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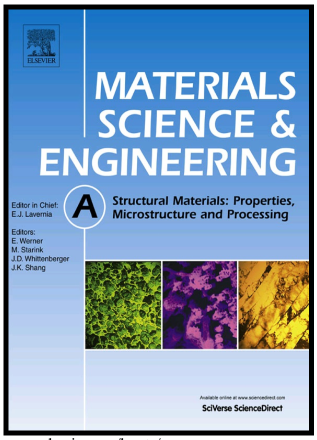

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Identification of elastic-plastic properties of metal materials by using the residual imprint of spherical indentation

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Abstract
In this paper, a novel inverse computation method is proposed to estimate the elastic-plastic properties of metal materials by using only the residual imprint of spherical indentation. The advantage of this method is that it does not need to know the entire loading history. The indentation experiment can be easily implemented on a hardness tester while the residual imprint can be measured using a 3D measuring laser microscope. We correlate the imprint snapshot with material constitutive parameters using proper orthogonal decomposition and parametric approximation, and then we solve the inverse problem using the "Interior-point" optimization algorithm. The effectiveness of this method is verified by application on 2099-T83 Al-Li alloys. Results show the inverse analysis gives well-posed solution of parameters of materials only when the penetration depth or the prescribed indentation load is sufficient, and the elastic-plastic properties obtained from indentation and uniaxial experimental data show good agreement. Besides, the sensitivity investigation indicates the use of weighting imprint obtained from different experiment loads is able to give a more stable and reliable result.
Keywords: Spherical indentation; parameters identification; metal materials; residual imprint; inverse analysis

1. Introduction

Instrumented indentation has long been used as an efficient and useful tool to the evaluation of materials properties, e.g. hardness, through measuring the ratio between contact force and residual area on the indented specimens [1-3]. Recent developments in high resolution depth-sensing instrumented equipment have greatly promoted the use of indentation experiments to measure the mechanical properties of various materials [3]. The advantage of this method is that it is none-destructive [4, 5]. Besides, it is well suitable for the extraction of the local mechanical properties form the exceedingly small samples, for which the classical uniaxial tests are not applicable [4, 6].

In 1951, Tabor [1] constructed a simple method to determine the flow stress-strain curve of metal materials using indentation experiments. Based on experiment conclusion, the concept of representative strain was introduced to correlate the indentation loading curve with the uniaxial flowing stress-strain curve of a material [7, 8]. The study of Tabor has provoked tremendous interests in determining the uniaxial mechanical properties of materials by using indentation tests [4-17]. Later, Johnson [9] developed an alternative approach called expanding cavity model using the classical plasticity deformation theory. The study of Johnson greatly extended the knowledge of the underlying evolution mechanisms involved in