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Crash behavior of telescopic crash box with aluminum foam

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2015 September 01
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BEYÇELİK GESTAMP

TOOLING PLANT
&
R&D CENTER

GEBZE CHASSIS PLANT

AUTOMOTIVE PLANT

10,000 m²

16,000 m²

60,000 m²

HOT STAMPING & G1 PLANTS

ASSEMBLY PLANT
&
STEEL CENTER

10,000 m²

22,500 m²

DIE and AUTOMOTIVE PARTS PRODUCTION INDUSTRY COMPANY
BEYÇELİK GESTAMP

Customers & References

- Fiat
- TOFAŞ
- Ford
- Otosan
- Dacia
- Automoción Gestamp
- Toyota
- Renault
- Volvo
- Audi
- Volkswagen
- PSA Peugeot Citroën
- Maserati
- BMW
Thin-walled tubular structures behind the bumpers of vehicles protect passengers and the structure during the impact.

**Fig.1** Frontal Impact
The bumper deforms first, then the following component deforms until the all energy is absorbed.

**Fig. 2** Division of crash force transmission
Thin-walled structures absorb most of the crash energy with a progressive folding deformation.

Fig. 3 Under Body Crash Force Transmission
Crash Box is a part which is usually advanced of the rails that should collapse at relatively low force to absorb energy in a controlled way [1].
In this study, aluminum foam effect of the crashworthiness behavior analyzed on the telescopic crash box geometry.

The geometric models were modeled with CATIA.

The post processing of the FEA models were prepared Hyper Mesh.

The crash simulations were performed with LS-DYNA.
The behavior of the crash box has been studied by simulating the impact of a rigid barrier.

**Fig.5**. Impact model and true stress-strain diagram of material
### 3. Finite Element Model

#### Table 1. Rigid Barrier Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Abbreviation</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid Barrier Velocity</td>
<td>v</td>
<td>15600</td>
<td>mm/s</td>
</tr>
<tr>
<td>Rigid Barrier Mass</td>
<td>m</td>
<td>0.36</td>
<td>t</td>
</tr>
<tr>
<td>Dynamic Friction Coefficient</td>
<td>$F_D$</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Static Friction Coefficient</td>
<td>$F_S$</td>
<td>0.1</td>
<td></td>
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</tbody>
</table>
### Table 2. DP600 Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Abbreviation</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>$\rho$</td>
<td>7.85x10^{-9}</td>
<td>g/m³</td>
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<tr>
<td>Yield Stress</td>
<td>$\sigma_{ak}$</td>
<td>390</td>
<td>MPa</td>
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<tr>
<td>Young’s Modulus</td>
<td>$E$</td>
<td>210000</td>
<td>MPa</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>$\nu$</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>$t$</td>
<td>1.5</td>
<td>mm</td>
</tr>
<tr>
<td>Parameter</td>
<td>Abbreviation</td>
<td>Value</td>
<td>Unit</td>
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<tr>
<td>Density</td>
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<td>$1.11 \times 10^{-9}$</td>
<td>g/m$^3$</td>
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<tr>
<td>Young’s Modulus</td>
<td>$E$</td>
<td>1100</td>
<td>MPa</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>$\nu$</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Yield Stress</td>
<td>SIGP</td>
<td>0.777</td>
<td></td>
</tr>
</tbody>
</table>

*Table 3. Al-Foam Properties*
Fig. 5. Undeformed, deformation characteristics and section view for empty telescopic crash box (deformed time=10 ms)
Fig.5. Undeformed, deformation characteristics and section view for aluminum foam filled crash box (deformed time=10 ms)
Fig. 11. Comparison of Kinetic Energy for with and without aluminum foam
• In order to maximize the absorbed energy, new telescopic box geometry with aluminum foam-filled is analyzed.
• It is revealed that aluminum foam filled crash box energy absorption capability is %47 higher than the empty one.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Total Absorbed Energy</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Crash Box</td>
<td>8.81</td>
<td>kJ</td>
</tr>
<tr>
<td>Aluminum Foam Filled Crash Box</td>
<td>13.57</td>
<td>kJ</td>
</tr>
</tbody>
</table>

Table 4. Total Absorbed Energies
Fig.10. Comparison of Reaction Force for with and without aluminum foam
The initial reaction force of the aluminum foam filled telescopic crash box profile %34 higher than the empty telescopic crash box profile.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Initial Reaction Force</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Crash Box</td>
<td>183</td>
<td>kN</td>
</tr>
<tr>
<td>Aluminum Foam Filled Crash Box</td>
<td>245</td>
<td>kN</td>
</tr>
</tbody>
</table>

*Table 4. Initial Reaction Forces*
Numerical simulation’s show that in terms of achieving maximum energy absorption, telescopic crash geometry and filling the box with aluminum foam can be preferable to thickening the box wall.


Steel is not Cold for Us!!!