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COMPUTATIONAL IDENTIFICATION OF RATE-DEPENDENT CONSTITUTIVE MODELS FOR DUAL-PHASE STEELS BASED ON DYNAMIC BULGE EXPERIMENTS

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ABSTRACT

A dynamic bulge testing cell for split Hopkinson pressure bar systems has been developed to perform high strain rate biaxial tensile tests on sheet metal [1]. The original idea is to make use of the input bar to apply and measure the fluid pressure in a dynamic bulging experiment. Careful analysis of the proposed testing system has demonstrated that conventional metallic bar systems cannot provide sufficient measurement accuracy. Instead, bars made from low impedance materials such as nylon must be employed.

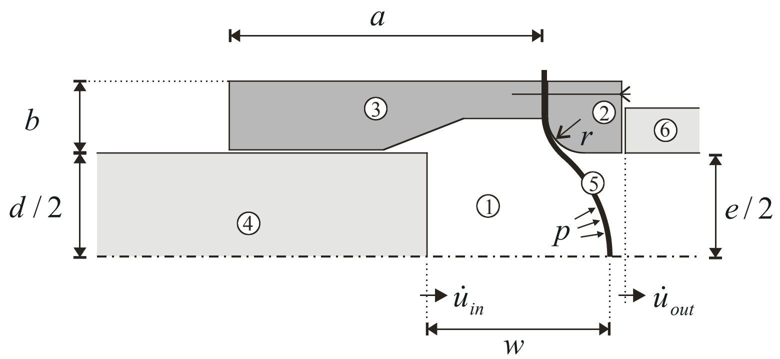

Figure 1. Axisymmetric bulge cell for dynamic testing composed of (1) fluid, (2) die ring, (3) thick-walled cylinder, (4) input bar, (5) sheet specimen, (6) tubular end of the output bar.

A series of dynamic experiments has been carried out on 0.8 mm thick dual phase steel DP450 sheets at an equivalent plastic strain rate in the range $[10^{-3};500]$ s^{-1}. A custom-made nylon input bar has been employed to achieve a pressure measurement uncertainty of less than 0.5 %. A detailed finite element model of the testing system has been used to determine the parameters of a rate-dependent plasticity model through inverse analysis. The parameters of a rate-dependent material model are then identified through inverse analysis to provide the best estimate of the pressure and displacement time histories. The pressure-time history and the effective displacement-time history are chosen to define the objective function of the inverse analysis algorithm. The optimal coefficients are found from minimizing the objective function using the gradient method of Levenberg-Marquardt (SiDoLo, 2003). In order to fully benefit from this new experimental technique, an approach to the inverse determination of rate-dependent material laws based on more abundant experimental data is developed. In particular, local strain measurements are used in additional to conventional force and displacement measurements.

The effect of strain rate on the inelastic behaviour of DP450 steel is discussed in great detail. It may be concluded from this study that the proposed dynamic bulge testing technique provides an attractive alternative to conventional dynamic tensile tests. The proposed experimental procedure appears to be more reliable than direct tension tests because it circumvents the inherent gripping and force measurement issues associated with direct tension tests.

References:

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