Analysis of the applicability of an airbag for safety improvement of the child travelling in the child restraint system in rear seat of a passenger car during a frontal crash

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I. INTRODUCTION

Each year nearly 10 million children are injured or disabled as a result of road traffic crashes [1], despite the use of child restraint systems (CRS). Since the elimination of car crashes is unachievable, improved child protection is necessary. Because of the anatomical differences between a child and an adult [2], the investigation of child protection needs special attention. Children are exposed to injury in different areas of their body which can be affected by different loading conditions during a vehicle collision.

This paper shows the protection potential of an airbag while a child is travelling in the rear seat of a vehicle equipped with a special airbag system. The effectiveness of forward-facing restraints varies with the methods of installation in the vehicle, the direction the child faces, harness tightness or mass and size of the child. The consequences of improper use of a restraint system can be mitigated by changes in the airbag system. The research presented in this paper focuses on the frontal impact, which is the most frequent type of crash [3].

II. METHODS

Numerical simulations were performed in order to investigate the possibility of assembling an airbag which could protect a child travelling in a child restraint system on the rear seat of a car. In the present analysis a software package for numerical calculations MADYMO was used. Tests were performed with a 3-year-old child dummy model of Q-series. The deceleration sled was configured according to European regulation ECE R44 (with a test speed of 50 km/h) [4].

Firstly, a simulation was performed with a child dummy in a reference configuration. Next, a series of simulations were conducted, which took into account the application of an airbag with a variety of inflator properties and different airbag mounting points. During the simulations, the various injury indicators were controlled (Thorax_CUM3MS 1; HIC_15 2; NIC*:* tension 3-4, shear 5-6, bending 7-8; Nij 9-12) [5]. Prediction of head, chest and neck injury potential was based on the information provided by Świetlik et al. [6].

A dual-stage inflator with given time delay between the first and second stages of inflation was used. The aggressiveness of the airbag was reduced in order to minimize the risk of fatality to children. Calculations were performed for the airbag displaced along the x and z axes to observe whether the change in the front seat settings can possibly diminish the positive effects of an airbag. This study investigated the situation in which contact of a child with an airbag occurred when the airbag was completely deployed (‘In-Position’). A forward-facing CRS with a five-point harness was considered.

III. INITIAL FINDINGS

In the case of the reference configuration, the acceptable limit of one of the indicators of damage to the neck exceeded its limits. In the configuration where a standard airbag was used, a significant excess of the limit values for the most standard risk indicators was observed which implies that there is a high risk of serious injury. These conclusions are consistent with studies carried out by Melvin et al. [7].

In the simulation where the special airbag was included, the normalized values of all injury indicators were smaller than unity which means that they did not reach critical values. The model with the special airbag was compared with the baseline model which resulted in a decrease in normalized values of all injury indicators by approximately 40%. The results are given in fig. 1. Indicators labelled number 6 and 8 have shown the highest sensitivity for airbag position changes. The simulations revealed that a small shift or tilt of the front seat does not cancel out the positive effects of the airbag.

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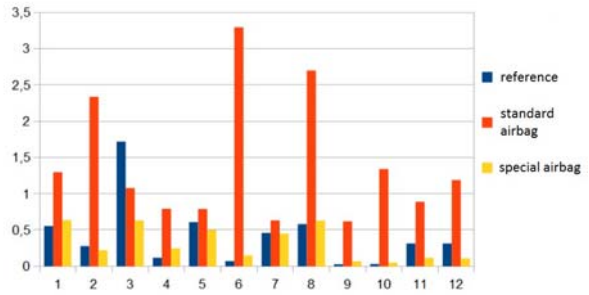

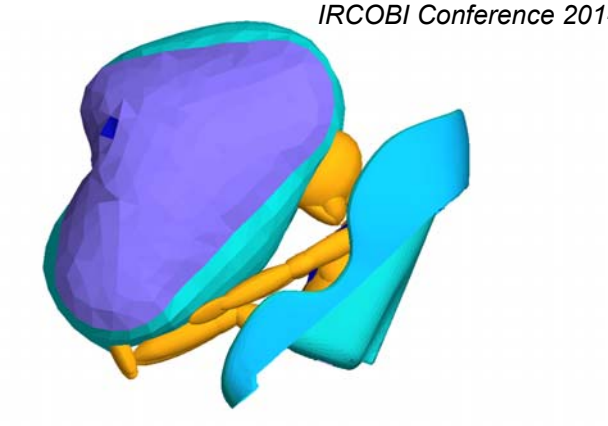

Figure 1. Comparison of the normalized injury indices for reference configuration, simulation with standard airbag and with special airbag.

IV. DISCUSSION AND CONCLUSIONS

This study found that a special airbag adjustment in order to protect the youngest passengers is possible. Despite the potential dangers of airbags the design and evaluation of age-appropriate parameters for airbag deployment are feasible. The most common types of injuries experienced by small children are brain injuries and fractures to the limbs [1]. A future advantage of the airbag is its ability to protect the child's legs. Minor disturbances characteristic of acceleration pulse caused quantitative and qualitative changes in response of the system. The experimental validation of a numerical model is necessary. Further research is essential in order to obtain optimized characteristics of the airbag inflator.

V. REFERENCES

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