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Review of Equal Channel Angular Pressing System

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***Abstract* - Equal channel angular pressing (ECAP) is a forming procedure. The Equal Channel Angular Pressing is a hardening treatment with which ductile metals can be processed to refine their grain and sub-grain structure. This process enhances the mechanical strength of metals in terms of tensile strength, stress-controlled fatigue strength, and fatigue crack growth resistance. The Equal Channel Angular Pressing is a hardening treatment with which ductile metals can be processed to refine their grain and sub-grain structure. This process enhances the mechanical strength of metals in terms of tensile strength, stress-controlled fatigue strength, and fatigue crack growth resistance. In this review, underline some critical aspects that have to be more investigated.**
***Keywords:* Equal channel angular pressing, plastic deformation, shear deformation, hydrostatic stress.**

I. INTRODUCTION

Equal Channel Angular Pressing (ECAP) which is known as one of the most promising material processing techniques involves severe plastic deformation. In contrast to rolling, drawing, extrusion the main purpose of ECAP is to accumulate deformation in material without any reduction in work piece cross-section.[3] Equal channel angular pressing (ECAP) is accompanied by the stresses emergence in various layers of deformable material. The intensity of surface stress characterizes the degree of hardening of the surface layer of the pressed material.

II. LITERATURE RIVIEW

F.Djavanroodi [1] presented research, commercial pure aluminum has been ECAPed at room temperature using conventional and ultrasonic vibration techniques to investigate the influence of ultrasonic wave on the pressing load and mechanical characteristics of deformed samples. The results showed that the superimposing ultrasonic vibration on the ECAP process not only decreases the required punch load, but also improves the mechanical properties of the material as compared to the conventional condition.

Konuk [2] presented study, an approach of application of ECAP method was used in surface plating. Previously manufactured ECAP dies using separated die design approach were used in the study. 5083 Aluminum and Ms 58 Brass alloy strips having 2 and 4 mm thickness were placed in the ECAP die side by side and processed with single and double passes in order to model the metallic plating under cold pressure welding conditions. There were no successful and full joints between the strips although some partial joints were observed.

R.A. Parshikov [3] presented paper the experimental and finite element analysis results of ECAP investigation were obtained. The influence of die geometry and friction condition on irregularity of shear strain field in the cross section of the billet and therefore on mechanical properties distribution was studied. ECAP was shown to be always characterized by irregular shear strain distribution. Depending on die geometry and friction condition that irregularity could be reduced.

Denis [4] shows plots, 3d contour graphs, of surface stress model made of Ti-6Al-4V alloy, exposed to equal channel angular pressing, from N-normal resultant and M-moment resultant, and operating on different portions of a deformable material.

Maria [5] concluded the steel St3 was processed by equal channel angular pressing. The structure and properties of the steel after two ECAP passes were determined. The different routes (Bc and C) resulted in different microstructure evolution during the equal channel angular pressing. It has been shown that equal channel angular pressing is a very suitable method for produce materials with good mechanical properties.

Fang [6] were investigated tensile strength, elongation, static toughness and fracture modes of casting Al–0.63 wt.% Cu and Al 3.9 wt.% Cu alloys subjected to equal channel angular pressing (ECAP). It is found that the grains of the two alloys can be refined to submicron level after four passes of ECAP. In addition, precipitation phase θ along grain boundaries in the Al–3.9 wt.% Cu alloy was also broken after ECAP treatment. The tensile fracture strength increases with increasing ECAP pass for both of the Al–Cu alloys, however, the elongation is almost independent of the ECAP pass. Consequently, the static toughness of the Al–Cu alloys is enhanced at high ECAP pass. The failure modes of Al–0.63 wt.% Cu alloy consist of necking and shear fracture, however, Al–3.9 wt.% Cu alloy displays normal fracture and shear fracture with different shear angle. Based on the results above, the tensile properties and failure modes of the Al–Cu alloys are discussed.

Ghourchibeigy [7] studied different external parameters related to the ECAP process of Cu-Al-Ni shape memory alloys by using ABAQUS 6.10 Software, which is widely used today. The parameters studied are outer corner angle and, die and billet temperature. Exploring optimum amounts for the influencing parameters, have made this work outstanding. Besides, there was no data for ECAPing Cu-Al-Ni shape memory alloys; so, the next work should be experimental study of the process. Based on the optimal strain homogeneity in the sample with lower dead zone formation, without involving any detrimental effects, outer corner angle was selected.

Hyoung [8] presented Equal channel angular pressing (ECAP) forming procedure to extrude material by use of specially designed channel dies without a substantial change in geometry and to make an ultrafine grained material by imposing severe plastic deformation. Because the evolution of microstructures and the mechanical properties of the deformed material are directly related to the amount of plastic deformation, the understanding of the phenomenon associated with strain development is very important in the ECAP process. The plastic deformation behavior during pressing is governed mainly by die geometry (channel sizes, a channel angle and corner angles), material properties (strength and hardening behavior) and process variables (temperature, lubrication and deformation speed). There is a need for modeling techniques which may permit a wider study of the effects observed for better process control and the understanding of process related phenomena. In this study, we describe a range of our continuum modeling results of the ECAP process in order to illustrate the modeling applicability. Firstly, the finite element results of ECAP modeling for various geometric factors are described. Secondly, the inhomogeneous deformation due to the hardening property of the material is explained. Lastly, modeling the temperature field coupled with stress as a typical process variable in ECAP is presented.

Chegini [9]discussed Equal-channel angular pressing (ECAP) is an effective fabrication process for obtaining ultrafine grained materials. In order to investigate the effect of grain refinement during ECAP on wear properties of Al 7075 alloy, the specimens were pressed up to four passes by route BC at room temperature. Followed by ECAP, dry sliding wear tests have been conducted using a pin-on-disk machine under different loads of 10, 20 and 30N at a constant sliding speed of 0.23 ms -1. Microstructural observations were undertaken using transmission electron microscopy (TEM) and the surface of worn specimens was investigated by scanning electron microscopy (SEM). The effect of load and ECAP process on the mass loss, have been explained with respect to microstructure and wear mechanism. Comparison of wear resistance of specimens shows that by using ECAP process, wear resistance of the specimens increases considerably due to the formation of very fine grains during ECAP.

Woo Jin Kim [10] discussed The effects of ECAP temperature and post-ECAP annealing on grain size, texture and mechanical behavior have been examined. The softening of ECAPed Mg alloys despite the considerable grain size refinement has been ascribed to the texture change during ECAP. The strength of the ECAPed AZ31 Mg alloys, however, increased with decrease in grain size following the standard Hall-Petch relation when the similar texture could be retained. Based on the present analysis, it could be concluded that it was practically hard to improve the strength of the Mg alloys significantly by grain-size refinement when ECAP was used, because texture softening effect was often more dominant over the grain strengthening effect.

Mitsak [11] studied Equal channel angular extrusion (ECAE) is a method often used to obtain large plastic strains. However, according to experimental results, there is a large tensile stress in the sample during deformation, which may lead in some cases, to cracking in metallic alloys and large curvature in polymeric materials. In order to overcome these drawbacks, the ECAE process can be conducted at high temperatures. But this contributes significantly to a decreased level of plastic deformation induced in the sample. Hence, a tool with multi-pass seems to be a very appropriate solution. In this paper, a new geometry die composed of two elbows has been simulated by finite element method aiming to provide an insight into the mechanisms of deformation and to determine the optimum geometry of the tool. The numerical results show that the length and the section of the second channel play a significant role on the homogeneity of the plastic strain distribution. It has been found that good homogeneity was obtained when the second channel has the same section as that of the entrance and the exit channels and with a length equal to three times of its width.

Chang [12] were prepared by powder metallurgy with the powders having the different sizes, *i.e.* < 30 μm and 30 μm <. The composites were subjected to equal channel angular pressing (ECAP) under various conditions and the microstuctural changes during ECAP were examined. A special focus was made on the effect of ECAP conditions on the distribution of SiC whiskers. The present investigation was aimed at exploring the feasibility of ECAP as a post working process for manufacturing the discontinuous metal matrix composites. The microstructural examination and the microhardness measurement of the ECAPed samples suggested that the optimum combination of the uniform microstructure and enhanced mechanical properties would be obtained by (a) using the powders having the smaller size, (b) decreasing ECAP temperature, and (c) repeating ECAP.

The 6061 Al–10 vol% SiC

Ondrej [13]studied Orientation imaging microscopy (OIM) which allows to measure crystallic orientations at the surface of a material. Digitalized data representing the orientations are processed to recognize the grain structure and they are visualized in crystal orientation maps. Analysis of the data firstly consists in recognition of grain boundaries followed by identification of grains themselves. Knowing the grain morphology, it is possible to characterize the grain size homogeneity and estimate structural parameters related to the physical properties of the material. The paper describes methods of imaging and quantitative characterization of the grain boundary structure in metals based on data from electron backscatter diffraction (EBSD). These methods are applied to samples of copper processed by equal-channel angular pressing (ECAP).

III. CONCLUSION

In this present review study, the finite element method was used to provide fruitful information on the plastic strain distribution in the extruded material using ECAE die. From a broader perspective, it can be understood that the deformation is more complicated with two turn 90° die compared to conventional ECAE die.

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