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Research paper

Verification and implementation of a modified split Hopkinson pressure bar technique for characterizing biological tissue and soft biosimulant materials under dynamic shear loading

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ABSTRACT

Modeling human body response to dynamic loading events and developing biofidelic human surrogate systems require accurate material properties over a range of loading rates for various human organ tissues. This work describes a technique for measuring the shear properties of soft biomaterials at high rates of strain (100–1000 s^{-1}) using a modified split Hopkinson pressure bar (SHPB). Establishing a uniform state of stress in the sample is a fundamental requirement for this type of high-rate testing. Input pulse shaping was utilized to tailor and control the ramping of the incident loading pulse such that a uniform stress state could be maintained within the specimen from the start of the test. Direct experimental verification of the stress uniformity in the sample was obtained via comparison of the force measured by piezoelectric quartz force gages on both the input and the output sides of the shear specimen. The technique was demonstrated for shear loading of silicone gel biosimulant materials and porcine brain tissue. Finite element simulations were utilized to further investigate the effect of pulse shaping on the loading rate and rise time. Simulations also provided a means for visualization of the degree of shear stress and strain uniformity in the specimen during an experiment. The presented technique can be applied to verify stress uniformity and ensure high quality data when measuring the dynamic shear modulus of soft biological simulants and tissue.

1. Introduction

An understanding of the dynamic mechanical properties of biological tissues is required to study the response of the human body to high-rate events including automotive crashes, ballistic impact (e.g. behind armor blunt trauma) and blast. Computational and experimental models of the human anatomy have been constructed to predict the risk

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