Back

STUDIES FOR MOTOR CYCLE AIRBAGS

S.Mukherjee, A. Chawla, Jayant Jangra
Transportation Research and Injury Prevention program,
Indian Institute of Technology, N. Delhi 110016 India

ABSTRACT

Advances in two wheeler rider safety have not kept pace with that of automobile rider safety. One of the safety systems in consideration, of late, has been deployment of airbags [Ijima etal, 1998] . Some of the limitations perceived in deploying airbags are that two wheeler riders are less likely to be in a fixed location with respect to the airbag at the point of impact and the lack of a supporting surface. The nature of these impacts has been analysed in simulation for a proposed airbag system to estimate the head accelerations when the initial contact with the airbag is during the deployment phase.

Keywords: Airbags, Motor cycle, Arbitrary Lagrange Euler, LS-Dyna

FE SIMULATIONS WERE CONDUCTED to study the effect of airbag deployment on the MC rider. Important issues in the design of airbags for motor cycles include the size of the airbag and its effectiveness in the face of varying rider position. Simulation studies were therefore conducted in LS DYNA platform with a 50th percentile Hybrid-III dummy to study the phenomenon over a range of airbag volumes and positions of the rider. Earlier studies [Ijima etal, 1998] have focussed on “large touring motorcycles”. In this study, however, we have focussed on a small (100cc) motor cycle commonly used on the Indian roads and are investigating the suitability of airbags for the same.

Though computationally expensive than the traditional Control Volume (CV) approach, an Arbitrary Lagrange-Euler (ALE) airbag model [Cirak and Radovitzky, 2003; Haufe etal, 2004; Marklund and Nilsson, 2002; Marklund and Nilsson, 2003] was able to simulate the initial stages of deployment better when compared to experimentally measured airbag shapes during deployment. The Control Volume approach typically underestimated the airbag pressure during the initial stages of deployment and consequently underestimated the injury that might be caused when the head is too close to the airbag. The novelty of the current work lies in the study of airbags when the rider head is very close to the airbag, using ALE approach with rider positions compatible to ISO 13232.

In order to study the effect of varying head distances, a series of simulation were run by varying the initial distance between the dummy and the airbag from 50 mm to 300 mm. Instead of freely positioning the head, the bend of the rider was made compatible to that of a seated Hybrid III dummy. This also determined the orientation of the head. The airbag volume was also varied from 120 l to 180 l such that the peak pressure in the free expansion of airbag remained same, for both the volumes. The setup of the simulation is shown in Figure 1.

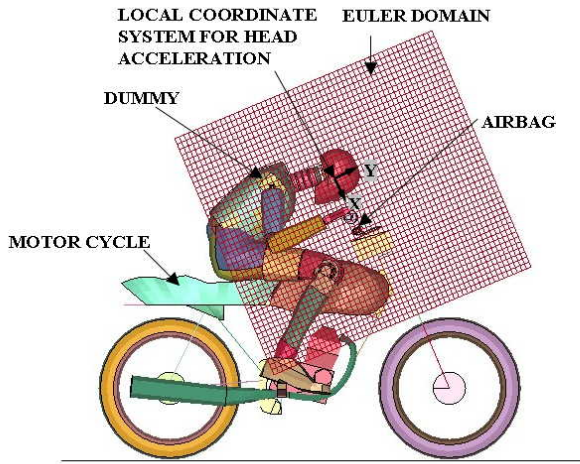

Figure 1: Setup for the Simulations

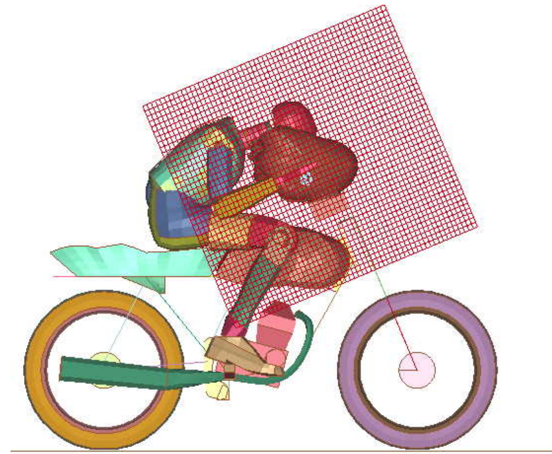

Figure 2: A typical inflated state of the motor cycle and the airbag

RESULTS OF FE SIMULATIONS

Simulations were conducted for airbags of volume 120 l and 180 l. with the distance of the of the nose of the dummy varying from 50mm to 300mm. In all the cases, the dummy was initially stationary and the first contact with the airbag surface was during the deployment phase. A typical inflated state looks as shown in Figure 2. The acceleration of the dummy head was plotted in a local coordinate system attached to the dummy head for analysis. Figure 3 and Figure 4 show the variation of head acceleration in x and y directions respectively, for the airbag volume of 120 l and distance between airbag and dummy varying from 50mm to 150mm. Figure 5 and Figure 6 show the variation of head acceleration in x and y directions respectively, for the airbag volume of 180 l and distance between airbag and dummy varying from 50mm to 150mm. All the simulations have been done for 100 ms. However the graphs have been presented for only 30 ms for clarity. The curves subsequently are of no particular significance.

CONCLUSIONS

Figure 3 to Figure 6 show that as the initial distance between airbag and dummy head was increased, the peak head acceleration decreased. The variation in peak acceleration is only 20% when the distance changes from 50 to 150mm. When the distance changes to 300mm, the peak acceleration falls to 25% of the value at 50mm. This is expected because the distance of 300mm is enough for the inflation of the airbag and the initial peak pressure in the airbag subsides by that time. While this demonstrates that the simulations have well captured the initial pressure peak and are good enough to study the effect of head distance variation, the initial acceleration peak seen in the 50-150mm range may not be alarming. This is because a 100g 4 ms pulse as observed here is equivalent in energy to a drop from a height of 0.5 m. The MC rider is helmeted and helmets are typically well equipped to absorb this impact. This is also confirmed by the simulations done using a helmeted rider. It is also seen that as we increase the head distance, there is a shift in the initial peak acceleration because of the delay in contact due to the change in distance.

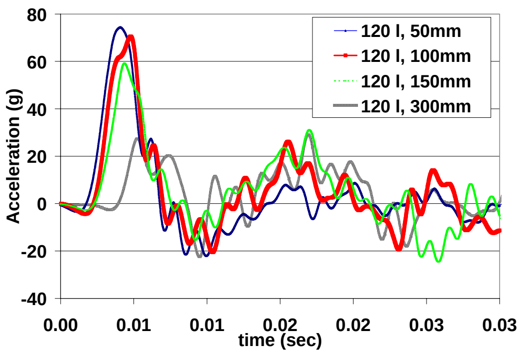

Figure 3: Variation of head x- acceleration with dummy position for 120 l airbag

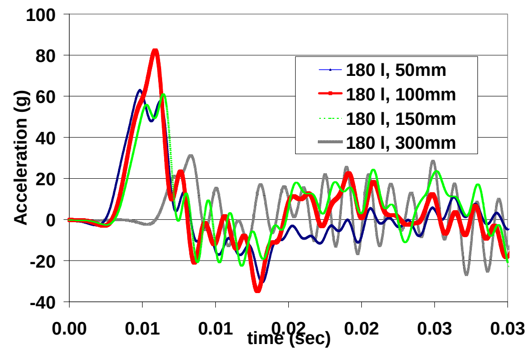

Figure 5: Variation of head x- acceleration with dummy position for 180 l airbag

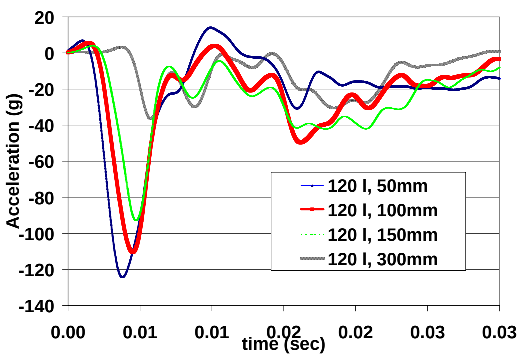

Figure 4: Variation of head y- acceleration with dummy position for 120 l airbag

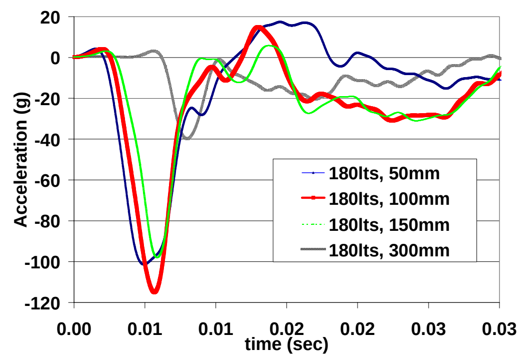

Figure 6: Variation of head y- acceleration with dummy position for 180 l airbag

For the study using different size airbags, the mass flow rate of the incoming gases had been adjusted to ensure that the peak pressure in the free run of the airbag was the same. This gave a peak mass-flow rate for the 120 l airbag as 3.3 kg/s, and for the 180 l airbag it was 3.9 kg/s. A comparison of Figure 3 with Figure 5, and of Figure 4 with Figure 6 shows an increase in peak accelerations of less than 10% with this 50% increase in airbag volume. We may conclude that the class of injury sustained by the rider due to contact with the airbag during its deployment phase is likely to have only a limited effect due to the initial distance and the airbag size for practical airbags.

The paper reports a step in the direction of studying the feasibility of airbags in motor cycles. The effect of introducing a helmet and backing surface for the airbag, as well as effect of MC velocity on the head / neck injury are currently being studied. The study is limited by the fact that only one type of airbag (same folding pattern, single chamber) was used in the study. Variations caused by change in folding schemes for the airbag as well as larger variations in the position of the rider may be studied in future.

ACKNOWLEDGEMENT:

The authors would like to acknowledge the support from the Volvo Research Foundation for funding the study.

REFERENCES

1. Cirak F., Radovitzky R., “A New Lagrangian Eulerian Shell Fluid Coupling Algorithm based on Level Sets”, Proceedings of the 44th AIAA/ASCE/ASME/AHS Structures, Structural Dynamics, and Materials Conference, Norfolk, VA, April 2003.
2. Haufe A., Weimar K., Gohner U., “Advanced Airbag Simulations Using Fluid-Structure-Interaction and the Eulerian Method in LS-DYNA”, 1st NAFEMS CFD-Seminar, Wiesbaden, Germany, April 2004.
3. Iijima, S., et al., “Exploratory Study of an Airbag Concept for a Large Touring Motorcycle,” 16th ESV, 1998
4. Marklund P.-O., Nilsson L., “Simulation of Airbag Deployment Using a Coupled Fluid Structure Approach”, 7th International LS-DYNA Users Conference, Detroit, USA, 2002.
5. Marklund P.-O., Nilsson L., “Optimization of Airbag Inflation Parameters for the Minimization of Out of Position Occupant Injury”, Computational Mechanics, Volume 31, pp. 496-504, 2003.

Back