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ANALYSIS ON DEFORMATION BEHAVIOR FOR PURE COPPER PROCESSED THROUGH EQUAL CHANNEL ANGULAR PRESSING DIE

***Raj Mohan[1] , Venkatraman R[2] and Raghuraman S[3]**

[1]PG Scholar, SASTRA University, SoME, Thanjavur, Tamil Nadu- 613 401, India
[2]Director, Shanmugha Precision Forging, Thanjavur, Tamil Nadu- 613 401, India
[3]Professor, SASTRA University, SoMe, Thanjavur, Tamil Nadu- 613 401, India

ABSTRACT

Equal channel angular pressing (ECAP) is a feasible forming technique to process the material through a die without a change in cross sectional area of sample. The current work has been carried out to identify the deformation behavior of pure copper and its flow behavior along the die using ANSYS V12. The Analysis is carried out for different channel angles of 90˚, 110˚ and 120˚ for different hydrostatic pressure conditions. The results show that deformation along the die during pressing is inhomogeneous for various channel angles under different hydrostatic pressure conditions. Total displacement of sample during pressing decreases with increases with channel angle.

Keywords: *Equal Channel Angular Pressing, Deformation Behaviour and Flow Behaviour*

1. Introduction

Severe plastic deformation (SPD) is an effective tool for producing bulk ultrafine grained (submicron or nanostructure) metals. Equal channel angular pressing is one of the SPD techniques developed for producing ultra fine grain structures in submicron level by introducing a large amount of shear strain into the materials without changing the billet shape or dimensions [1]. Uniform and unidirectional deformations can be produced under relatively low pressure and load for massive products Production of Ultrafine-equiaxed grained (UFG) materials has been achieved e.g. grain size less than 1 µm. The crystallite size decreased and the dislocation density increased as a result of ECAP deformation. The ECAPed sample illustrates severe dynamic recovery during simple compression, perhaps promoted by the developed texture during ECAP. The higher strain hardening of the ECAPed samples during simple compression in the initial part of the deformation is due to the refined structure and the relatively high boundaries misorientation. It leads to achievement of Powder Compaction / Consolidation. High strength and high ductility phenomenon occurred. Loading conditions can be predicted. Significant increase in microhardness is obtained after the first pressing through the ECAP dies. To minimize the development time and cost. Equal channel angular pressing , a die with two intersected channel of equal cross section to set up severe strain by simple shear by passing material through it.

The current work dealt with the prediction of deformation behaviour for pure copper and its flow behaviour through analysis in ANSYS V12 for different channel angles of 90˚, 110˚ and 120˚ with different hydrostatic pressure conditions.

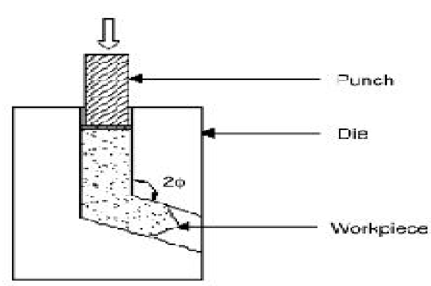

Fig. 1 Schematic Diagram of ECAP Process

Many FEM-based investigations have been carried out to determine the deformation behavior of materials and study includes the effect of channel angle and outer corner for frictionless condition [2]. The billet showed inhomogeneous deformation on the surface of the billet with channel angle 90˚ and 120˚ and without or without fillets after one-pass ECAE. The deformation homogeneity with fillets at corner angle is better than that without fillets from the simulation and experimental results, because fillet at the inner channel surface junction where the two straight channels meet helps

**Corresponding Author - E- mail: 23.rajmohan@gmail.com*

process materials with high percentage of flow softening [3].

The deformation behaviour is more complicated with acute channel angles $\phi < 90^\circ$, and becomes smooth with obtuse channel angles $\phi > 90^\circ$. Lack of free flow of the sample caused strain heterogeneity with acute channel angles. Large corner gap formation and inadequate length of plastic zone caused the strain heterogeneity with obtuse channel angles [4]. The less sheared zones are formed in non-strain hardening materials of the round corner die conditions and in strain hardening materials. In the strain hardening materials, the deformed geometry was predicted to be almost independent of the die corner angle [5]. The work piece material used in the analysis was annealed pure copper and result implies that there are many possibilities to control the deformation behaviour of materials during ECAP by simply combining the die and work piece geometries [6].

The work aims to predict deformation behaviour and to investigate the deformation flow for pure copper along the die during pressing.

2. Modeling and Analysis

'A' is sample cross section area 10 mm and 'F' is force in Ton, hydrostatic pressure is to be around 1269 MPa for 10 tons ie. 1 Ton = 9964 N. Analysis carried for five different hydrostatic pressure conditions they are 127 Mpa (1 Ton), 381 Mpa (3 Ton), 635Mpa (5 Ton), 888.5 Mpa (7 Ton), and 1269 Mpa (10 Ton).

The Die for Equal Channel Angular Pressing is designed with three different channel angles i.e. 90˚, 110˚, 120˚.

Die with channel angle 'ϕ' 90˚, as shown in Fig. 2. , Die with channel angle 'ϕ' 110˚, as shown in Fig. 3. and Die with channel angle 'ϕ' 120˚, as shown in Fig. 4.

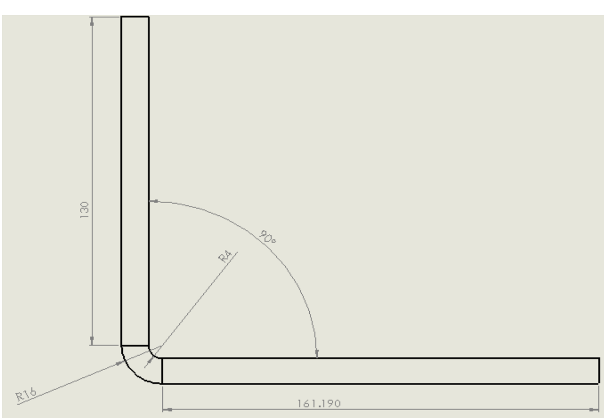

Fig. 2 Die with Channel Angle 'ϕ' 90˚

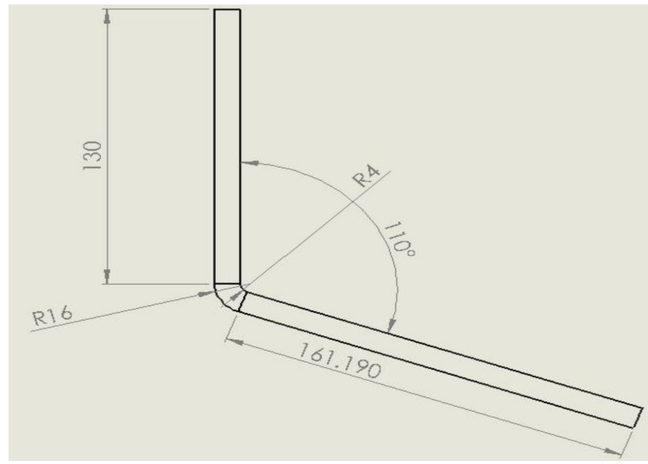

Fig. 3 Die with Channel Angle 'ϕ' 110˚

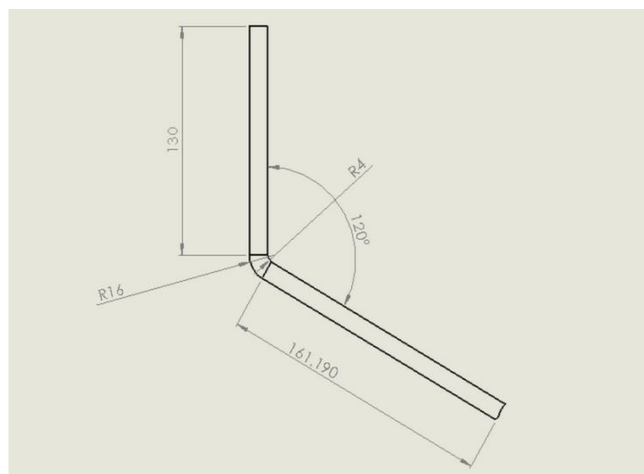

Fig. 4 Die with Channel Angle 'ϕ' 120˚

2.1 Assumptions

The material is considered as continuous, isotropic and homogeneous. Heat generated due to deformation and friction was neglected. The von Mises flow rule is used.

2.2 Boundary Conditions

Displacement and rotation in x, y and z direction for all nodes in the die were arrested.

Apply the Pressure on the top surface of the work-piece resulting the sample displacement.

The dislocation in the direction perpendicular to the plane and rotation about other two directions were detained.

3. Result and Discussion

Total deformation or displacement is obtained w.r.t various hydrostatic pressure for different channel angles were analysed. The deformation for channel angles 90˚, 110˚, and 120˚ during the application of various hydrostatic pressure conditions as shown below in Fig.5.

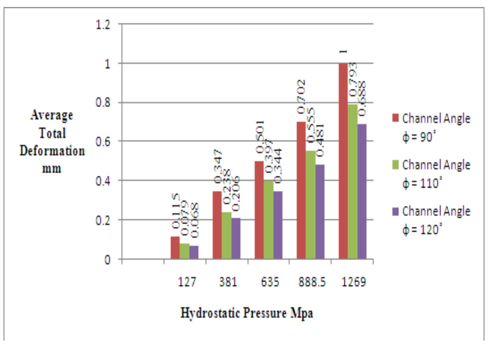

Fig. 5 Consolidated Average Total Deformation for Different Channel Angles

Deformation flow along the die w.r.t various hydrostatic pressure for different channel angle were analyzed. The flow behaviour for channel angle 90˚, 110˚, and 120˚ during the application of various hydrostatic pressures as shown below in Fig.6, Fig.7, Fig.8.

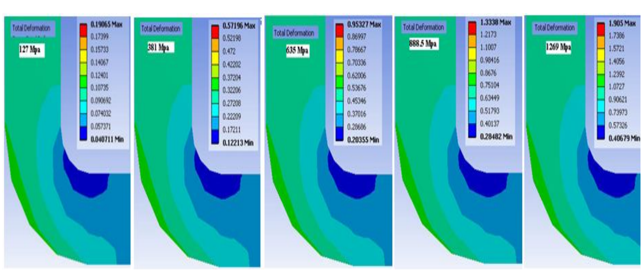

Fig. 6 Deformation Flow for Channel Angle 90˚

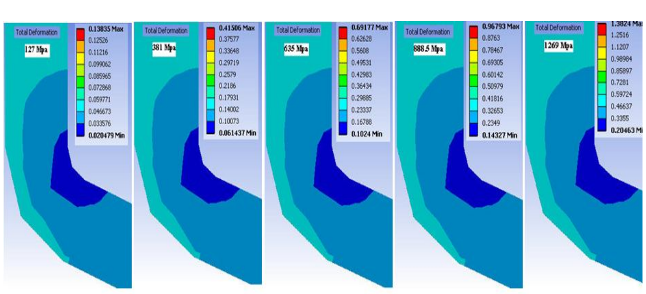

Fig. 7 Deformation Flow for Channel Angle 110˚

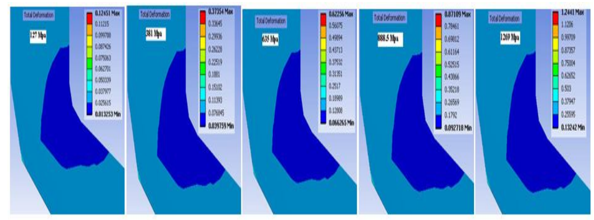

Fig. 8 Deformation Flow for Channel Angle 120˚

4. Conclusion

It was observed that deformation along the die during pressing is inhomogeneous for various channel angles 90^o, 110^o, and 120^o under different hydrostatic pressure conditions.

Results shows that the total displacement of sample during pressing decreases with increases with channel angle. It leads to reduce the requirement of Ejector Pin and facilitates the flow during Pressing.

5. Scope of the Future Work

During analysis, Friction factor is to consider and predicting behaviour of the material.

Analysis will carried out with application of back pressure and predicts the corresponding behaviour.

If Mesh Density differs, deformation differs. So, analysis will carried out with different mesh density.

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