# MODELLING AND ANALYSIS OF AIRCRAFT WIND SHIELD MADE OF PVB AND PMMA MATERIAL

**Abstract**

The portion of a car, bus, motorcycle, or tram that faces forward is called the windscreen. The windscreen is a crucial component of an airplane and is dependent upon for the functionality of one of its most significant features. Some of the most important characteristics of the windscreen are visibility through the canopy, structure stiffness, impact resistance, dependability of the internal mechanics, and construction lightness. On light training aircraft, glass is the windshield material of choice. It is suggested that the glass be replaced by a light trainer in the current development. In the current experiment, two more materials for windshieldspolymethyl methacrylate (PMMA) and polyvinyl butyl (PVB) were taken into consideration. Pro/Engineer software was used to create a 3D model of the windscreen. ANSYS, the Fluid-Solid-Interaction (FSI) approach, and computational fluid dynamics (CFD) were used in a dynamic simulation to evaluate fluid pressure, stress distribution, and windshield deformation at varied air speeds. Analysis is conducted on all three materials at various air speeds of 900, 800, 600, and 400 km/hr. In this thesis, the pressure, velocity, stress, and deformation are calculated for various materials and speeds using the FSI analysis.

**Keywords:** CFD, PMMA, PVB, FSI Technique, wind shield, ANSYS.

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## I. INTRODUCTION

The windshield or windscreen of an aircraft, car, bus, motorcycle, or tram is referred to as the front window in Commonwealth countries and North America, respectively. The majority of current windshields are composed of laminated safety glass, a type of treated glass, which is fused between two sheets of glass (often curved) for protection and bonded into the window frame. The majority of motorcycle windscreens are made of high-impact acrylic plastic. Windshields provide a front glass that is aerodynamic and protect the car's occupants from flying debris including dust, insects, and rocks as well as the wind. To block harmful ultraviolet rays, the screen's outside may be coated with a UV coating. This is normally not necessary, though, as the majority of car windshields are made of laminated safety glass. The glass absorbs the majority of UV-B rays, while the PVB bonding layer is responsible for most UV-A and the remainder of UV-B absorption. In comparison to a car, a motorcycle's principal function is to shield the rider from the wind. When the rider gets the ideal aerodynamic configuration with his or her body cooperating with the vehicle, the windshield's principal function in sports and racing bikes is to reduce drag. When seated upright, it does not shield the rider from the wind. Various air speeds are utilized in conjunction with computational fluid dynamics (CFD) and fluid-solid interaction (FSI) methods to compare and evaluate fluid pressure, stress distribution, and deformation in wind shields for all 4 materials. In order to determine pressures during stress study, air speeds of 900, 800, 600, 555, and 400 km/hr were applied to the windshield during fluid analysis.

## II. MATERIALS AND METHODS

A dynamic simulation was conducted using ANSYS, the Fluid-Solid-Interaction (FSI) method, and computational fluid dynamics (CFD) to assess fluid pressure, stress distribution, and windshield deformation at various air speeds. All three materials are subjected to analysis at varying air speeds of 900, 800, 600, and 400 km/hr. In the current experiment, backup materials such as polymethyl methacrylate and polyvinyl butyl for windshields were taken into consideration. A 3D model of the windscreen was produced with the use of Pro/Engineer software.

**Table 1: ANSYS Parameters**

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

"Fluid-structure interaction" (FSI) is a method for combining the laws controlling fluid dynamics and structural mechanics. The interaction of a deformable or moving structure with an internal or external fluid flow—which may be steady or oscillatory is what causes this phenomenon. A solid is put under pressures and strains that could deform it when a fluid flow interacts with a structure. Depending on the pressure, velocity, and material composition of the flow, these deformations can range from fairly big to very little. As long as the temporal fluctuations are also very gradual and modest, the behavior of the fluid won't be considerably impacted by the stresses that result from the deformations of the structure.

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However, even minor structural deformations will cause pressure waves in the fluid if the time variations are rapid—greater than a few cycles per second. These pressure waves cause structures to shake, which creates sound. Instead of considering these problems as fluid-structure interactions, consider them as acoustic problems.  A bi directionally coupled multi physics analysis is required to find a solution since the fluid's velocity and pressure fields will be altered by the structure's significant deformation. Fluid pressure affects structural deformations as well as the fields of flow and pressure.

## III. RESULTS AND DISCUSSIONS

As seen in the fig.1 and 2, finite element analysis (FEA) represents an actual project as a "mesh" made up of a number of little, connected, regularly formed tetrahedrons. After which enormous arrays of simultaneous equations are built up and solved. The results are more precise as the mesh is finer, but more processing power is needed. The input parameters cannot be used directly in CFD. As a result, boundary conditions for air entry and air outflow must be established. right-click, create named section, input name, choose faces, and then click the air inlet right-click, create named section, input name, select faces, and then click the air outlet.

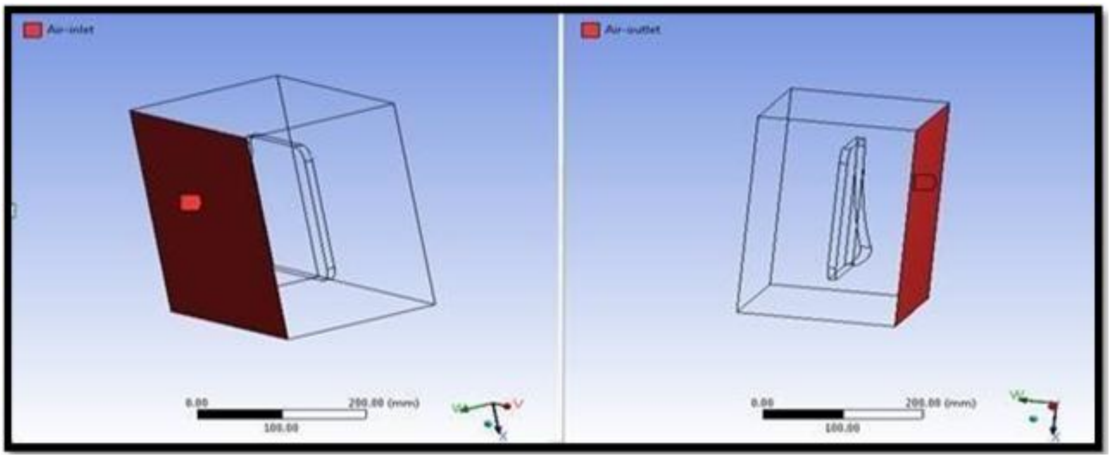

**Figure 1:** Air Inlet　　　　**Figure 2:** Air Outlet

Project update>model setup>edit model selection>energy equation (on)>ok Choose a fluid substance or specify parameters in Materials> Materials > new >create or update > OK. Choose a liquid. put the necessary inlet values after boundary conditions and inlet. Speed of the inlet air

**Table 2: Boundary Conditions**

| Speed | Velocity |
|---|---|
| 900 km/hr | 250 m/s |
| 800 km/hr | 222 m/s |
| 600 km/hr | 166 m/s |
| 400 km/hr | 111 m/s |

Temperature=313K and pressure=101325Pa

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Hybrid Initialization > Solution Initialization > Done
Calculate; set the number of iterations to 100; calculate; and then click "OK"
Results>edit>select contours>ok>select a location (such as an outlet or a wall)>select pressure>apply

1. **Counter of Pressure:** The corners of the border of the intake are where static pressure is highest, and the boundary of the outflow is where static pressure is lowest, as seen by the contour map above. The maximum static pressure is 7.51e+02Pa, and the minimum static pressure is 3.75e+01Pa, according to the contour map above.

2. **Magnitude for Velocity:** According to the contour map above, the wind shield's maximum velocity magnitude is inside the border and its minimum velocity magnitude is outside. The contour figure above shows that the maximum velocity is 2.51e+02m/s and the minimum velocity is 1.28e+01m/s.

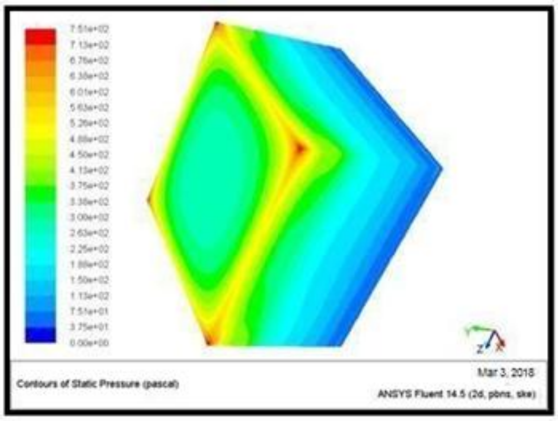


**Figure 3:** Pressure Counter

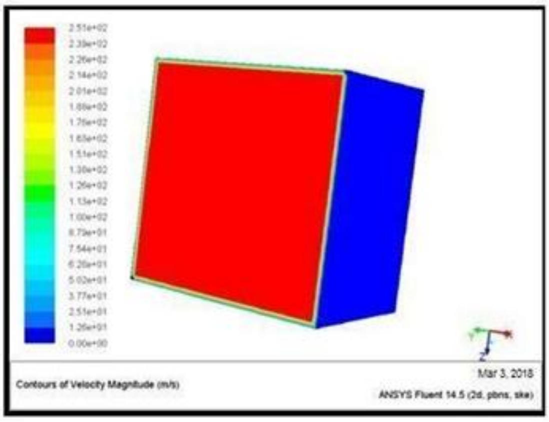


**Figure 4:** Velocity Magnitude

3. **Deformation:** This method produces the distortion of the wind shield caused by opposing air forces, which is necessary for the wind shield to operate precisely under difficult circumstances. It has been noted that the wind shield has significantly deformed. When the applied loads, namely velocity and pressure, are imported and placed on the wind shield, the maximum deformation value is 2.5173e-5. The wind shield's edge receives the highest stress value of 0.0082824MPa and the lowest stress value of 0.00012595MPa when the stresses of pressure and velocity are applied. The greatest strain value at one edge of the wind shield is 1.2947e-7, and the minimum strain is 2.7565e-9 when the stresses, such as pressure and velocity, are applied.

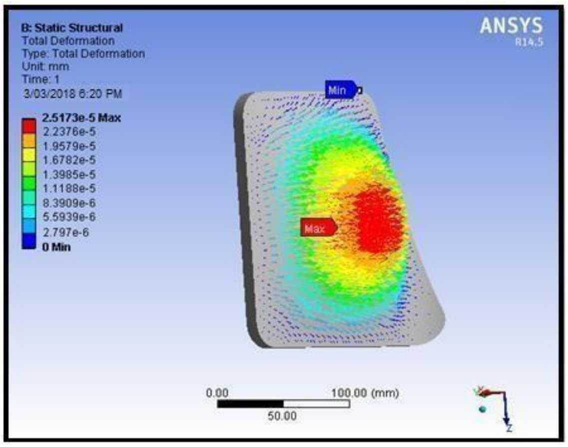


**Figure 5:** Deformation in Glass Material

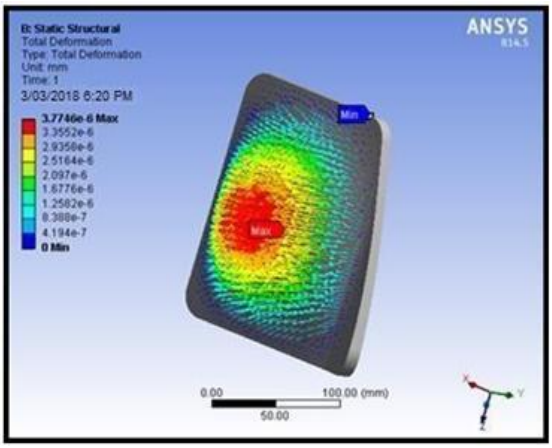


**Figure 6:** Deformation in Polymethyl Methacrylate (PMMA)

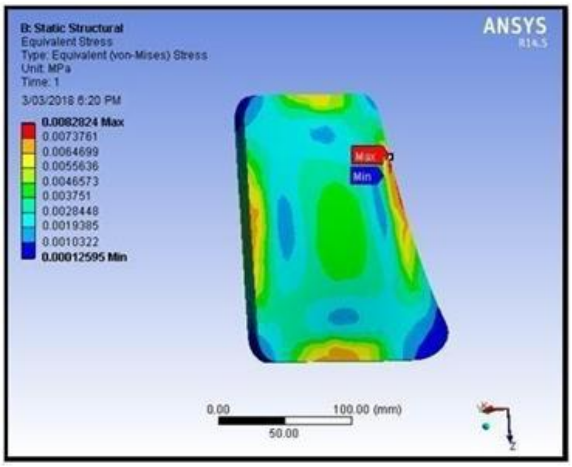


**Figure 7:** Maximum Stress

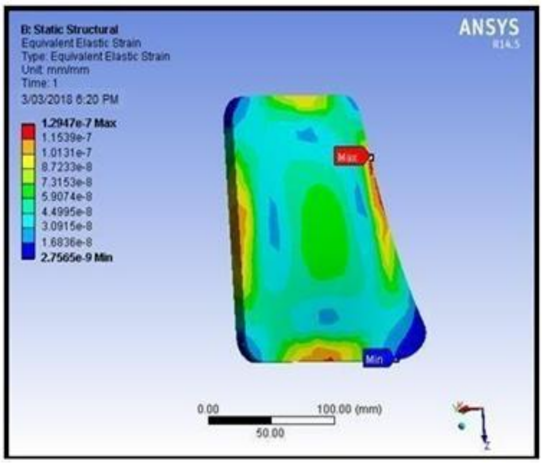


**Figure 8:** Maximum Strain

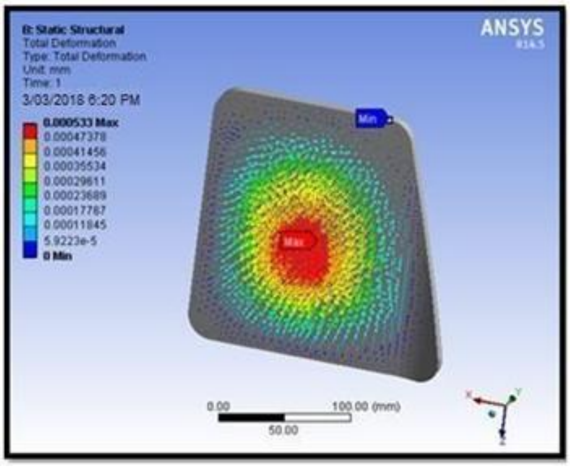


**Figure 9:** Deformation in Poly Vinyl Butyl material(PVB)

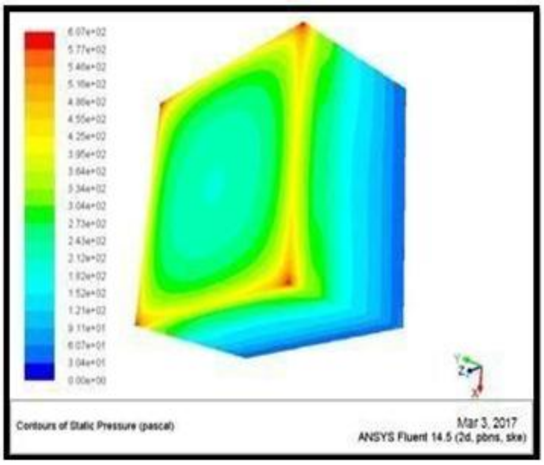


**Figure 10:** Pressure Contour

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**Table 3: CFD Result Table**

| Speed | Pressure | Velocity |
|---|---|---|
| 900 km/hr | 7.51e+02 pa | 2.51e+02 m/s |
| 800 km/hr | 6.07e+02 pa | 2.23e+02 m/s |
| 600 km/hr | 3.54e+02 pa | 1.67e+02 m/s |
| 400 km/hr | 1.66e+02 pa | 1.12e+02 m/s |

**Table 4: Structural Analysis Table with Stress and Strain Values**

| Speed km/hr | Material | Deformation Values in mm | Stress values | Strain values |
|---|---|---|---|---|
| 900 | Glass material | $2.5173e^{-5}$ mm | 0.00828 mpa | $1.2947e^{-7}$ mpa |
| | PMMA | $3.7746e^{-6}$ mm | 0.00820 mpa | $2.2197e^{-8}$ mpa |
| | PVB | 0.000533 mm | 0.00823 mpa | $3.1699e^{-6}$ mpa |
| 800 | Glass material | $2.0156e^{-5}$ mm | 0.00665 mpa | $1.041e^{-7}$ mpa |
| | PMMA | $3.0223e^{-6}$ mm | 0.00660 mpa | $1.7859e^{-8}$ mpa |
| | PVB | 0.00042677 mm | 0.00662 mpa | $2.5505e^{-6}$ mpa |
| 600 | Glass material | $1.1825e^{-5}$ mm | 0.00391 mpa | $6.1193e^{-8}$ mpa |
| | PMMA | $1.7731e^{-6}$ mm | 0.00388 mpa | $1.0498e^{-8}$ mpa |
| | PVB | 0.00025038 mm | 0.00389 mpa | $1.4993e^{-6}$ mpa |
| 400 | Glass material | $5.6415e^{-6}$ mm | 0.00186 mpa | $2.9088e^{-8}$ mpa |
| | PMMA | $8.4594e^{-7}$ mm | 0.001843mpa | $4.9874e^{-9}$ mpa |
| | PVB | 0.00011945 mm | 0.001849 mpa | $7.1224e^{-7}$ mpa |

4. **Pressure Plot:** Figure 11 above depicts a plot between maximum pressure and velocity using the FSI technique. The graphic shows the fluctuation in the maximum static pressure. Speed increases result in a rise in maximum static pressure.

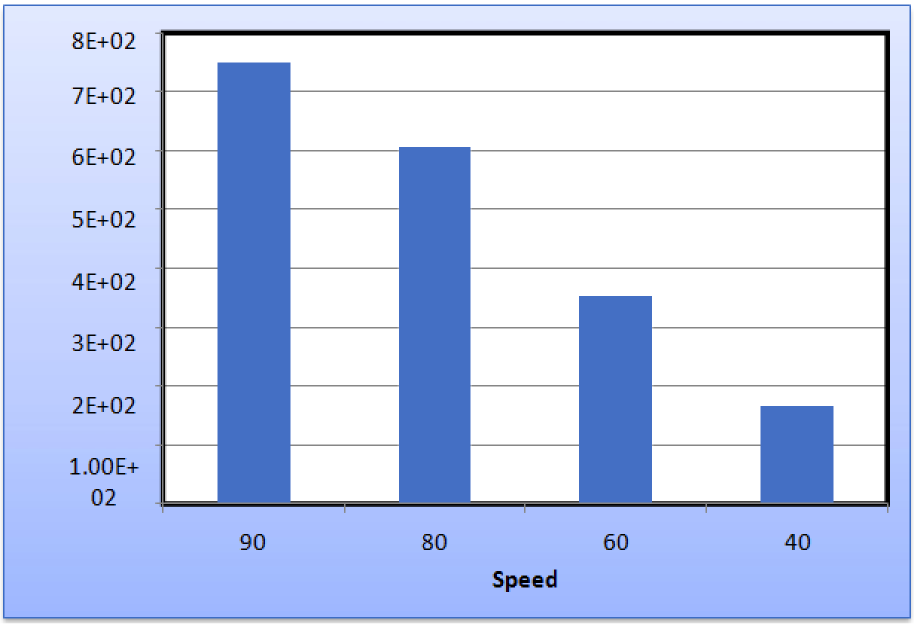


**Figure 11:** Pressure plots at various speeds (Pressure vs Speed)

5. **Velocity Plots:** The FSI approach is used to exhibit the relationship between maximum velocity and speeds in Figure 12. The graph displays the maximum velocity's variation. As speed increases, maximum velocity also rises.

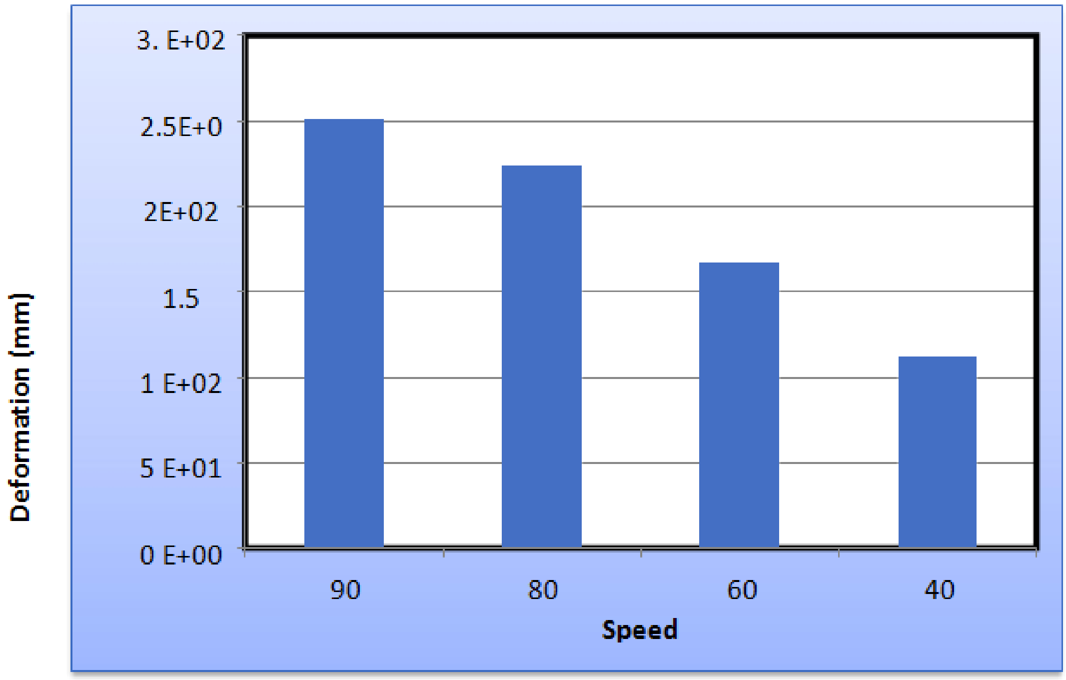


**Figure 12:** Velocity Plots (Velocity vs Speed)

## IV. CONCLUSION

In order to assess fluid pressure, stress distribution, and deformation, a windscreen for a light trainer aircraft is examined in this work utilizing computational fluid dynamics (CFD) and a fluid-solid interaction (FSI) technique at various air speeds using ANSYS. The Pro-E Wildfire 5.0 software was used to create the windscreen's 3D model. Glass, poly methyl methacrylate, and poly vinyl butyl were the three materials that were taken into consideration to assess the deformation and stress at varied speeds of 900, 800, 600, and 400 km/hr. According to the CFD study's findings, pressure and velocity rise as air speed does. The CFD research shows that when speed increases, velocity likewise increases but pressure decreases. The static analysis shows that lowering the speeds lowers the stress values, and the varied pressure values are gathered through the CFD study. Compared to glass and poly vinyl butyl, poly methyl methacrylate material has a lower stress value. In light of this, we may say that poly methyl methacrylate is a better material for wind shields.

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