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Parameter identification of an elasto-plastic behaviour using artificial neural networks–genetic algorithm method

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ABSTRACT

The simulation of the metal forming processes requires accurate constitutive models to describe the material behaviour at finite strain taking into account several conditions. The choice of a rheological model and the determination of its parameters should be made from a test that generates such conditions. The major difficulty encountered is that there is no experimental test satisfying all these criteria. The use of more than one test seems more and more essential, and it is utilized to characterize the rheological behaviour at operating conditions that correspond to metal forming applications. An Inverse analysis is then considered. Therefore, the difficulty lies within the long computing time taken when an optimization procedure is coupled with a finite element computation (FEC) to identify the material parameters. In order to solve the computing time problem, this paper proposes a hybrid identification method based on finite elements, neural network computations and genetic algorithm (GA) of an elasto-plastic behaviour model. The strategy suggested is then applied to identify the Karafillis and Boyce criterion and the Voce parameters model of the Stainless Steel AISI 304 using two tests (plane tensile test and bulge test with a circular die) at the same time.

1. Introduction

The numerical simulation of sheet metal forming processes has proven its efficiency and usefulness to decrease the cost of the experimental investigations [1–3]. In the last twenty years, considerable efforts have been made to improve the numerical methods to solve the non-linear problems starting from material behaviour, geometry and friction. Moreover, by means of the graphical interfaces and due to increasing computer capacity, the use of numerical simulation to analyze the sheet metal forming process has been promoted at an industrial scale. Despite the advances in this domain, the final result of the simulation of metal forming processes depends greatly on the limitations of the constitutive material behaviour model used in the simulations [3]. Thus, some efforts are still required to improve the considered models behaviours and to identify them in the most correct way.

For this reason, and considering the complexity of the loading paths undergone by the material during its forming, the tensile test is not enough anymore, yet additional information are sought out from other tests like the plane tensile test (tensile test with a wide specimen), the simple shear test and the bulge test [4,5]. The identification becomes more difficult. Indeed, scarcely do the parameters identified from one of the tests make it possible to find, at a reasonable precision, the results of the other tests [6]. Within this framework, the aim of the present work is to develop a strategy for the material parameters identification using more than one test at the same time with a reasonable computing time.

Then, the identification based on the experimental tests is converted into errors minimizations between the experimental results and the predicted ones. The resulting problem of the multi-objective optimization spurs many solutions which do not carry out all the minima at the same time [7,8]. Thus, the finite element computing is necessary for the evaluation of the objective functions. Such analysis which is often used has to become more viable because it is based on finite element simulations of these tests requiring a prohibitive computing time [9]. Furthermore, the number of these simulations increases as well as the number of the model parameters to be identified.

Many works have been developed in order to reduce the computing time using more adequate tools. In fact, many researchers sought the use of the evolutionary and the artificial methods [9–11] to solve this problem.

In this work, a hybrid optimization strategy based on finite element method (FEM), artificial neural networks (ANN) computation and genetic algorithm (GA) is proposed. This strategy is applied to identify the Karafillis and Boyce criterion [12] and the Voce law

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