IDENTIFICATION OF MACROSCOPIC HARDENING LAW THROUGH SPHERICAL INDENTATION: DEFINITION OF AN AVERAGE REPRESENTATIVE STRAIN AND A CONFIDENCE DOMAIN

Charbel Moussa, MINES ParisTech, France
Charbel.moussa@mines-paristech.fr
Xavier Hernot, LGCGM, EA 3913, INSA de Rennes, France
Olivier Bartier, LGCGM, EA 3913, INSA de Rennes France
Gérard Mauvoisin, LGCGM, EA 3913, INSA de Rennes, France

Key Words: Spherical indentation, hardening law, representative strain, confidence domain

The instrumented indentation test is widely used for the identification of the stress-strain curve.
One of the disadvantages of the indentation test is that the plastic strain field in the deformed sample is not homogenous which makes it difficult to identify the hardening law of the material from an indentation curve. This difficulty can lead to some complications such as the uniqueness of the solution due to the sensitivity of the indentation test. The use of the concept of the representative strain can simplify the analysis of the indentation response and has often been used in the stress-strain curve identification. In the present work, a new method based on the definition of an "average representative strain", ε_{aR}, is developed for the determination of the hardening law using the load displacement curve, F-h, of a spherical indentation test. The advantage of the proposed ε_{aR} is that it is directly obtained from the material's response to the indentation test. This method consists to calculate the error between an experimental indentation curve and a number of FE simulation curves. For the smaller values of these errors, the error distribution shape is a valley, which is defined with an analytical equation. Based on a sensitivity study, the ε_{aR} and the corresponding value of stress σ_{aR} can be calculated for every penetration depth. Hence, the hardening law is constructed with no assumptions on its mathematical form. Because of the local aspect of the indentation test, materials heterogeneities can lead to differences between several indentation curves obtained under the same conditions. The proposed method allows the determination of a confidence domain that takes into account the experimental imprecision and the material heterogeneity using several indentation curves[1, 2]. The present method points out the limitation od the indentation test to characterize the mechanical behavior for large deformations. The uniqueness of the solution and the sensitivity of the indentation test are also discussed. The results obtained for a 20MnB5 steel alloy show that the identified hardening law (and confidence domain) is in agreement with the tensile test curve (Figure 1). A similar approach can be used for Vickers indentation for determining the representative strain[3]. Results obtained for Vickers indentation are discussed and compared to the literature.

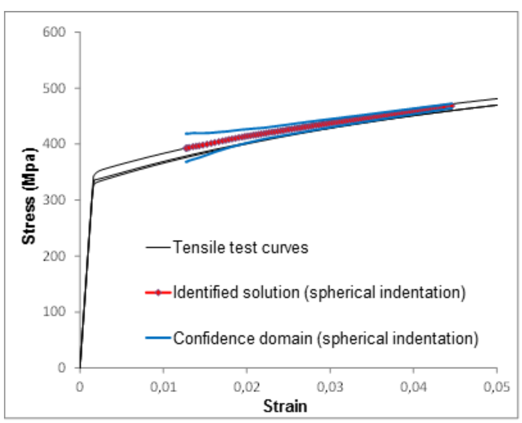

Figure 1 – Comparison between identified hardening law from tensile test and spherical indentation

[1] C. Moussa, X. Hernot, O. Bartier, G. Delattre, G. Mauvoisin. J. Mater. Sci 49 (2014), 592-603
[2] C. Moussa, X. Hernot, O. Bartier, G. Delattre, G. Mauvoisin. Mater. Sci. Eng. A 606 (2014), 409-416
[3] X. Hernot, C. Moussa, O. Bartier. Mech. Of Mater. 68 (2014), 1-14