« Development and evaluation of a new rider airbag safety system for thorax protection »

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Motorcycle

< 1% of the traffic but 15 % of deaths

1981 (NHTSA, Los Angeles area), nearly 4,500 motorcyclist crashes analysed [1]:
   - Injuries to the chest and head = the most deadly injuries
   - No effective security systems to prevent or reduce thoracic injuries

2002, a study performed by Krauss confirmed these observations [2]:
   - Safety helmet allowed reducing severe head injuries
   - But little safety systems to reduce the severity of thoracic injuries

1996 -> 2003 (Rhone Road Trauma Registry in France) [3]:
   - 50% of severely injured riders due to severe chest injuries
   - 44.8% suffer from severe head injuries
- Motocycle airbag
  (source Honda)

- Airbag jacket
  (source Helite)

Drawbacks:
- Trigger time
- Cable connection

Objectives:
- Improving passive safety of motorcycles
- Evaluate a new safety system
ANR-Predit PROMOTO Project

Introduction

Accidentology, Experimental (subsystem tests and crash tests) and numerical (Multibody and FEM) approaches

- DD (Bron)
- LBA (Marseille)
- UMRESTTE (Bron)
- MA (Salon)

Development of the physical airbag

Numerical approach: FEM
Materials & Methods

Test configurations

- Numerical simulations performed with the HUMOS model (with and without airbag)
- HUMOS project : 50th percentile European Human Model (1998-2001)
- HUMOS model : local (subsystem tests) and global (sled tests) validation [4-7]

2 different configurations

• **Configuration 1**
  - Impact on the lower sternum
  - Impact speed : 12, 16, 19 km/h
  - Impactor: flat pendulum (mass 12kg) perpendicular to the impact area

• **Configuration 2**
  - Impact on the upper sternum
  - Impact speed : 10, 20, 30, 40 km/h
  - Impactor : flat pendulum (mass 12kg) parallel to the impact area
Analysis method

- Evaluation of the applied load
- Evaluation of the chest deflection
- Evaluation of the injury report based on the AIS

\[ \text{AIS} = -3.78 + 19.56 C \]

\[ C = \% \text{ chest compression} \]

\[ \text{[Kroell and al., 1971,1974]} \]

Note: Correspondence between AIS and rib fractures [9]

<table>
<thead>
<tr>
<th>AIS</th>
<th>Rib Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 rib fracture</td>
</tr>
<tr>
<td>2</td>
<td>2-3 rib fractures</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 3 on one side &lt;= 3 on the other side</td>
</tr>
<tr>
<td>4</td>
<td>&gt; 3 rib fractures on the both side, flail chest</td>
</tr>
<tr>
<td>5</td>
<td>bilateral flail chest</td>
</tr>
</tbody>
</table>
Inflation of the airbag

Airbag pressure = 1.4 bar
Kinematics Comparison

Rib stress comparison

Results
Comparison of maximum applied load, with and without airbag

- $F_{\text{max}}$ decrease of 32 and 21% respectively for $V = 12$ and 16 km/h, with airbag
- $F_{\text{max}}$ decrease only of 1.5% $V = 19$ km/h, with airbag
Configuration 1

Comparison of maximum chest deflection, with and without airbag

- Strong decrease of chest deflection for the 3 impact speeds, with airbag
- At 19 km/h, 10 mm deflection with airbag against 40 mm, without airbag
Comparison of injury assessment, with and without airbag

- Same injury report with and without airbag for low impact speeds (<16 km/h) – AIS ~ 0
- Minor injury report at 19 km/h
  
  AIS = 1.3 without airbag
  AIS = 0 with airbag

AIS in case of perpendicular pendulum position for each impact speed
Comparison of maximum applied load, with and without airbag

- $F_{\text{max}}$ decrease of 50, 32 and 21% respectively for $V = 10$, 20 and 30 km/h with airbag
- $F_{\text{max}}$ decrease only of 5% for $V = 40$ km/h with airbag

Maximul load of pendulum in lateral position for each impact speed
Configuration 2

Comparison maximum of chest deflection, with and without airbag

- Strong decrease of chest deflection for impact speed between 10 to 30 km/h with airbag
- At 30 km/h, deflection close to 10 mm with airbag against 40 mm without airbag
- For test with airbag at 40 km/h, strong increase of the chest deflection (more than 3 times) as compared to the test at 30 km/h
Comparison of injury assessment, with and without airbag

- At 30 km/h without airbag, serious injury report (AIS = 5+) as compared to the test with airbag (no injury observed, AIS = 0)

- At 40 km/h with airbag, injury report not null (AIS = 1.8, one or two rib fractures) but largely decreased as compared to the test without airbag (AIS = 5+, bilateral flail chest)
Discussion

Configuration 1

• Applied load strongly decrease with airbag (impact energy dissipated) until 16 km/h
• No injury was observed when the airbag was used

Configuration 2

• Applied load strongly decrease with airbag until 30 km/h (31%)
• At 40km/h the applied load with and without airbag are similar
• Chest deflection strongly decrease at 30 km/h (80%) and 40 km/h (47%) with airbag
• Chest deflection strongly decrease => Good injury assessment: AIS = 0 up to 30 km/h and AIS < 2 in the case of impact at 40 km/h

Airbag fully plays its role

Notes: Impact speeds are in agreement with the ones estimated by Hurt [1981].
- Median pre-crash landing speed was estimated to 29.8 mph
- Median crash landing speed closed to 21.5mph (35 km/h).
Conclusion & Future Works

• The main objective was:
  - To develop and evaluate the benefit of an integrated airbag jacket

• According to our results:
  - Using the applied load on the chest as unique injury criterion raises strong limitations
  - Benefits of the airbag for the biker (AIS = 0) seem significant

• Future works
  - Perform other tests to extend the model validation
  - Evaluate the airbag in a whole accident car/motorcyclist configuration

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References


