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M. Hrapko, J. A. W. van Dommelen, G. W. M. Peters, and J. S. H. M. Wismans
Eindhoven University of Technology, Department of Mechanical Engineering

Introduction

The head is often considered as the most critical region of the human body for life-threatening injuries sustained in accidents. During a crash the head is exposed to external mechanical load which causes an internal mechanical response of the brain tissue. To study the effect of damage during the impact numerical models are developed. One of the most important parts of the input of these numerical models is the mechanical behavior of brain tissue.

Methods

The material properties of brain tissue are studied with a variety of testing techniques. Mostly these are shear oscillatory tests which give the frequency or strain dependent dynamic modulus G_{d} characterizing the linear viscoelastic behavior of brain tissue. However, results from different groups vary by orders of magnitude [Fig. 1], and therefore, the test procedures have to be improved and more clearly defined.

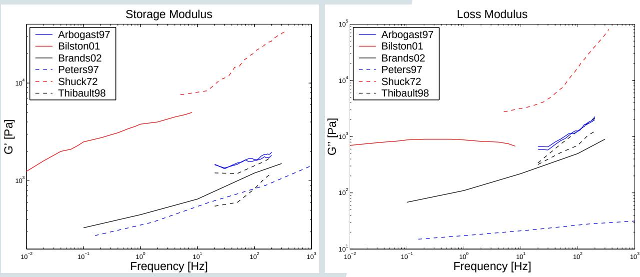

Fig 1: Dynamic frequency sweep of brain tissue from literature.

In the dynamic tests, the oscillatory strain is applied to the sample through a plate on one side, while the shear resistance is measured on the other side with a fixed plate. To improve the quality of rheological measurements of brain tissue and to be able to perform tests with homogenous white or gray matter only, the sample radius must be smaller than (approximately) 6 mm. The areas in the brain from where sufficiently small sample can be made are limited (corpus callosum, thalamus, midbrain) [Fig. 2].

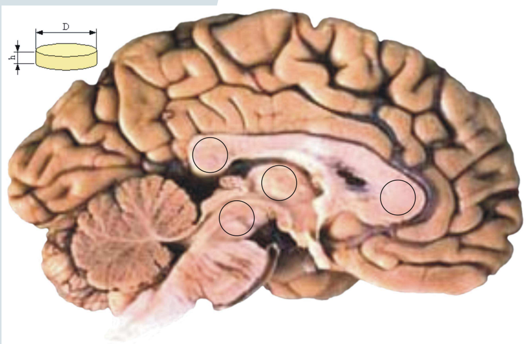

Fig 2: Sample areas in midsaggital section of brain.

For such small samples, the obtained response in a normal configuration [Fig. 3, left] is in the order of the minimum torque that can be measured. To improve the measured signal, we are using oversampling [7] and in order to increase the signal we shift the sample from the center to the edge of the plate [8] [Fig. 3, right].

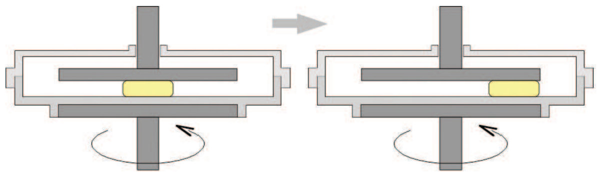

Fig 3: Normal and new measuring configuration.

The dynamic shear modulus for the linear viscoelastic regime is calculated from the measured torque M and the applied shear strain γ at R or R_1, respectively.

$$G = \frac{2M}{\pi R_1^3 \gamma_{R_1}} \quad \rightarrow \quad G = \frac{MR}{2\pi R_1^2 \left(\frac{(R-R_1)^2}{2} + \frac{R_1^2}{8} \right) \gamma_R}$$

where R is the plate radius and R_1 is the sample radius.

Results

As can be seen from our results [Fig. 4] the signal still needs improvement because of the scatter below strain 0.1%.

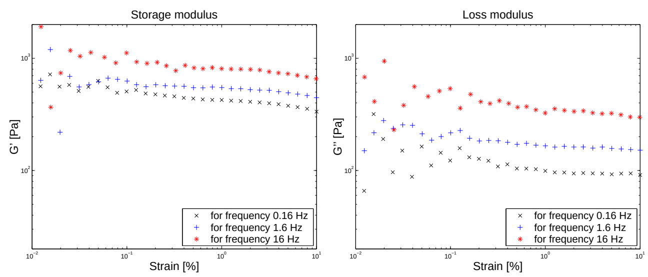

Fig 4: Dynamic strain sweep of brain tissue.

Conclusions

By placing a sample at the edge of the plate the deformation is more homogenous than in the centre of plate and the measured signal is increased. Therefore smaller samples can be used and the measuring error will be reduced. Moreover, by increasing the sample rate, the signal to noise ratio is improved.

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PO Box 513, 5600 MB Eindhoven, the Netherlands