Design of an airbag system to prevent the ejection of forklift truck drivers in case of tip-over

J. REBELLE[1]

I. INTRODUCTION

Every year in France, forklift trucks (FLT) cause more than 8,000 accidents leading to work stoppage and 4 to 6 lethal accidents related to the lateral vehicle tip-over. Many FLT drivers do not fasten the seat belt as it may hinder the work tasks. A tip-over lasts about 1.5 second and is enough time for the driver to react, grip the steering wheel or jump out of the cab. INRS[1] has conducted research to assess the efficiency of current production restraint systems and worked out a new strategy to prevent driver ejection as well as minimize the risks of head impacts against the cabin. A new prototype based on airbag technology is being currently experimented following a dedicated test protocol. This article presents intermediate results.

II. METHODS

The test bench is composed of a simplified FLT cab comprising a Hybrid III dummy positioned at the driver's workplace. This assembly is mounted on a cradle that runs along guide rails (see Figure1). An initial slope of 7° accelerates the test bench. Then the guide rails turn on the left which generates enough centrifugal acceleration to cause a realistic tip-over. A Hybrid III dummy was modified and positioned in the cabin to approach the human dynamics in the precise conditions of side ejection. The modified dummy was validated by comparing its dynamic behaviour to human subject responses during tests performed under safer conditions (tilt angle < 75°). Inside the cabin, three airbags were mounted: one was inflated between the steering wheel and the dummy's legs to prevent the body from rising up and hitting the cab top, one was placed at the cab top's level to absorb the shocks on the head and one covered the side of the cabin to prevent the dummy's ejection (see Figure 2). At this stage of the study, the airbag structure was tested in inflated conditions.

Figure 1

III. RESULTS

Comparisons were made between seat belt tests and airbag tests. The likelihood of a skull fracture on an Abbreviated Injury Scale of level 4 due to head shocks on the roof is estimated using the HIC_{15ms} (Head Injury Criteria)[1-2]. With the seat belt, the results gave a mean HIC of 255 (±108), a likelihood of 0.1 and a resultant acceleration peak of 124g (± 17g). With the airbag restraint system, the same tip-over conditions led to a mean HIC of 19 (±6), a likelihood less than 10^{-6} and a resultant acceleration peak of 20g (±3g). Moreover, with the seat belt fastened, the upper limbs of the dummy move out of the cabin structure at the end of the tip-over whilst the dummy stays inside with the airbag system and the head shocks are drastically reduced.

Figure 2

IV. Discussion and Conclusions

The airbag under the steering wheel restrains the motion of the body by holding the lower limbs in position. Thus it is easier to protect the driver against lateral ejection and keep him inside the cabin space. Future research will focus on the triggering conditions of the airbag. In addition to safety aspects, this approach also improves the working conditions: unlike with the belt the drivers are not hindered while driving and getting visual information all around the vehicle.

V. References

[1] Eppinger R. et *al*., Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II, NHTSA, Nov. 1999.

[2] Kuppa S, Injury criteria for side impact dummies, 2004.

[1] J. REBELLE is Researcher in the Department of Working Engineering Equipment at the Institut National de Recherche et de Sécurité in Vandoeuvre-lès-Nancy, France.