A comparison of the performance of two advanced restraint systems in frontal impacts


Abstract—Objective: The goal of the study is to compare the kinematics and dynamics of the THOR dummy in a frontal impact under the action of 2 state-of-the-art restraint systems.

Methods: Ten frontal sled tests were performed with THOR at 2 different impact speeds (35 and 9 km/h). Two advanced restraint systems were used: a pretensioned force-limiting belt (PT+FL) and a pretensioned belt incorporating an inflatable portion (PT+BB). Dummy measurements included upper and lower neck reactions, multipoint thoracic deflection, and rib deformation. Data were acquired at 10,000 Hz. Three-dimensional motion of relevant dummy landmarks was tracked at 1,000 Hz. RESULTS are reported in a local coordinate system moving with the test buck.

Results: Average forward displacement of the head was greater when the PT+FL belt was used (35 km/h: 376.3±16.1 mm [PT+BB] vs. 393.6±26.1 mm [PT+FL]; 9 km/h: 82.1±26.0 mm [PT+BB] vs. 98.8±0.2 mm [PT+FL]). The forward displacement of T1 was greater for the PT+FL belt at 35 km/h but smaller at 9 km/h. The forward motion of the pelvis was greater when the PT+BB was used, exhibiting a difference of 82 mm in the 9 km/h tests and 95.5 mm in the 35 km/h test. At 35 km/h, upper shoulder belt forces were similar (PT+FL: 4,756.8±116.6 N; PT+BB: 4,957.7±116.4 N). At 9 km/h, the PT+BB belt force was significantly greater than the PT+FL one. Lower neck flexion moments were higher for the PT+BB at 35 km/h but lower at 9 km/h (PT+FL: 34.2±3.5 Nm; PT+BB: 26.8±2.1 Nm). Maximum chest deflection occurred at the chest upper left region for both belts and regardless of the speed.

Conclusion: The comparison of the performance of different restraints requires assessing occupant kinematics and dynamics from a global point of view. Even if the force acting on the chest is similar, kinematics can be substantially different. The 2 advanced belts compared here showed that while the PT+BB significantly reduced peak and resultant chest deflection, the resulting kinematics indicated an increased forward motion of the pelvis and a reduced rotation of the occupant's torso. Further research is needed to understand how these effects can influence the protection of real occupants in more realistic vehicle environments.

Index Terms—belted, crash dummies, front impact, occupant kinematics, pretensioners, seatbelt

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