FFI

MCB technology – Neck injury research for frontal impacts

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

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1. Executive summary

The goal of the project was to verify the need of additional protection with regards to whiplash related injuries in frontal collisions, evaluate new criteria developed to assess risk of whiplash in frontal collisions and evaluate the injury reducing potential of new airbag technology.
Accident data studies performed by Kullgren et al. at the department of public health – Karolinska Institutet, provided input on influence of crash severity measures on long term neck injury risks in frontal impacts based on cases with crash recorder data. The results show that occupants reporting neck symptoms in average were exposed to a higher impact severity than those not reporting neck symptoms. Further, occupants reporting long term symptoms were in average exposed to higher impact severity as compared to the whole group of occupants reporting symptoms. The majority of occupants reporting symptoms lasting more than 1 month were exposed to impacts of deltaV 10-40km/h and mean acceleration 2,5-10g. At approximately 40km/h and 10g a temporary decline in injury risk is seen. This is likely to be due to the positive effect of airbags, belt pretensions and load limiters. The study also indicate a higher risk for drivers as compared to front seat passenger and higher risk for females as compared to males, confirming other studies.This study provides important input to the project and together with Volvo Cars inhouse data base analyses to the requirement development process at Volvo Cars.

The project also included evaluation of new airbag technology. The aim of the MCB (Multi Cell Bag) is to create an airbag with tailored characteristics by means of multiple cells to enable a better balance between head / neck and torso.
During a crash the occupant loads into the airbag. The airbag applies forces on the occupant, these forces consist of 2 main parts:
1. Forces created by internal airbag pressure acting directly on the impacting body surface.
2. Membrane forces created by strain in the airbag fabric caused by pressure acting on various parts of the airbag.
The functionality of the MCB technology is to control the membrane forces through geometrical constraints thereby creating different forces on different body regions.
This cerates additional tuning parameters in system development to achieve a better balance between head/neck and torso.

During the project several successful test methods were developed or adapted to enable:

- Volume measurement of advanced airbag geometries.
- Measure response of MCB. (to determine force response on different body regions)
- Component methods to determine/verify airbag geometry
- Production methods to efficiently produce advanced airbag geometries.

Some of these methods are being evaluated further and considered to be implemented in development of conventional airbags.

The project also included a large amount of testing, both on component and system level. Component testing showed that the MCB technology provided the expected effect on reducing membrane forces and that the forces can be controlled differently in different regions of the airbag. This performance is a prerequisite to achieve a controlled balance between head/neck and torso and a positive result of the component tests.

A large amount of sled tests was performed to evaluate different versions of the MCB airbag both with regards to specific whiplash injury criteria as well as standard rating and regulatory criteria for different body parts.
The tests showed that the MCB technology has potential to perform according with conventional airbags with regards to rating and legal requirements.

The tests performed also showed that the MCB technology requires substantial efforts to tune all available parameters in order to achieve optimal performance for all body parts in all situations.

One of the challenges was the lack of good evaluation tools with regards to frontal whiplash. The project chose the THOR crash test dummy, representing a 50%-ile male, as the main tool for evaluation and development of the MCB technology. The reason was the THOR's superior biofidelity, especially in the spine and neck region, as compared to the HIII crash test dummy. A down-side of this choice was that the THOR dummy only is available in 1 size and that there was no CAE model available of THOR.

2. Background

Neck injuries (Whiplash Associated Disorders) represent one of the most significant types of injury in car collisions regarding both frequency and long-term consequences. In Sweden the insurance companies have estimated that 25000 occupants report neck injuries annually. About 25% of these will be absent on sick leave one week or more. About 1500 (6%) of these will develop permanent disability (Whiplashkommissionen 2003). In the European Union it is estimated that more than 300 000 citizens suffer neck injuries from car collisions every year and 15 000 result in long term consequences. The associated socio-economic impact of these injures is in the order of 4 billion Euros per year. Even though rear end impacts account for the highest risk (Morris and Thomas 1996, Lundell et al. 1998) frontal impacts account for a large proportion (30% to 50% depending on source) of all neck injuries (Galasko et al. 1993, Krafft 1998, Jakobsson 1998 and Morris and Thomas 1996). The injury mechanisms behind neck injuries are not fully understood. Because of the complex anatomy of the neck, it is very likely that several injury mechanisms are behind the symptoms usually referred to as neck injuries, this in addition to that there are limitations in objectively detecting the damaged tissues; make this a delicate area of research.

During the last decades, substantial research on protection of neck injuries in rear end impacts has been carried out, both in the area of injury mechanism research and protection system development. WHIPS (Lundell et al. 1998) was developed by Volvo Cars and Autoliv in mid 90's and has shown in real world data to offer significant protection in rear end impacts (Farmer et al. 2003, Jakobsson and Norin 2004, Kullgren et al. 2007, Jakobsson et al. 2008). Accident investigations were an important part of WHIPS development as well as establishing injury criteria and test methods, such as the recently launched EuroNCAP method.

Research on neck injuries in frontal impacts is more limited than in rear impacts, although the partners in this project are among the main actors in this area. Several studies summarizing accident data (Kullgren et al. 1999, Kullgren, Krafft, Nygren et al. 2000, Kullgren, Krafft, Malm et al. 2000, Jakobsson et al. 2003, Jakobsson, Norin and Svensson 2004, Jakobsson 2004) and performing occupant modeling studies using mathematical and physical occupant models (Kullgren et al. 1999, Bohman et al. 2000, Boström et al 2000, Jakobsson, Franzén et al. 2004) have been published by Volvo Cars, Autoliv and Folksam/Karolinska.

Kullgren, Krafft, Malm et al. (2000) showed that frontal impact airbags in combination with seat belt pretensioners reduce neck injury risk substantially. Boström et al. (2000) and Jakobsson, Franzén et al. (2004) emphasize the importance of keeping the head and torso in balance throughout the movement.

In frontal collisions the occupant is restrained by a seatbelt and an airbag. Lessons learned from the work with reducing neck injuries in rear end collisions as well as the research in the area so far is to control the relative movements between the head and

torso. Challenges are seen in the area of exploring the feasibility of a new technology (MCB) to help balance the occupant's body in frontal impact situations.

3. Objective

The overall objective of the project was to confirm the need to address Whiplash related injuries in frontal collisions and to evaluate new technologies potential to improve vehicle crash performance.

The project consists of the following parts.
Field study: with the objective to gain knowledge in:

- Relevant crash speeds / pulses for evaluation of Whiplash related injuries in frontal collisions.
- Effect of other parameters such as presence of airbag, is risk of injury dependent of gender or position in the vehicle.

Development of new requirements with the purpose to ensure that optimization of new technology is possible, improvements measurable.

- Development / evaluate of new evaluation criteria.
- Development of requirement sets for new criteria.

Method development with the purpose to enhance production and development efficiency and enable CAE validation.

- Develop / evaluate reliable methods for volume measurements for airbags with advanced geometries.
- Develop methods for geometry verification for airbags with advanced geometries.
- Development of component test methods to evaluate airbag properties in different parts of the airbag.

Perform System tests (sled tests) with purpose to:

- Map/evaluate performance of existing projects with regards to new whiplash criteria.
- Verify performance of different configurations of MCB airbags with regards to whiplash performance.
- Verify if MCB airbags can compete with recently developed airbags with regards to rating and legal performance.

4. Project realization

Field study was performed, led by Anders Kullgren – Karolinska Institutet utilizing crash data from insurance company Folksams database. The material contains data from accidents that occurred between 1992 and 2009.

Development of requirements and test methods have been performed by Volvo Cars and evaluations have been done by performing sled tests with various versions of airbags, both conventional and with MCB airbags.

Component and System development have been performed by Autoliv using compressed air, static - and dynamic deployment tests.

5. Results and deliverables

5.1 Delivery to FFI-goals

Project has contributed to FFI goals though increased research and innovation capacity in Sweden and can contribute to maintain competitiveness of Swedish vehicle industry.

6. Dissemination and publications

6.1 Knowledge and results dissemination

Final Report från Karolinska Institutet for FFI – MCB, 28 June 2010

Sub-report Karolinska Institutet for FFI – MCB,

Internal report Autoliv Research Summary / Status 2010-03-03

Internal report Autoliv – Component development 2011

Internal report Volvo – System Development 2011.

Internal workshops (Volvo / Autoliv)

Various Test reports Volvo sled tests (2009-2011)

Various Test reports Autoliv component tests.(2009-2011)

Autoliv internal Test method descriptions

7. Conclusions and future research

MCB technology shows potential to perform well compared to conventional airbags and have an advantage with more tuning possibilities.
Component tests have proven that the principles of MCB technology works and that the airbag can be designed providing tailored response for different body regions.

New occupant performance criteria have been developed to access risk for whiplash in frontal impacts, these criteria are however new and need further evaluations to gain more knowledge of the criteria and threshold levels. Further studies to better understand injury mechanisms with regards to whiplash in frontal impacts are strongly encouraged.

During the study no CAE models of the THOR crash test dummy was available, in future development CAE must be incorporated for a more efficient development process.
There is a need of the THOR dummies (both CAE and Physical) in different sizes or aditional crash test dummies specifically designed for evaulating whiplash injury protection in frontal impacts.

Further accident data studies are strongly encouraged. Such data should preferably contain both detailed data about the occupants including neck symptom duration as well as detailed data on impact severity. The study in this project used one of the few data sets comprising these details, however the vehicle sample was not representative of the vehicle type used in the rest of the sample. Futher accident data studies should further investigate the differences in injury risk on passenger and driver side as well as taking more aspects of individual differences into account. Of special interest is to further understand the effect of sitting posture at impact. So far, a general positive effect of airbags is seen but further studies are recommended, especially to gain knowledge of the effects of deploying airbags in lower speeds (<15km/h)

8. Participating parties and contact person

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