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On the inverse calibration of sheet metal anisotropic plasticity constitutive models using the Arcan test and full-field measurements

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Abstract: To develop new products, the modern industry relies on simulation tools which use constitutive models and their parameters to predict material mechanical behaviour. With recent technological advancements, it is now possible to measure a variety of strain states using heterogeneous test configurations and full-field measurements. The full-field kinematic data can be coupled with inverse calibration techniques to provide a robust approach for characterising the mechanical behaviour of materials. However, the accuracy of this methodology is influenced by a variety of factors, including the test configuration, the constitutive model and the selection of a suitable identification strategy. In this work, the Arcan mechanical test is used to identify anisotropic plasticity constitutive parameters of sheet metals. Different Arcan test configurations are simulated and analysed using a set of indicators to select the most suitable configuration. To virtually reproduce a real experiment, the computational results are used to numerically deform a speckle pattern image, which is further processed with digital image correlation technique. The full-field measurements are then used for the inverse identification of the constitutive parameters using the virtual fields method.

Keywords: Sheet metal, Anisotropic plasticity, Arcan test, Heterogeneous test evaluation, Inverse identification, Virtual fields method, Digital image correlation.

1 Introduction

Sheet metal part development is becoming more virtual and assisted by the use of numerical simulation. Sheet metal anisotropy is a critical property that has a significant impact on the accuracy of numerical results. Therefore, the quality of the results is strongly dependent on the calibration of the model, which defines the behaviour of the materials during the forming process, including anisotropy. Furthermore, mechanical testing is of utmost importance for the full characterisation of the material mechanical behaviour since the configuration utilised determines the heterogeneity and richness of the information measured. The scientific community has made an increasing effort to develop novel heterogeneous test configurations to replace classical mechanical tests [1], which provide insufficient kinematic data for the full

characterisation of the material behaviour. Moreover, full-field measurements can be coupled with inverse identification techniques [2], such as the virtual fields method (VFM), to fully characterise the material behaviour. This approach uses an optimisation technique to solve a non-direct problem in order to determine the constitutive parameters that best describe the experimental data. This work aims to investigate the use of the Arcan test to identify anisotropic plasticity constitutive parameters of sheet metals through the VFM approach.

2 Inverse identification using the Arcan test

The Arcan test is an interesting test configuration since it allows the loading direction to be varied in a standard uniaxial tensile testing machine. Although some authors used the Arcan test in sheet metal plasticity [3], it is seldom used in heterogeneous test design for the calibration of plastic constitutive models. Nonetheless, the Arcan test has the potential to provide interesting heterogeneous test configurations when used for test design in sheet metal plasticity. Several Arcan test configurations are simulated and further evaluated regarding their mechanical state heterogeneity using a set of indicators. The numerical results are then used to generate synthetically deformed speckle pattern images which are processed by digital image correlation (DIC). This kinematic data is then used for the inverse calibration of the sheet metal constitutive parameters using the VFM.

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4 Disclaimer

The results reflect only the authors' view, and the European Commission is not responsible for any use that may be made of the information it contains.

References

[1] Pierron F, Grédiac M. Towards Material Testing 2.0. A review of test design for identification of constitutive parameters from full-field measurements. Strain 2021; 57:e12370.

[2] Henriques J, Conde M, Andrade-Campos A, Xavier J. Identification of Swift Law Parameters Using FEMU by a Synthetic Image DIC-Based Approach. Key Eng. Mater. 2022; 926:2211–2221.

[3] Kumar A, Singha M K, Tiwari V. Structural response of metal sheets under combined shear and tension. Structures 2020; 26:915–933.