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# Material Modeling and Development of a Realistic Dummy Head for Testing Blast Induced Traumatic Brain Injury

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Protective measures against Traumatic Brain Injury (TBI) are gaining in importance due to the increasing rate of non-fatal occurrence of such injury. According to reports of Sandia National Laboratory (2008), it is estimated that, 1.4 million people in the United States are affected by TBI per year with 50,000 deaths and 235,000 hospitalizations [1, 2]. In cases involving improvised explosive devices (IEDs), TBI occurs due to the blast wave generated by the explosive. This certain case is known as blast-induced TBI, and the role of primary blast exposure (associated with direct exposure of the head and body to the blast wave) in the development of TBI remains less well understood [1,3]. Research has been and is currently being performed to understand [4, 5] or physically simulate [1, 6] this phenomenon and to design appropriate protective measures against it.

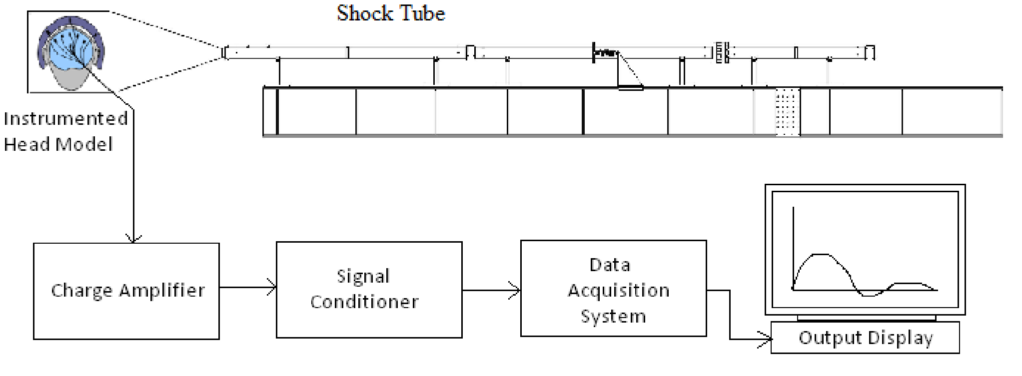


Fig.1. The complete setup of the blast TBI analysis system.

This work focuses on performing tests on various materials which have potentials of having similar mechanical and viscoelastic properties as live human brain tissue. The responses of these materials under different types of applied loading conditions were found. Four materials were tested for step response under the application of constant load, and they were compared to mathematical models developed to represent the properties (low-frequency screening). These materials also went through rheometry and DMA analysis (high-frequency screening), and the storage and loss modulus values were obtained. The results were then compared to brain matter properties found in the literature and the most suitable material was chosen to be used as a brain simulant in the surrogate head model. The head model consisted of a molded, single-piece skull surrogate into which the artificial brain was inserted. The brain was embedded with an array of thin piezoelectric sensors having sub-microsecond response. The head model was mounted to a commercially available neck model originally designed for automotive crash testing. The whole assembly was fitted into a blast tube specially designed to create the particular shock-wave flow profiles produced by free-field explosions [7]. In contrast to approaches taken by other researchers, a larger diameter shock tube is constructed so that the head model can be placed inside the tube rather than in front of the tube. This is necessary to ensure that the loading applied to the head model is representative of the uniform, open-field blast, and not a non-uniform shock combined with a high-speed jet of air as occurs outside the aperture of the shock tube [5]. Fig.1 shows the complete testing schematics.

Fig. 2 illustrates the preliminary two piece skull head model with the instrumentation. A finite element model is also developed to represent the head model. Finally, blast tests are performed on the head model and the results are compared to the finite element model to validate the results obtained by these tests.

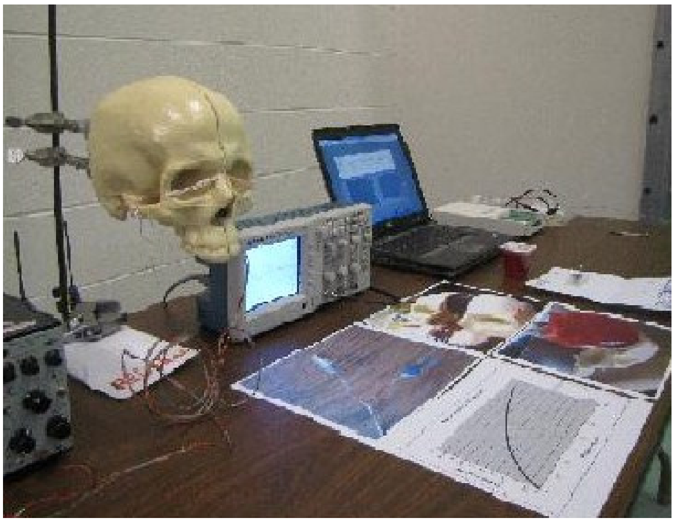

Fig. 2. The preliminary head model and the instrumentation

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