

Review

A Pulsed Current Application to the Deformation Processing of Materials

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Abstract: A review of studies on the electroplastic effect on the deformation process in various conductive materials and alloys for the last decade has been carried out. Aspects, such as the mode and regimes of electric current, the practical methods of its introduction into materials with different deformation schemes, features of deformation behavior accompanied by a pulsed current of different materials, structural changes caused by the combined action of deformation and current, the influence of structural features on the electroplastic effect, changes in the physical, mechanical, and technological properties of materials subjected to plastic deformation under current, possible mechanisms and methods of physical and computer modeling of the electroplastic effect, and potential and practical applications of the electroplastic effect are considered. The growing research interest in the manifestation of the electroplastic effect in such new modern materials as shape-memory alloys and ultrafine-grained and nanostructured alloys is shown. Various methods of modeling the mechanisms of electroplasticity, especially at the microlevel, are becoming the most realistic approach for the prediction of the deformation behavior and physical and mechanical properties of various materials. Original examples of the practical application of electropulse methods in the processes of drawing, microstamping, and others are given.

Keywords: pulsed current; deformation; electroplastic effect; deformation behavior; microstructure; properties; mechanisms of electroplasticity; modeling



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1. Introduction

The physical phenomena that occur when a pulsed current is applied to solid metal materials are well known. These include the thermal effect, the appearance of a magnetic field (and, as a result, skin and pinch effects), vibration, etc. [1]. Often, such phenomena occur simultaneously. The most notable among the listed effects is the thermal effect, which is often used in electric pulse treatment (EPT) technologies to change various properties due to the structural changes associated with the effect [2,3]. Note that EPT usually refers to technologies in which the object is not subjected to external deformation treatments. In the case of a combined effect on the material of simultaneously pulsed current and plastic deformation (for example, rolling, drawing, pressing, bending, tension, and compression), such processes are called electrically assisted manufacturing (EAM) or electroplastic deformation (EPD) in contrast to EPT. Those processes will be discussed in detail in this review.

The EPD is based on all the above mechanisms in interaction with plastic deformation (that is, with the movement of dislocations), which can be enhanced, leading to increased deformability and carried out at lower stresses due to the occurrence of the electroplastic effect (EPE) [4]. EPE is a phenomenon that depends on many external and internal factors [5]. The external factors include those associated with deformation. They are the scheme of the stressed strain state, strain rate, strain temperature, pulse-current modes, and regimes. Factors, such as the material, its structure, and phase composition, are internal factors.

Deformation Processing

**George E. Dieter, Howard A. Kuhn, S.
Lee Semiatin**



Deformation Processing:

Deformation Processing Walter A. Backofen, 1972 **Advances in Deformation Processing** John J. Burke, Volker Weiss, 2012-12-06 The Army Materials and Mechanics Research Center has conducted the Sagamore Army Materials Research Conference in cooperation with the Materials Science Group of the Department of Chemical Engineering and Materials Science of Syracuse University since 1954 The purpose of the conference has been to gather to gether scientists and engineers from academic institutions in dustry and government who are uniquely qualified to explore in depth a subject of importance to the Army the Department of Defense and the scientific community This volume **Advances in Deformation Processing** addresses the areas of Analytical Advances Workability Processing to Optimize Properties Advanced Applications Materials and Advanced Applications Processes The dedicated assistance of Mr Joseph Bernier of the Army Materials and Mechanics Research Center throughout the stages of the conference planning and finally the publication of the Sagamore Conference Proceedings is deeply appreciated The support of Helen Brown DeMascio of Syracuse University in p paring the final manuscript is acknowledged The continued active interest and support of these conferences by Dr A E Gorum Director of the Army Materials and Mechanics Research Center is appreciated Syracuse University Syracuse New York The Editors vii Contents SESSION I INTRODUCTION A E Gorum Moderator Continuum Mechanics and Deformation Processing 1 Metal Deformation Processing F. W. Boulger, A. F. Gerds, R. L. Jentgen, G. E. Meyer, H. Ll. D. Pugh, Alan R. Rosenfield, D. E. Strohecker, Volker Weiss, 1967 As part of the Metalworking Processes and Equipment Program information was collected on deformation characteristics of metals and their effect on processing operations The report presents the information collected from technical engineering reports on Government contracts and from general engineering and metallurgical publications The objective is to help the nonspecialist in recognizing the implications of scientific findings and in applying them in specific operations This report contains a series of articles covering the following subjects Ductile Fracture Application of High Pressure to the Forming of Brittle Metals Superplasticity Lubrication in Metal Deformation Processes Swaging Adiabatic Conditions in Deformation Processing Residual Stresses produced by Deformation These subjects are treated in two ways 1 generalized discussions of common processes point out why specific variables must be modified in order to deform certain types of metals satisfactorily and 2 data on the more difficult to form metals are used to illustrate the principles limitations and effects of the processes Author Deformation Processing [by] Walter A. Backofen Walter A. Backofen, 1972

DEFORMATION PROCESSING OF CERAMICS. Xin Wu, 1991 investigated and analyzed with an approximate analytical model and with a numerical method **Metal Deformation Processing** F. W. Boulger, W. M Baldwin (Jr), Allan H. Clauer, J. A. Houck, M. J. Klein, H. R. Ogden, C. N. Reid, Alan R. Rosenfield, Alvin M. Sabroff, D. E. Strohecker, 1964 As part of the Metalworking Process and Equipment Program a survey was conducted to collect and summarize information on deformation characteristics of metals and their effect on processing operations This report presents information obtained from reports on

Government-sponsored work and from articles in technical publications. The report covers eight subjects: extrusion, forging, rolling, thermal mechanical variables affecting the properties of refractory metals and alloys, development of preferred orientations, anisotropy of strength and ductility, high strain rate deformation and strain aging. In order to be useful to engineering students and production engineers, the topics are treated in two ways. Generalized discussions of common processes point out why specific variables must be modified in order to deform certain types of metals satisfactorily. When practical data on the more difficult-to-form metals are used to illustrate the principles, limitations, and effects of the processes. The objective is to help the non-specialist recognize the implications of specific findings and to apply them to specific operations.

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 George E. Dieter, Howard A. Kuhn, S. Lee Semiatin, 2003-01-01. Severe Plastic Deformation Ghader Faraji, H.S. Kim, Hessem Torabzadeh Kashi, 2018-07-14. Severe Plastic Deformation Methods Processing and Properties examines all severe plastic deformation techniques developed over the past two decades, exploring the appropriate severe plastic deformation method for a particular case. The book offers an overview of these methods, introduces ultrafine grained and nano grained metals, and methods for various bulk sheet, tubular, and large size samples. Reviews effective parameters to make a severe plastic deformation method better from property, mechanical, and processing cost, time, load, etc. viewpoints. Discusses mechanical, physical, and chemical properties of UFG and NS metals and concludes with various applications for these methods. Over the last several decades, a large number of severe plastic deformation methods have been developed for processing a wide array of metals for superior properties, making this a timely resource. Collects all severe plastic deformation methods in a unique reference. Compares severe plastic deformation methods from several viewpoints, including processing and final property. Classifies severe plastic deformation methods based on the sample shape and mechanics, as well as the properties achieved in the processed metal. Introduces ultrafine grained and nano grained metals and methods for various bulk sheet, tubular, and large size samples.

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