield was performed due to this emergency requirement. The benefit of computer design process compared to the classic design process on a paper was confirmed here by easiness to simulate kinematics of the mechanisms and to inspect how do they behave in specific situations.

III.PROBLEM DESCRIPTION AND METHODOLOGY

Dynamic analysis was carried out by Computational Fluid Dynamics (CFD), Fluid-Solid-Interaction (FSI) approach and ANSYS in order to evaluate fluid pressure, stress distribution and deformation in windshield with different air speeds. The analysis is carried out for all the three different materials at various air speeds of 900,800,600 and 400km/hr.

In the present work two different materials were considered namely polymethyl-methacrylate and poly vinyl butyl for windshield. Windshield modeling was done in 3D using Pro/Engineer software.

IV. INTRODUCTION TO CAD

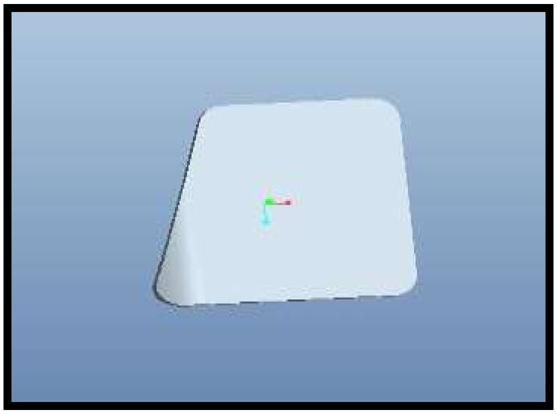
Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design and Drafting) is also used.

INTRODUCTION TO CREO

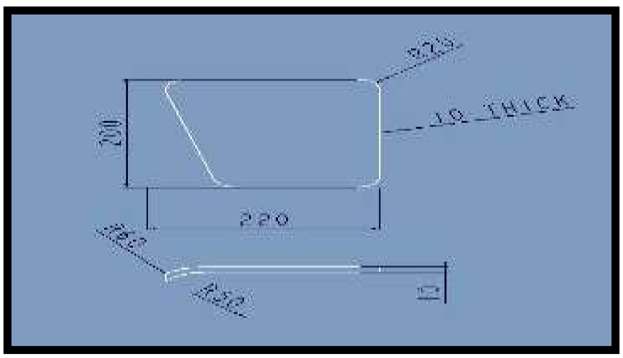
PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.

Fluid-Structure Interaction

Fluid-structure interaction (FSI) is a multiphysics coupling between the laws that describe fluid dynamics and structural mechanics. This phenomenon is characterized by interactions – which can be stable or oscillatory – between a deformable or moving structure and a surrounding or internal fluid flow.



2D DRAWINGS

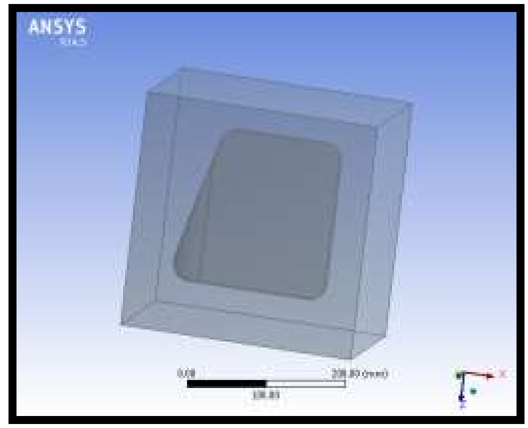


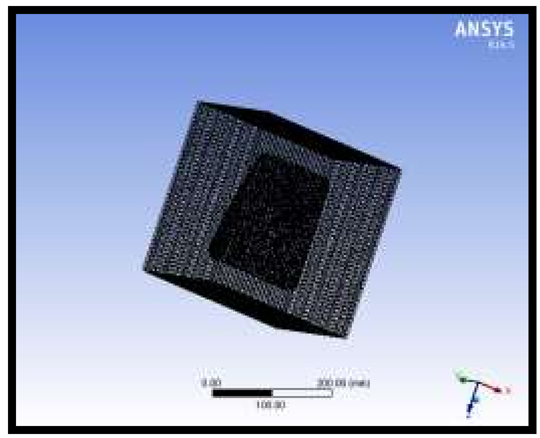
V. CFD & Structural analysis of windshield (FSI -Fluid Structure Interface)

5.2(a) Boundary conditions

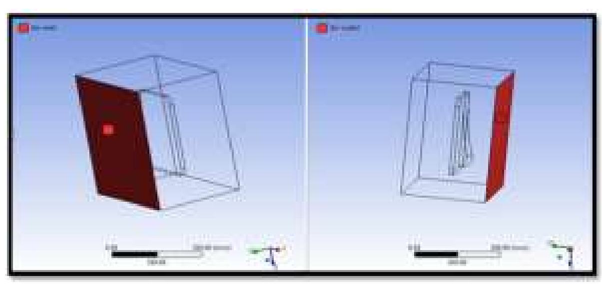
For CFD analysis, velocity and pressure are applied at the inlets. For structural analysis boundary conditions will be pressure which is obtained from the result of CFD analysis.

Case.1 AT SPEED 900 km/hr





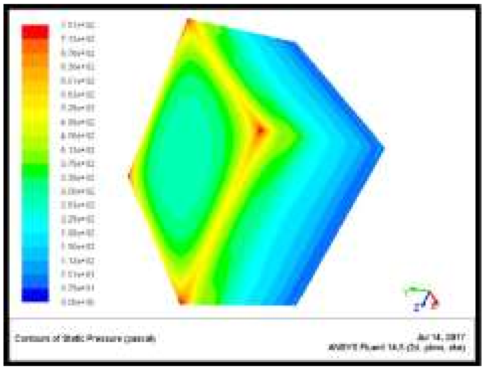
5.2 (a) Meshed model



5.2 (b) Air Inlet 5.2 (c) Air outlet

SPEED – 900 km/hr

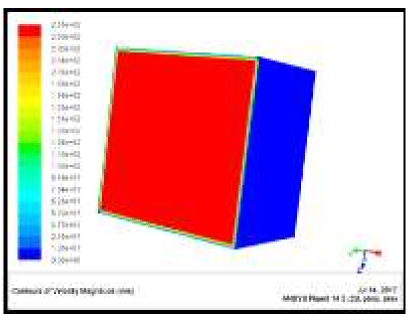
PRESSURE CONTOUR



According to the above contour plot, the maximum static pressure at corner portions of the boundary of inlet and minimum static pressure at the boundary of outlet.

According to the above contour plot, the maximum pressure is 7.51e+02Pa and minimum static pressure is 3.75e+01Pa.

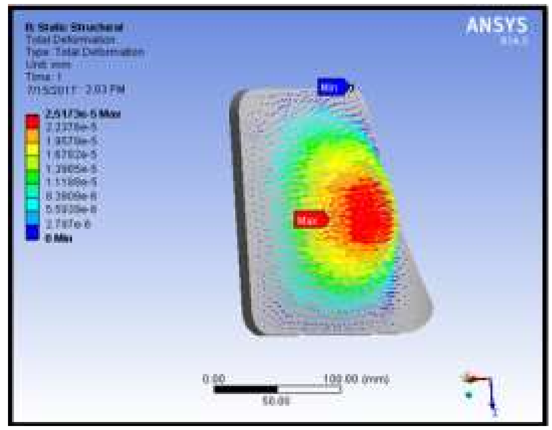
VELOCITY MAGNITUDE



According to the above contour plot, the maximum velocity magnitude of the wind shield at inside of the boundary and minimum velocity magnitude at outside of the boundary. According to the above contour plot, the maximum velocity is 2.51e+02m/s and minimum velocity is 1.28e+01m/s.

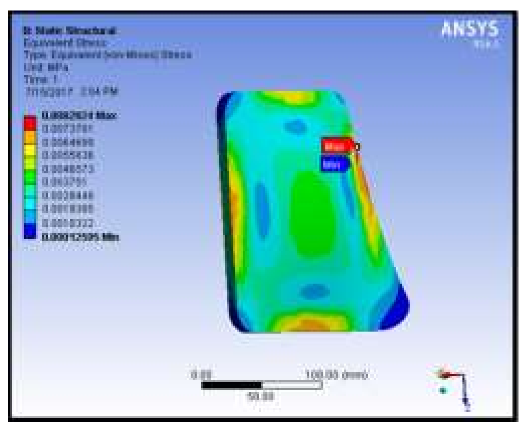
MATERIAL- GLASS

DEFORMATION (at speed 900 km/hr)



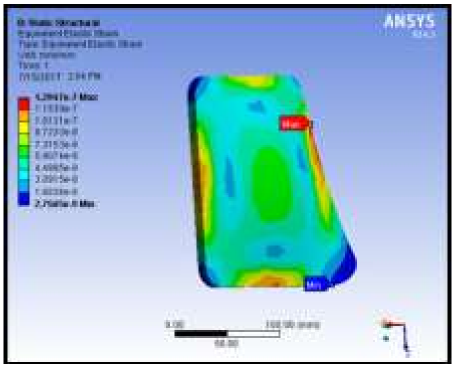
we get to know this technique gives the deformation of the wind shield due to action of opposed air forces developed which is important for accurate performance of the wind shield operation under severe conditions It is observed that there is substantial amount of deformation of the wind shield. When the loads applied i.e. velocity and pressure are imported and applied on wind shield, the maximum deformation value is 2.5173e-5.

STRESS



When the loads i.e. pressure and velocity applied on wind shield, the maximum stress value is 0.0082824MPa at one side of the edge of the wind shield and minimum stress is 0.00012595MPa.

STRAIN



When the loads i.e. pressure and velocity applied on wind shield, the maximum strain value is 1.2947e-7 at one side of the edge of the wind shield and minimum strain is 2.7565e-9.

VI. CFD ANALYSIS RESULTS

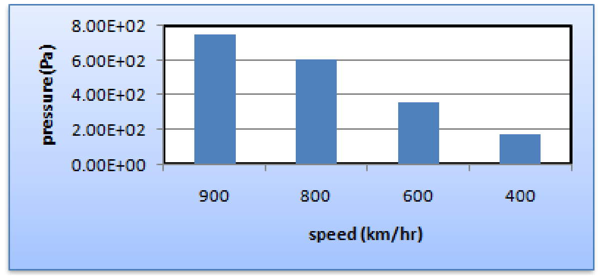
Speed km/hr	Pressure(Pa)	Velocity(m/s)
900	7.51e+02	2.51e+02
800	6.07e+02	2.23e+02
600	3.54e+02	1.67e+02
400	1.66e+02	1.12e+02

STATIC ANALYSIS RESULTS

Speed km/hr	Materials	Deformation(mm)	Stress(MPa)	strain
900	Glass	2.5173e-5	0.0082824	1.2947e-7
	polymethyl methacrylate	3.7746e-6	0.0082039	2.2197e-8
	Poly vinyl butyl	0.000533	0.0082324	3.1699e-6
800	Glass	2.0156e-5	0.0066598	1.041e-7
	polymethyl methacrylate	3.0223e-6	0.0066007	1.7859e-8
	Poly vinyl butyl	0.00042677	0.0066238	2.5505e-6
600	Glass	1.1825e-5	0.0039146	6.1193e-8
	polymethyl methacrylate	1.7731e-6	0.0038801	1.0498e-8
	Poly vinyl butyl	0.00025038	0.0038937	1.4993e-6
400	Glass	5.6415e-6	0.0018608	2.9088e-8
	polymethyl methacrylate	8.4594e-7	0.0018433	4.9874e-9
	Poly vinyl butyl	0.00011945	0.0018498	7.1224e-7

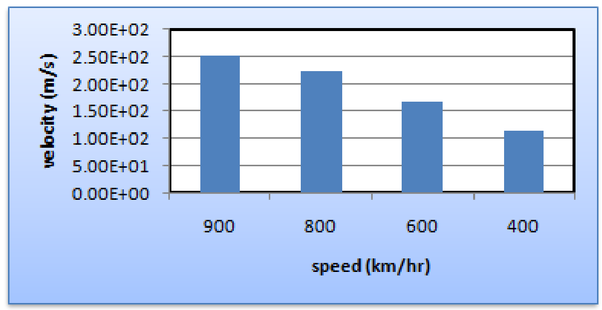
GRAPHS

PRESSURE PLOT



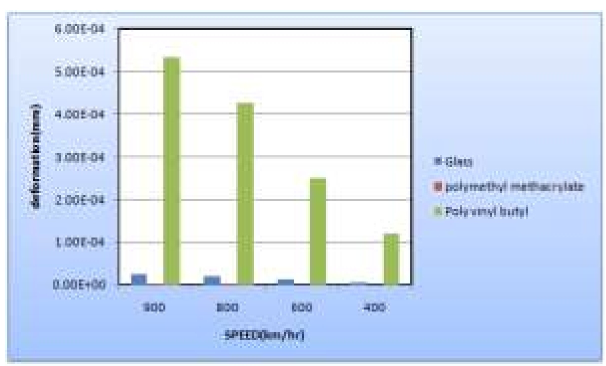
A plot between maximum pressure and speeds by FSI approach is shown in above fig. From the plot the variation of maximum static pressure is observed. Maximum static pressure increases by increasing speeds.

VELOCITY PLOT

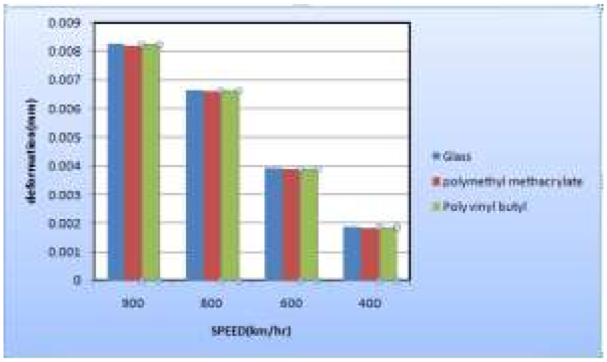


A plot between maximum velocity and speeds by FSI approach is shown in above fig. From the plot the variation of maximum velocity is observed. Maximum velocity increases by increasing in speeds.

DEFORMATION PLOT



STRESS PLOT



CONCLUSIONS

In this report, a windshield for a light trainer aircraft is analyzed by using computational fluid dynamics (CFD) and fluid-solid-interaction (FSI) approach with different air speeds using ANSYS in order to evaluate fluid pressure, stress distribution and deformation. Windshield is modeled in 3D by using software Pro-E Wildfire 5.0. Three different materials like glass, polymethyl methacrylate and poly vinyl butyl were considered to analyze the deformation and stress at various speeds of 900, 800, 600 and 400 km/hr. By observing the CFD analysis results, the pressure and velocity are increasing by increasing air speed.

By observing the CFD analysis the pressure drop and velocity increases by increasing the speed km/hr.

By observing the static analysis, the stress values are decreases by decreasing the speeds, the taken different pressure values are from CFD analysis. The stress value is less for polymethyl methacrylate material than glass and poly vinyl butyl

So we can conclude the polymethyl methacrylate material is better for wind shield.

SCOPE FOR FUTURE WORK:

- The same analysis can be done for the other thermoplastic materials which are less in weight like Polyurethane, polyester, polypropylene.
- The same analysis can be done at other speeds of the aircraft.

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