Schematic of biaxial testing device

Consider homogeneous biaxial deformation

The output of the biaxial machine yields following quantities:

- Two stretch ratios λ_1, λ_2
- Applied forces f_1, f_2

The thickness T of the tissue has to be measured optically prior testing (reference configuration)
Specimen geometry X_1, X_2 (width and length) is known in reference configuration

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The Cauchy stress (actual, current force divided by current area) can be defined as follows:

$$\sigma_{11} = \frac{f_1}{t x_2} \qquad \sigma_{22} = \frac{f_2}{t x_1}$$

assuming incompressibility simplifies analysis, as thickness t is purely dependent on changes in width and hight:

$$t = \frac{T X_1 X_2}{x_1 x_2}$$

Using the definition of the stretches $\lambda_1 = \frac{x_1}{X_1} \qquad \lambda_2 = \frac{x_2}{X_2}$
The Cauchy stress can be then calculated as follows

$$\sigma_{11} = \frac{f_1 \lambda_1}{T X_2} \qquad \sigma_{22} = \frac{f_2 \lambda_2}{T X_1}$$