How to determine the properties of viscoelastic material ?

To define a viscoelastic material, you need to know the stress-strain response of your material for several strain rate. The best is to have at least three curves: one at high strain rate, one at low strain rate and finally one for an intermediate strain rate.

The material properties needed to define your viscoelastic model is :

- Density (only needed if you use mass fraction to specify the amount of fiber in your composite)
- Bulk and shear modulus
- Prony's serie weights and relaxation times

The formulation of the bulk and shear modulus is the following :

$$G(t) = G_0\left[1 - \sum_{i=1}^{2} w_i\left(1 - \exp\left(-\frac{t}{\tau_i}\right)\right)\right]$$

$$K(t) = K_0\left[1 - \sum_{i=1}^{2} w_i\left(1 - \exp\left(-\frac{t}{\tau_i}\right)\right)\right]$$

where w_i are the weights of Prony's series and τ_i are the relaxation time.

The procedure to determine the G_0 , K_0 and Prony's serie term is the following :

1. We consider the experimental stress-strain curve at high strain rate. At high strain rate, the term $\left(1 - \exp\left(-\frac{t}{\tau_i}\right)\right)$ becomes very small and is negligible. The equation then becomes :

   $$G(t) = G_0$$
   $$K(t) = K_0$$

   We can determine the value of G_0 and K_0 by comparing the experimental stress-strain curve at high strain rate with the stress-strain response provided by DIGIMAT at high strain rate. You will have to iterate a little bit to get the best couple of values (G_0 , K_0).

2. Now, we can consider the low strain rate data to determine the Prony's serie weight and relaxation times. Usually we consider only two terms in the Prony's serie. We have therefore to determine the couples (τ_1, w_1) and (τ_2,w_2). These couples of value

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are determined to get stress-strain response as close as possible to the experimental curves at low strain rate. You should not modify the G_0 and K_0 to do this fit.

3. Finally, we can validate our model by running the DIGIMAT computation for intermediate strain rate and compare the stress-strain response with the experimental strain-stress curve at intermediate strain rate.

   It is possible that the fit for the intermediate strain rate was not perfect. In this case, you have to adjust a little bit the six parameters to get a better fit at intermediate strain rate in keeping an acceptable fit at low and high strain rate.

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