Topic 1
Identification of a viscoplastic constitutive relation

This study deals with the parameter identification of a homogeneous constitutive relation using a monotonic tensile test.

1: Forward problem

Assuming a homogeneous constitutive relation allows the choice of a 1-DOF model, parameterized by time t.

The tensile test is load-controlled: whereas one of the grips of the testing machine is fixed, the force measured on the other one (attached to the crosshead) is $F_d(t)$. The test is driven slowly enough so that the inertial effects can be neglected: the longitudinal stress (homogeneous in the gauge section) is thus directly related to the tensile load applied by the machine:

$$\sigma(t) = \frac{F_d(t)}{S}$$

where S is the cross-section area of the specimen's gauge section. We also assume that the test is driven with a constant speed equal to $\dot{\sigma}(t) = 0,8\,\mathrm{MPa}\cdot\mathrm{s}^{-1}$.

During the test, the displacement of the crosshead is measured. Assuming that the deformation comes mainly from the specimen's gauge section, the following longitudinal displacement can be considered:

$$u(L,t) = \varepsilon(t)L$$

where $\varepsilon(t)$ is the total longitudinal strain and L the length of the gauge section.

The total strain rate can then be written as the sum of the elastic strain rate and of the viscoplastic strain rate:

$$\dot{\varepsilon}(t) = \frac{\dot{\sigma}(t)}{E} + \dot{\varepsilon}^{vp}(t)$$

where E is the Young's modulus. The viscoplastic flow rule is assumed nonlinear, as follows:

$$\dot{\varepsilon}^{vp}(t) = \left(\frac{\sigma(t)}{K}\right)^n$$

with initial condition $\varepsilon^{vp}(0) = 0$.

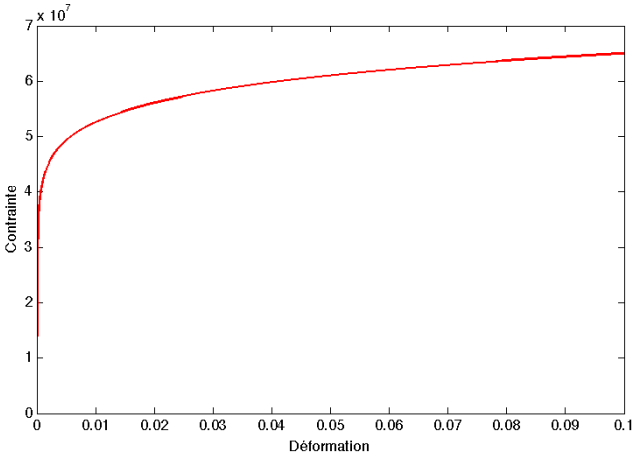

Figure 1. Example of a stress-strain curve simulated using `ode45`

2: Proposed identification problem

The aim is to identify the material parameters E, K and n using a given stress-strain curve $\sigma(t)$–$\varepsilon(t)$. Except for Question 2.4, synthetic data obtained with simulations of the forward problem will be used.

The following questions should be seen as guidelines rather than an exhaustive list of points to address.

2.1: Propose a misfit function allowing the quantification of the discrepancy between the experimental stress-strain curve and the curve obtained using a simulation of the forward problem. Study how the misfit function varies with respect to the parameter values and the test duration. Set up several methods for minimizing the misfit function and comment on their ability to converge towards the sought minimum for different initial values of the parameters (test a couple of minimization methods).

2.2: Study the influence on the identification results of adding some noise to the synthetic data (test several noise levels). Analyse how some regularization techniques could improve the results.

2.3: Study how/if the choice of the time steps (for both synthetic data and forward simulation) modifies the identification results.

2.4: Solve the identification problem for the proposed experimental data (associated file `id1.mat`).