BIRD STRIKE ANALYSIS ON AIRCRAFT WINDSHIELD

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ABSTRACT

This research title concerns in developing the Windshield with greater strength. Since the physical testing on bird strike is expensive, consumes more time. The simulation are carried out in the NASTRAN, PATRAN analysis, In that the bird is taken as a Force using software and strikes on aircraft windshield. With the help of simulation, the von mises tress, forces, time and displacement are obtained as a result. The Detailed CAD geometry of the windshield is modeled in CATIA V5 R19, Meshing in the NASTRAN PATRAN. The results obtained from the simulation are compared with the data and the process is validated. It has been suggested that the results obtained from simulation can be utilized in the initial design stages as well as for certification of an Aircraft for Bird strike requirements as per rules of Federal Regulations.

Key words: Aircraft Windshield, Displacement, Von-mises stresses, Forces, Time.


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1. INTRODUCTION

Bird strikes is considered to be a major concern from the early days of powered flight for safety aviation. As a result of bird strike, first accident happened in 1912 that was occurred when the flyer experienced a flock of gulls while conducting a demonstration of flight. The investigation made had found that one of the gulls had jammed the rudder control that causes the aero plane to dive into the surf, breaking the pilot’s neck. Since 1912 it has been predicted that 47 fatal accidents have occurred due to a bird strike involving commercial air transports. The total number of fatalities is about 242 people and 90 hulls lose. The total number of fatal incidents in military navigation is believed to be much higher when compared with commercial air transport.
Thus the crashed surface of an aircraft is said to be unloaded; the effect that is caused because of preloading on the impact behavior has great significance\(^1\). In past years it has been a familiar process for bird-proof designing of aircraft components that has to be built and tested, then again redesigned and tested\(^2\). Composite materials are well known in order to show its increased stiffness or strength properties under highly dynamic loaded conditions. The exterior aircraft system, foreign object damages such as hail, runway debris or impact of tire rubber about 90% of all these accidents that occur today are been reported is mainly occurred by bird strike\(^3\).

The contact algorithm that has to match with large deformations and splitting of the projectile, sliding of the bird material over the target surface and the creation of multiple contact interfaces due to its possible fracture and structure penetration. Based on continuum damage mechanics and stiffness degradation, nonlinearities are taken into account in increasing the damage which is caused due to micro level cracks under load\(^4-6\).

2. DESIGN CONSIDERATION

![Figure 1](image1.png) Front view of a wind shield  ![Figure 2](image2.png) Top view of a wind shield  

![Figure 3](image3.png) Side view of a wind shield  ![Figure 4](image4.png) Isometric view of a wind shield

Fig. 1, 2, 3 & 4 represents the Front view, Top view, Side view and Isometric view of a wind shield has been modeled using CATIA.
2.1. Meshed File

The wind shield has been meshed with equal intervals to achieve the result in periodic manner which is shown in the Fig. 5

3. BOUNDARY CONDITIONS

3.1. Material Property

Polyethylene Terephthalate : PET is a material which has its stiffness, light weight, glass-reinforced resin offering the process to be easier that can possess its high ability performance in parts. PET is also clear, tough, and shatter proof which is identified to be used as a barrier to oxygen, water and carbon dioxide and is identified.

<table>
<thead>
<tr>
<th>Table 2 Material Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength($\sigma_t$)</td>
</tr>
<tr>
<td>Elastic limit</td>
</tr>
<tr>
<td>notch test</td>
</tr>
<tr>
<td>Glass transition temperature</td>
</tr>
<tr>
<td>Vicat B</td>
</tr>
<tr>
<td>linear expansion coefficient</td>
</tr>
<tr>
<td>Water absorption (ASTM)</td>
</tr>
</tbody>
</table>

2D properties have applied to the meshed model. 2D shell elements are given to the wind shield. Load and boundary condition have to wind shield section. Edges of the wind shield are fixed using displacement constraint and load is applied as nodal force. Force is calculated for bird strike from mass of the bird and velocity at which it is hitting.

After applying loads and materials properties are applied in NASTRAN. PATRAN gives us a different type of analysis like linear static non-linear thermal.
For wind shield linear static analyses have been done to find out loads, Solution sequence is 101. BDF file is created, it consists of information like elements grid or node spc and the property of material load and its boundary condition. BDF of bulkhead and then the run command is shown below. The analysis is made and the results is achieved as shown in the figure.

4. RESULT AND DISCUSSION
4.1. Linear Static Analysis for Windshield

![Figure 8 Maximum Principal Stress 114 N/mm²](image1)

![Figure 9 Maximum Principal Stress -0.0181 N/mm²](image2)

![Figure 10 Maximum Shear Stress 6.21 N/mm²](image3)

![Figure 11 Von mises stress 10.9 N/mm²](image4)
4.2. Linear Static Analysis for Acrylic

**Figure 12** Displacement the maximum displacement 1.35 mm

**Figure 13** maximum principal stress 0.386 N/mm²

**Figure 14** Minimum principal stress 0.0152 N/mm²

**Figure 15** Maximum Shear Stress the maximum shear stress 0.427 N/mm²

**Figure 16** Von mises stress The von mises stress at wind shield 0.779 N/mm²
4.3. Result Validation

The result is validated based on material ultimate strength with R.F = ultimate strength/obtained stress

- Component fails - R.F value < 1.
- Component is safe - R.F value is > 1 to 1.5.
- Component is too safe - R.F value is > 1.5.

<table>
<thead>
<tr>
<th>Type of stress (N/mm²)</th>
<th>Ultimate stress (N/mm²)</th>
<th>Obtained stress (N/mm²)</th>
<th>R.F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. principal</td>
<td>65</td>
<td>11.4</td>
<td>5.7</td>
</tr>
<tr>
<td>Max. shear</td>
<td>39</td>
<td>6.21</td>
<td>6.2</td>
</tr>
<tr>
<td>Von mises</td>
<td>65</td>
<td>11</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Table 3 R.F (wind shield) PET (30% Glass Reinforced)

<table>
<thead>
<tr>
<th>Type of stress (N/mm²)</th>
<th>Ultimate stress (N/mm²)</th>
<th>Obtained stress (N/mm²)</th>
<th>R.F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. principal</td>
<td>80</td>
<td>38.6</td>
<td>2.07</td>
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<tr>
<td>Max. shear</td>
<td>48</td>
<td>42.7</td>
<td>1.21</td>
</tr>
<tr>
<td>Von mises</td>
<td>80</td>
<td>72.9</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Table 4 R.F (wind shield) Acrylic

<table>
<thead>
<tr>
<th>Type of stress (N/mm²)</th>
<th>RF Value for PET</th>
<th>RF Value for Acrylic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. principal</td>
<td>5.7</td>
<td>2.07</td>
</tr>
<tr>
<td>Max. shear</td>
<td>6.2</td>
<td>1.21</td>
</tr>
<tr>
<td>Von mises</td>
<td>5.9</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Table 5 RF value comparison table

5. CONCLUSIONS

Glass materials are very brittle and require little energy to create the first failure in the material. Just to create a safety product, union of the acrylic material is added to the glass material that increases the safety possibility. The interlayer of the glass retains the fragments and this avoids the propagation. Due to double curvature of the surface, windshield geometric shape and the impact angle reducing factors of the effects of the bird strike. Damage is reduced by increasing the certification requirement in an effective way.
REFERENCES


