C38 Modeling Occupant Head Displacement in Frontal Collisions

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After attending this presentation, investigators will gain insight into the development of a unique method and tool for assessing occupant head motion in automotive collisions. Specifically, the development of an improved head displacement model will be explored and a new mathematical model proposed.

This presentation will affect the forensic community by offering an advanced scientific method and tool for assessing occupant head displace- ment in frontal collisions. Investigators will gain insight into the effect of occupant height, weight, crash severity and seat belt geometry on peak head excursion in frontal collisions that will aid them in reconstruction of automotive collisions.

Accident reconstruction of real world collisions requires the quantifi- cation of occupant motion for the purposes of identifying likely points of contact within the vehicle and assessing the effectiveness and performance of the restraint system. Occupant protection research has led to extensive testing of seat belt systems and the effects of changes to vehicle and restraint system design on occupant performance. Using this data however for the reconstruction of real world crashes poses a number of challenges due to variations in test setup, crash severity, occupant size, restraint system, data reported, etc. Prior researchers have attempted to develop simple mathe- matical models based on grouping results from this wide range of available occupant displacement data found in the literature (Araszieski et. Al., 2001, Happer et al., 2004). However due to the confounding variables from study- to-study mentioned above, applicability of the model to real world cases has limitations as well as potentially significant error. Happer et al. (2004) acknowledged the need for the development of a model based upon controlled laboratory studies where variables may be controlled confound- ing factors minimized. In addition, simulation may be used model varia- tions in vehicle and crash environment (Sieveka et al., 2001). From this type of controlled study, a more robust mathematical model may be developed for use in accident reconstruction where case-specific simulation and/or crash testing are not practical options for the reconstructionist.

The first stage of the research quantified the effect of occupant size on head displacement in simulated frontal collisions of increasing severity. Sled testing was performed utilizing a generic occupant compartment and popu- lar passenger car seat and seat belt system. Three crash severities were evaluated utilizing two occupant sizes: 50th percentile male and 5th percentile female. Motion tracking of high speed video was performed for quantifying occupant head displacement. Linear regression analysis was performed to investigate the relationship with head displacement to occupant size and crash severity. Results compared well with prior research for the 50th percentile male.

The effects of variations in seat belt geometry were evaluated through MADYMO rigid-body-model simulations. Dummy response variables and seat belt loads from sled tests performed in the first stage of the research served as the validation data for the development of the models. A Design- of-Experiments (DOE) was be performed analyzing seat belt geometry by varying D-ring fore/aft location and buckle attachment location, in effect representing different vehicle environments.

Results demonstrated a linearly increasing relationship between impact severity and head displacement for both 5th and 50th percentile dummies. The 5th percentile female experienced significantly less head displacement at each impact severity compared with the 50th percentile male dummy irrespective of seat belt geometry ($p < 0.05$). The 50th percentile male dummy results were consistent with results from prior research studies. Occupant mass and height were investigated as key parameters accounting for the consistent offset between 5th and 50th peak head displacement. Peak head displacement as a function of change in occupant kinetic energy demonstrated the best fit ($r^2 = 0.98$). Additional data are provided for modeling head displacement of the 95th percentile male dummy.

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Accident Reconstruction, Occupant Kinematics, Restraints

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