C39 A Proposed Stress Index for Predicting Whiplash Injury

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Participants at this presentation will understand 1) the mathematical formulation of a combined stress index, 2) simple load stress values for predicting neck injury, and 3) using the proposed stress index with combined load stresses for predicting neck injury during a whiplash event.

Background: A 2-D mathematical model was developed to simulate the dynamics of vehicles and occupant dummies during collisions. The author presented a description of the model to the AAFS Engineering Sciences Section at the 1994 meeting in San Antonio. A 3-D mathematical model was developed as an extension of the 2-D mathematical model. The author's paper "Mathematical 3-D Model for Whiplash Simulation" was published in the NAFE (National Academy of Forensic Engineers) Journal December 1996. The mathematical formulations are based on a "lumped parameter" approach wherein the vehicles and the dummy occupants are represented as a series of rigid masses interconnected by springs and dampers. Nodes are selected to be at the dummy neck and low back positions and at strategic points in the vehicle body and its seat. Empirical values of various parameters in the mathematical model are the author's best estimates based in part on barrier and vehicle crash tests as reported by other researchers for crash tests that were primarily frontal and rear end crashes. Sources include, but are not limited to, AAFS Annual Meeting presentations and SAE (Society of Automotive Engineers) publications. Computer simulations of crash dynamics are solutions of initial value problems using the mathematical model programmed in a scientific language.

Computer simulations produce tabulations of values for accelerations, velocities, and positions as functions of time from the initial vehicle contact for all the mass lumps in the mathematical model expressed in linear and angular coordinates. Tabulations also give values for all forces, bending moments, and torques at the nodes between the mass lumps.

Machine design methods for predicting probable failures in machine parts typically involve: determination of stresses (force per unit area) at all critical points in the structure, selection of an appropriate failure mode, and comparing results to the strength of the material from which the part is made. When combined loads are considered, analytical methods typically employ a model known as the "Mohr's Circle." This gives calculated results for maximum shear stress, maximum principal (tension) stress, and minimum principal (compression) stress at each critical point. Material strengths are usually determined from independent destructive tests according to accepted standards.

Proposed Stress Index: It is desired to use computer simulation results to predict whether neck injury is probable during the simulated crash. Machine design methods are employed for determining the stresses in the dummy occupant neck during a simulated vehicle crash using the calculated forces, bending moments, and torques during the simulation. If the material strength(s) and critical point location(s) for the human neck are known, then the desired task can be completed. In order to obtain approximate values for these parameters, the author analyzed data published in SAE J1460 MAR85 "Human Response Characteristics," SAE J885 JUL86 "Human Tolerance to Impact Conditions as Related to Motor Vehicle Design," and SAE J833 MAY89 "Human Physical Dimensions." Results of those analyses are given in this presentation. Several crash simulations are presented including calculations using the proposed stress index.

Whiplash, Stress Index, Load Stress

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