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# Microstructure Analysis Evolution for Channel Angular Pressing

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**ABSTRACT**

**Recently new methodology SPD technique is developed for equal channel angular pressing with parallel channels. Present paper addresses the ECAP, that is applied to the Al alloys 6063 and pure Cu. The Al6063 alloy and pure Cu is subjected to ECAP at room temperature for 2 passes to study the effect on the microstructure and mechanical properties after processing. .To investigates the ECAP processed billets. CAP was done using a 90° die.**

Keywords - **Channel angular pressing, alloy and pure Copper, Mechanical properties, Fracture and Hardness.**

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## I. INTRODUCTION

Equal channel angular pressing is a severe plastic deformation technique capable of introducing severe plastic strain in bulk metals, leading to significant grain refinement. Although the mechanical and physical properties of all crystalline materials are determined by several factors, the average grain size of the material generally plays a very significant and often a dominant, role. Thus, the strength of all polycrystalline materials is related to the grain size. The grain sizes of commercial alloys [1-4] are generally tailored for specific applications by making use of pre-determined thermo-mechanical treatments in which the alloys are subjected to specified regimes[5,6] of temperature and mechanical testing. However, these procedures cannot be used to produce materials with sub-micrometer grain sizes because there is invariably a lower limit, of the order of a few micrometers, which represents essentially the minimum grain size readily, attained using these procedures. Accordingly, attention has been directed towards the development of new and different techniques that may be used to fabricate ultrafine-grained materials with grain sizes in the sub-micrometer and the nanometer range.

To place this review in perspective, it is first necessary to provide a formal definition of ultrafine-grained materials (UFG). With reference to the characteristics of polycrystalline materials, UFG materials are defined as poly-crystals, having very small grains with average grain sizes less than ~1μm. For bulk UFG materials[7,8,12], there are the additional requirements of fairly homogeneous and reasonably equiaxed microstructures and with a majority of grain boundaries having high angles of misorientation. The presence of a high fraction of high-angle grain boundaries is important in order to achieve advanced and unique properties Two basic and complementary approaches have been developed for the synthesis of UFG materials and these are known as the ''bottom-up'' and ''top-down'' approach[9,10,11] is different because it is dependent upon taking a bulk solid with a relatively coarse grain size and processing the solid to produce a UFG microstructure through heavy straining or shock loading. This approach avoids the small product sizes and the contamination which are inherent features of materials produced using the ''bottom-up'' approach and it has the additional advantage that it can be readily applied to a wide range of pre-selected alloys.

The first observations of the production of UFG microstructures using the ''top-down'' approach appeared in the scientific literature in the early 1990s in several publications dealing with pure metals and alloys. It is important to note these early publications provided a direct demonstration of the ability to employ heavy plastic straining in the production of bulk materials having fairly homogeneous[13] and equi-axed microstructures with grain sizes in the sub-micrometer range and with a high fraction of high-angle grain boundaries. In order to convert a coarse-grained solid into a material with ultrafine grains[14], it is necessary both to impose an exceptionally high strain in order to introduce a high density of dislocations and for these dislocations to subsequently re-arrange to form an array of grain boundaries.

## II. DEVELOPMENT OF PROCESSING USING ECAP

It is a relatively simple task to establish a facility for conventional ECAP by two-piece split die consisting of a highly polished smooth plate bolted to a second polished plate containing a square-sided channel. This type of die works well in the laboratory and can be used for multiple passes provided care is taken to manually tighten the bolts between each separate pass. A suitable lubricant such as MoS2 is generally used to minimize frictional effects at the die walls. However, an alternative approach for minimizing friction[15] is to make use of more complex configurations incorporating moving die walls. An alternative approach is to construct a solid die from tool steel. Solid dies have an advantage because they avoid any problems associated with the extrusion of slivers of material between the separate parts of a die. However, solid dies require the use of a channel having a circular cross-section and, in addition, the die must be constructed finite outer arc of curvature at the point of intersection of the two parts of the channel so that.

In practice, experiments have shown that little or no in homogeneity is introduced into the pressed samples by using solid dies having arcs of curvature of Ψ=20°. Furthermore, model experiments with billets made of plastic have revealed no significant differences when using samples with either square or circular cross-sections. When working with solid dies, it is important to note that it is necessary to remove each specimen from the die by pressing the next specimen into the die. In practice, therefore, the final specimen is generally removed using a dummy specimen which then remains within the die. The scaling of ECAP processing to incorporate large billets and the pressing of hard to deform materials require more complex construction of the ECAP facilities in order to maintain enhanced loading during the pressing operation. This is true also for the development of ECAP processing for commercial use as discussed and for these conditions the construction of an optimal die requires special technical solutions.

There are four basic processing routes in ECAP and these routes introduce different slip systems during the pressing operation so that they lead to significant differences in the microstructures produced by ECAP. The four different processing routes are summarized schematically in. Thus, in route A the sample is pressed without rotation, in route BA the sample is rotated by 90° in alternate directions between consecutive passes, in route BC the sample is rotated by 90° in the same sense (either clockwise or counterclockwise) between each pass and in route C the sample is rotated by 180° between passes.

Various combinations of these routes are also possible, such as combining routes BC and C by alternating-rotation through 90° and 180° after every pass, but in practice the experimental evidence obtained to date suggests that these more complex combinations lead to no additional improvement in the mechanical properties of the as-pressed materials. Accordingly, for the simple processing of bars or rods, attention is generally devoted exclusively to the four processing routes given in following figure In this project was done by route 'A' up to two passes.

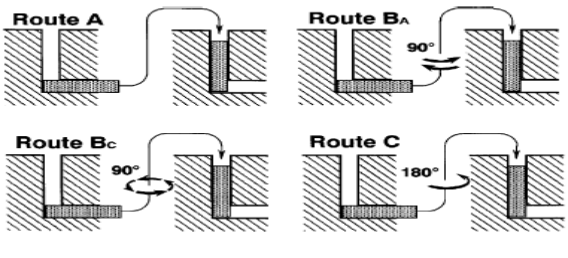



Fig:1 The four fundamental processing routes in ECAP

## III. LITERATURE SURVEY

Recently many studied has been going on over the Equal Channel Angular Pressing, with the increase of mechanical properties and getting the ultrafine grain particles. Ramesh (2014) found that hardness values and the mechanical strength increases as the number of passes increases. Interestingly, the percentage elongation also increases as the number of passes increases. Fine grains, fragmented precipitates, formation of new Al-Mg precipitates by depleting Mg from matrix and texturing are responsible for the increase in the strength and ductility simultaneously.

Kondaiah Gudimetla found that consolidation of Al 5083 mechanically alloyed powder through ECAP was carried out up to three pass with four different routes. Al 5083 alloy powder with a crystallite size of approximately 24 nm was achieved by mechanical alloying route. Near full density has been achieved through the ECAP process. Among all routes, Route A is the best with respect to density and hardness. 97.54 % of theoretical density was achieved in route A, after three passes in BP-ECAP and the maximum hardness 83 HRB was achieved.

## IV. EXPERIMENTAL PROCEDURES

In this study material of Al 6063 alloy and pure Cu. Initial billets was a circular rod of 12mm diameter and 50mm height undergo pressing. Hydraulic press capacity 100T show in fig.2 has been used for pressing.


Fig.2 Hydraulic Pressure machine

The ECAP die used in the present work consists of two channels with an equal cross-section that intersect at an angle $\Phi$, called die channel angle, which is 90°, and the outer corner of the die angle is called die corner angle, which is 20°.A schematic diagram of ECAP die show in Figure.

The die is made up of HSS steel with equal and parallel channel and the diameter is 12mm and plunger is used as the bridge for the sample and hydraulic press. The subjected billets is put in the die and its lubricated using

MoS2 and the die has been clamped and then tighten the screws After that die has been placed in the hydraulic press and applied load of press is 570 psi. Once the pressing was done the load have to reduced and then the die has been taken out from the hydraulic press and remove the clamping and the billets has been taken out. The processed billets called 1$^{st}$ pass. After that billets undergo lathe for second pass. Same procedure is followed for both Al 6063 alloy and Cu. Fig 4 shows the Die used in this work.

Al-Aluminum As-Arsenic Bi-Bismuth C- Carbon Ca-calcium Co-Cobalt Cr-Chromium Cu-Copper Fe-Iron Mg-Magnesium Mn-Manganese Mo-Molybdenum Nb-Niobium Ni-Nickel P-Phosphorus Pb-Lead S-Sculpture Si-Silicon Sn-Tin Ti-Titanium V-Vanadium W-Tungsten Zn-zinc. The composition of the material was tested by using the spectrometer.

Table.1 Al6063 alloy composition

| Material | Composition |
|---|---|
| **Al** | **98.56** |
| Si | 0.365 |
| Fe | 0.207 |
| Cu | 0.029 |
| Mn | 0.026 |
| Mg | 0.581 |
| Cr | 0.041 |
| Ni | 0.055 |
| Zn | 0.015 |
| Sn | 0.018 |
| Ti | 0.005 |
| Pb | 0.046 |
| Ca | 0.002 |
| Sr | 0.001 |
| Zr | 0.002 |
| Bi | 0.041 |
| Ga | 0.018 |
| Cd | 0.016 |

## V. TENSILE TESTING:

Tensile testing was carried out as per ASTM E8 standard using TENSO-METER. Both Copper and Al 6063 alloy are taken in to tensile testing. Specimen from after ECAP undergo machined using lathe to get material as described size given below.

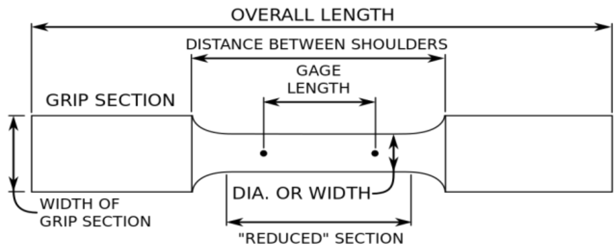
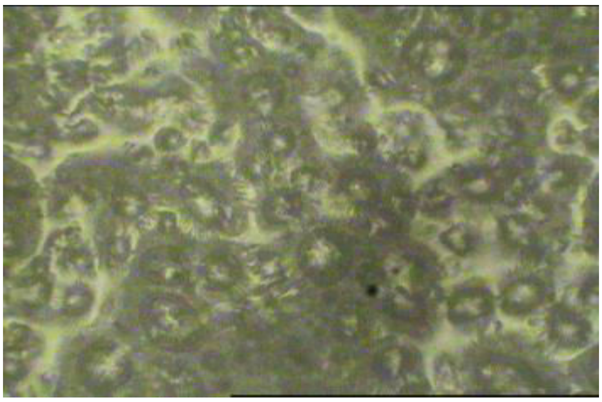



Fig.3 Tensile Specimen nomenclature

A tensile specimen is a standardized sample cross-section. It has two shoulders and a gauge (section) in between. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area, tensile specimen of Al6063 alloy and Copper.

## VI. RESULTS AND DISCUSSION

The characteristics of the microstructures introduced by ECAP have been evaluated in numerous investigations. However, almost all of these investigations employ transmission electron microscopy for determinations of the grain sizes produced by ECAP and the nature of any dislocation interactions occurring within the grains. An alternative approach is to employ optical microscopy to study the shearing of the original grains as they pass through the shearing plane within the die. An initial examination of shearing at the macroscopic level provides an opportunity to make direct comparisons with the theoretical predictions both for the three-dimensional shearing behavior of large solid bodies and for the slip systems visible on orthogonal sections after ECAP processing. Experiments were conducted at the macroscopic level using Al 6063alloy and pure Copper as a model material with an initial annealed equiaxed with microscopic level of 5x and 10x where x=10.



**Al 6063 base material:** The following image shows the microstructure Al6063 alloy without doing ECAP process.

**REFERENCES**

[1] Ramesh Kumar S, Gudimetla K, Ravisankar B, and Jayasankar K, Grain Refinement of Al powder by equal channel Angular Pressing. Mater Science Eng (2012)

[2] Thermal conductivity of Aluminium fabricated by Equal Channel Angular Pressing. S. Lee/Presenter, S. Kwon.(2012).

[3] CS Reddy, et al. "Focal point computation and homogeneous geometrical transformation for linear curves." Perspectives in Science (2016).

[4] Micro structural and texture changes during equal channel angular pressing of an Al-Mg-Sc alloy- Oleg Sitdikov(2015).

[5] Reddy, C. S., et al. Obtaining Description for Simple Images using Surface Realization Techniques and Natural Language Processing, Indian Journal of Science and Technology 9.22 (2016).

[6] Microstructure evolution and mechanical properties of Al–6% Mg al- loys processed by ECAP. R. Haghayeghi (2015) .

[7] CS Reddy, et al, An Efficient Line Clipping Algorithm in 2D Space, In press, International Arab Journal of Information Technology, 2017.

[8] Equal channel angular pressing technique for the formation of ultra-fine grained structures- Kazeem O. Sanusi(2012).

[9] Mamatha, E., C. S. Reddy, and K. R. Prasad. "Antialiased Digital Pixel Plotting for Raster Scan Lines Using Area Evaluation." Emerging Research in Computing, Information, Communication and Applications. Springer Singapore, 2016. 461-468.

[10] Mamatha, E., C. S. Reddy, and Ramakrishna Prasad. "Mathematical Modeling of Markovian Queuing Network with Repairs, Breakdown and fixed Buffer." i-Manager's Journal on Software Engineering 6.3 (2012): 21.

[11] Reddy, C. Chandra Sekhar, et al. "Performance evaluation of homogeneous parallel processor system of Markov modeled queue." i-Manager's Journal on Software Engineering 3.2 (2008): 58.

[12] Reddy, P. Sudarsan, et al. "Finite Element Analysis of Thermo-Diffusion and Diffusion-Thermo Effects on Convective Heat and Mass Transfer Flow through a Porous Medium in Cylindrical Annulus in the Presence of Constant Heat Source." International journal of applied mathematics and mechanics 6.7 (2010): 43-62.

[13] Reddy, C., and K. Ramakrishna Prasad. "The Study State Analysis of Tandem Queue with Blocking and Feedback." *arXiv preprint arXiv:1006.2693*(2010).

[14] Densification of Al-Y2O3 composite powder by equal channel angular pressing. by Ramu Yarra, et al (2010).

[15] Mamatha, E., S. Saritha, and C. S. Reddy. "Stochastic Scheduling Algorithm for Distributed Cloud Networks using Heuristic Approach." *International Journal of Advanced Networking and Applications* 8.1 (2016): 3009.