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Influence of Equal Channel Angular Pressing Modified Die on the Mechanical Properties & Micro Structure of Copper Alloy

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Abstract. *One of the best suited method for producing grain refinement/severe plastic deformation is Equal channel angular pressing, without any change in dimension of sample/billets. In this work a modified die is presented in which not only nut and bolts are used but a pair of studs also used for better alignment of two piece die. The change in hardness and microstructure has been studied after equal channel angular pressing has in copper alloy by Vickers hardness testing. The billets were examined after two, four and six passes operations by route* B_C*. ECAP die has die channel angle 120º and angle of curvature 35º. The microscopic view indicates that the strain produced during ECAP and the grain size reduces after each pass in the direction nearly parallel to die channel exit. Different UFG can be obtained by changing processing routes and parameters of die.*

Keywords—ECAP, SPD, Die design, UFG

1. Introduction

At present most important area of research is study of Materials & their properties. There is lack of materials having good characteristics/properties. If we tried to overcome this problem we have to improve the properties/structure of the existing materials. The properties (strength & ductility) of the existing materials can be improved by the various methods like work hardening (Grain size reduction), alloying, precipitation hardening, grain boundary strengthening. [1].

Hall Petch Strengthening or grain boundary strengthening is most common method of strengthening the metals by changing the metals grain size[2]. The concept of SPD is firstly introduced by P.W.Bridgmanat Harvard University in 1930 [3][4] It can be defined as metalwork techniques which produced very high strain regions & high shear zone resulting in ultrafine grain. Large plastic deformation can be achieved by simply forming techniques like cold rolling and wire drawing, but the most popular methods/techniques for producing SPD are E-CAP technique, high pressure torsion technique, accumulative roll bonding technique, constrained groove pressing technique, accumulative back extrusion technique, tubular channel angular pressing technique.

ECAP is an extrusion process, introduced by V.M. Segal in 1977 in USA[5][4]. The most important quality of ECAP method which makes this technique unique from others is that in ECAP considerable grain refinement takes place without any change in dimension of sample. Multiple pressing in the die provides ultra-fine grains structure. The ultrafine grained structure produced by the ECAP is quite depend on the details of the type of process like route and number of passes, type of lubricant used like oil[6]

The die geometry has a massive influence on the strain introduced during pressing of material by ECAP. The properties of samples are powerfully dependent mainly on the die design The effectiveness of die depends on the two angles known as die channel angle and angle of curvature. Φ is known as die channel angle which varies from 90 to 150 & ψ is known as die corner angle/angle of curvature which varies from 0 to (180- ϕ) [7][8]

The die has been made of in the form of two halves each of dimensions 100mm*40mm*120mm. The channel is of diameter 12.7mm, die channel angle is selected as 120^0 and angle of curvature is preferred as 35^0

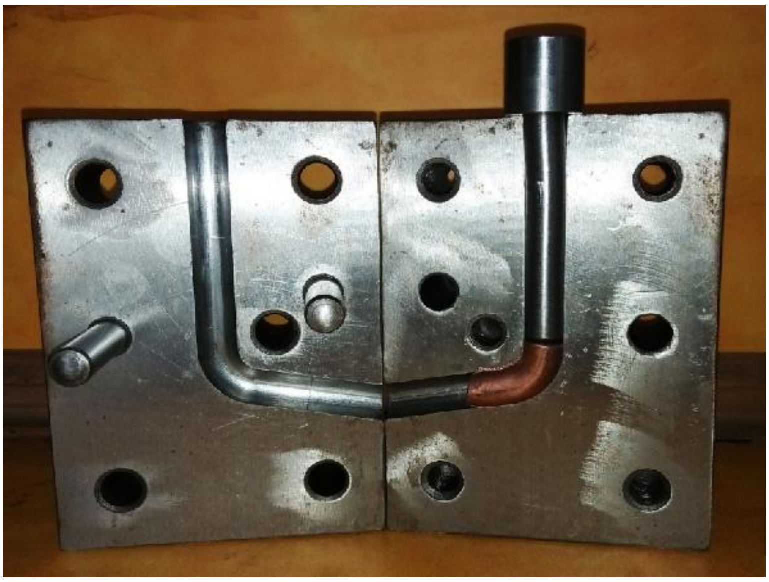

Figure-1: Modified Die design

2. Experimental Procedure

A copper alloy was chosen for the experimentation [9]. The important properties of copper alloy is a good electrical conductivity, good thermal conductivity, corrosion resistant, ductile, tough, non-magnetic, easy to alloy, recyclable attractive colour etc. A billet of copper alloy is passed through the die having dimensions 100mm*40mm*120mm & die channel angle of 120^0& angle of curvature 35^0 [10] Three billets are taken for the experimentation. The billet is passed through the die for two, four and six time for different-different billets, preferring the route B_C.[11] The billets are pressed with the help plunger, which is pushed with high load applied by the UTM (Universal testing machine).

3. Results

Here, results after passing through die are presented. Copper billets were passed through die and following observations were made.

The billet of copper alloy was taken. This billet was passed through the die two times by using route B_C. The value of maximum load applied is 21kN with a displacement of 49.8 mm. Another billet of copper alloy was considered. This billet was passed through the die four times. The maximum value of load this time was 27 kN reaching a displacement of 47.9 mm.

Figure-2: Copper billet after two passes

Figure-3: Copper billet after four passes

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Another billet of copper alloy was passed through the die. This billet was passed six times. The maximum value of load was 31kN with displacement reaching 46 mm.

Figure-4: Copper billet after six passes

Tables and charts

The load applied by the plunger moving into the die has not been uniform during its passage. The maximum loads during each passes have been recorded in table 1 and corresponding graph is shown in figure-5.

Table-1: Variations of loads with displacement after various passes

S. No.	Number of passes	Displacement (in mm)	Load applied (in kN)
1	1	45	18
2	2	49.8	21
3	3	49	24.2
4	4	47.9	27
5	5	46.8	28.6
6	6	46	31

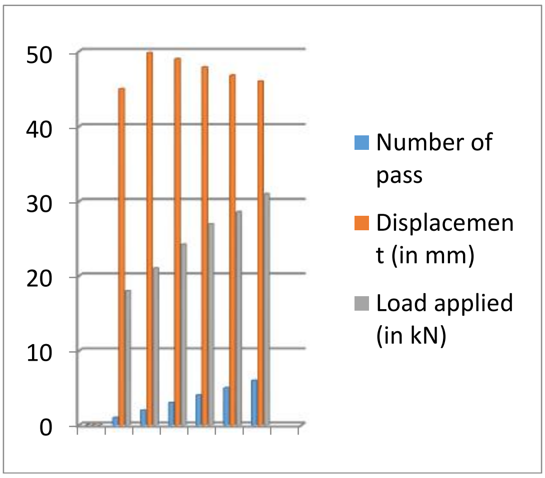

Figure-5: Graph showing variation of load and displacement after various pass

Hardness & Microstructure Result

The final aim of the present work is to improve the properties & grain structure of copper alloy. For this, very fine grains were tried to fabricate using one of the best SPD technique known as equal channel angular pressing process. Afterward, various mechanical and optical microstructure tests have been done for justification of hall petch rule.

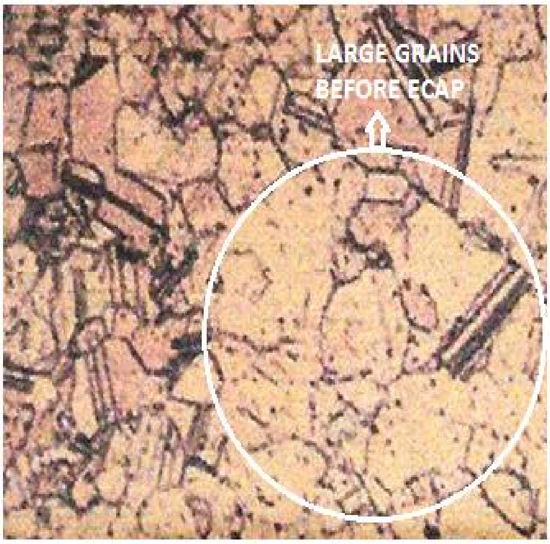

Figure-6: Microstructure of specimen

Figure-7: Microstructure after two passes

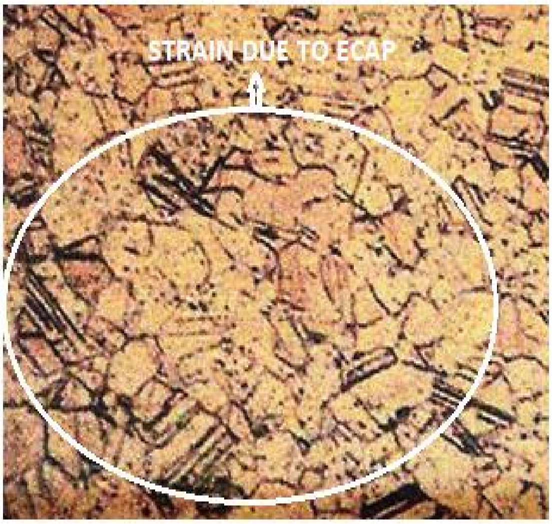

Figure-8: Microstructure after four passes

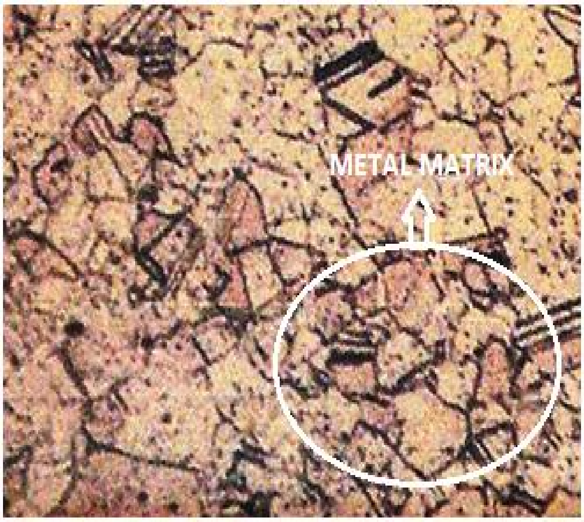

Figure-9: Microstructure after six passes

4. Discussion

The whole experiment of ECAP was done with accuracy. Mainly micro hardness and micro structure was analysed in detail for better understanding between changes in structure with respect to hardness after every pass. The change in the value of Vickers hardness (HV) with respect to number of passes through ECAP die by specific route B_C has been recorded in Table no.2. The Vickers micro hardness (HV) magnitudes of Cu alloy is 81 HV before ECAP process. After applying severe plastic deformation technique i.e. equal channel angular pressing on the as-received billets shows significant improvements at the HV values. It can be observed that there is major increase in hardness values after the first pass for the billet. In addition, it can be said that the increase in hardness magnitude changes/improving with the number of passes.

Table-2: Variation of Vickers Hardness with number of passes

S .NO.	NUMBER OF PASS	VICKERS HARDNESS (in Hv)
1	0	81
2	2	93
3	4	95
4	6	99

5. Conclusion

The measurement of mechanical property (hardness) and microstructure has been examined when processed by ECAP, by using modified die.

1. The grains in the centre are well framed than that in the end part of the billets.
2. The value of Vickers hardness observed 81,93,95,99 for zero, two, four and six passes, the values shows that hardness increases with increasing ECAP pass.
3. Homogeneity of grain particles can be detected more uniform after sixth pass.
4. Structure shows fine grains of copper to form metallic matrix after sixth pass.

6. References

[1] S. Technical and A. Engineer, “Enhancement of Microstructure and Mechanical Properties Through Equal Channel Angular Pressing of Aluminium Processed By Powder Metallurgy Route,” vol. 2, no. 9, pp. 4964–4976, 2013.
[2] Y. Ito, K. Edalati, and Z. Horita, “High-pressure torsion of aluminum with ultrahigh purity (99.9999%) and occurrence of inverse Hall-Petch relationship,” *Mater. Sci. Eng. A*, vol. 679, pp. 428–434, 2017.
[3] A. Azushima *et al.*, “Severe plastic deformation (SPD) processes for metals,” *CIRP Ann. - Manuf. Technol.*, vol. 57, no. 2, pp. 716–735, 2008.
[4] F. Salimyanfard, M. R. Toroghinejad, F. Ashrafizadeh, M. Hoseini, and J. A. Szpunar, “Investigation of texture and mechanical properties of copper processed by new route of equal channel angular pressing,” *Mater. Des.*, vol. 44, pp. 374–381, 2013.
[5] M. Samaee, S. Najafi, A. R. Eivani, H. R. Jafarian, and J. Zhou, “Simultaneous improvements of the strength and ductility of fine-grained AA6063 alloy with increasing number of ECAP passes,” *Mater. Sci. Eng. A*, vol. 669, pp. 350–357, 2016.
[6] F. Salimyanfard, M. R. Toroghinejad, F. Ashrafizadeh, M. Hoseini, and J. A. Szpunar, “Textural evaluation of copper produced by equal channel angular pressing with routes A and B30,” *Mater. Sci. Eng. A*, vol. 527, no. 23, pp. 6260–6269, 2010.
[7] M. Farshidi and M. Kazeminezhad, “The effects of die geometry in tube channel pressing: Severe plastic deformation,” *Proc. Inst. Mech. Eng. Part L J. Mater. Des. Appl.*, vol. 230, no. 1, pp. 263–272, 2016.
[8] F. Djavanroodi, B. Omranpour, M. Ebrahimi, and M. Sedighi, “Designing of ECAP parameters based on strain distribution uniformity,” *Prog. Nat. Sci. Mater. Int.*, vol. 22, no. 5, pp. 452–460, 2012.
[9] A. Morozova and R. Kaibyshev, “Grain refinement and strengthening of a Cu–0.1Cr–0.06Zr alloy subjected to equal channel angular pressing,” *Philos. Mag.*, vol. 6435, no. May, pp. 1–24, 2017.
[10] F. Djavanroodi and M. Ebrahimi, “Effect of die parameters and material properties in ECAP with parallel channels,” *Mater. Sci. Eng. A*, vol. 527, no. 29–30, pp. 7593–7599, 2010.
[11] K. Rajeshwaran and M. Sureshkumar, “Microstructure Evalution of Equal Channel Angular Extrusion In Aluminium 5083 Alloy by Cryogenic Treatment,” pp. 200–205, 2016.