IMPACT SIMULATION ON THE REAL PART OF AIRCRAFT STRUCTURES

Radek Doubrava
VZLU a.s., Czech Republic
**Aim:** prediction of the impact behavior of hard and soft body immediately after the impact to part of aircraft structures.

- **Description of problem**

- **Projectile impact**
  - Measurement
  - FE simulation
  - Comparison between measurement and FE simulation

- **Bird strike**
  - Measurement
  - FE simulation
  - Comparison between measurement and FE simulation

- **Conclusions**
Description of problem

In the service of an aircraft has been possibility risk of emergency cases from point of view unforeseeable circumstances (e.g. bird strike, sucked impurities to the engine etc.), or owing to human factor (e.g. projectile, missiles etc).

http://en.wikipedia.org/wiki/Bird_strike
Projectile Impact

Aircraft surface scanning

ATOS measurement

Result of scanning

Comparison between real damage and non-damage (CAD) surface
Projectile Impact

Numerical simulation

**Material:** 2024-T3

<table>
<thead>
<tr>
<th>Elastic</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>74000 MPa</td>
<td></td>
</tr>
<tr>
<td>ν</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Johnson-Cook constants</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ρ</td>
<td>2.77E-09 t/mm³</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>368.9 MPa</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>683.9 MPa</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.0083</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>D_1</td>
<td>0.112</td>
<td></td>
</tr>
<tr>
<td>D_2</td>
<td>0.123</td>
<td></td>
</tr>
<tr>
<td>D_3</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>D_4</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>D_5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Elastic Johnson-Cook constants**

**Elastic Johnson-Cook failure**

**Model of real projectile**

**FE model**

**Results of FE simulation**

**Results of FE simulation**

**Impact velocity [m/s]**

**Residual velocity [m/s]**

**Projectile velocity [m/s]**

**Impact velocity [m/s]**

**Time [s]**
Comparison between measurement and FE simulation

Measurement

FE simulation

Skin results between ribs.

Leading edge results.
Bird strike
Test Method and Facility

<table>
<thead>
<tr>
<th>Diametr of muzzle [mm]</th>
<th>length of muzzle [m]</th>
<th>weight of bird</th>
<th>velocity of bird [km/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>25</td>
<td>2lb (0,91kg)</td>
<td>650</td>
</tr>
<tr>
<td>125</td>
<td>25</td>
<td>4lb (1,81kg)</td>
<td>450</td>
</tr>
</tbody>
</table>
Bird strike

**FE simulation**

- The ABAQUS/Explicit has been used for impact simulation onto the part of aircraft structure.

- The bird for sharp parts such as pitot probe was modeled as a cylinder with refine mesh on the contact surface for point of view some numerical singularities elimination. For oblique parts has been used standard bird model (cylinder with spherical ends).

- In the simulation, the bird adopts an elastic-plastic model with shear and tensile failure.
  - *TENSILE FAILURE*
  - *SHEAR FAILURE*

- The bird nodes are charged with an initial velocity.
Bird strike

Pitot probe

Bird mass = 2lb (0.91kg)
Velocity = 180 m/s (648 km/h)
Bird strike

Windshield glass of civil aircraft

Bird mass = 4 lb (1.82 kg)
Velocity = 300 - 450 km/h
Bird strike
Windshield glass of military aircraft

Bird mass = 4 lb (1.82 kg)
Velocity = 300 - 450 km/h
Future works

- Development of the new synthetic model of bird with inner skeleton stiffness simulation
- Simulations will be increased about CEL (Coupled Eulerian – Lagrangian) technique
- Improve boundary conditions (frame, gasket etc.)
- Improve material properties
Conclusions

The result shows good agreement between measurement and FE calculation. Although this work is only a first approximation, and implemented in relatively simplified terms, this method of finding damage propagation is applicable for:

- diagnostics of airframe damage - scanning of aircraft surface, photogrammetric system application etc.
- application for structure repair evaluation – damage of inner structure, composite path application etc.
- service operations – visual inspection
- performance of airworthiness from point of view bird strike
Thank you for your attention