Optimization of Equal Channel Angular Pressing Dies for Aluminium Alloys Rod/Bar through Critical Fem Analysis

Pavankumar Yakulwar[1] Akash Keshavshetty[2] Sameer Bagwan[3] Sandip Dhumal[4] Dr. Changela Kandarp[5]

[1,2,3,4]Student [5]Associate Professor

[1,2,3,4,5]Department of Mechanical Engineering

[1,2,3,4,5]G.H.Raisoni College Of Engineering And Management Wagholi, Pune - 412 207 MH, India

Abstract— This research paper incudes the total study of simulation and FEM analysis of ECAP Die for aluminium alloy. The die consists of the angular channel which have some angles. Which are shown in fig 1.1; fig1.2; fig1.3. These three 3D animated models which are developed in the Catia V5 and also, we are getting the analysis of the aluminium rod in the Ansys software. The FEM analysis includes some Inputs which are the Temperature, Time, Area, coefficient of Heat Transfer(H) and the thermal conductivity of Die(K) or an Aluminium Bar. The Output come in terms of Heat Flux and Direction of Heat Flow.

Keywords: ECAP, FEM analysis, Thermal Conductivity

I. INTRODUCTION

From the Last five to ten years, we see the research community focused on the plastic deformation of the material. Which have any kind of matters, The Unique physical and the mechanical properties obtained by plastic deformation processing. The plastic deformation of a work-piece, resulting in alteration of the microstructure and texture, in principal reduction of the grain size to the sub-micron or the nano-meter scale. The most common process of plastic deformation is the equal channel angular pressing (ECAP), which involves pressing a billet through a die consisting of two channels of equal cross sections, intersecting at an angle, typically it is 90,100,120 degree. The process of ECAP allows us to introduce very large plastic deformations to a work-piece without altering the overall geometry of the work-piece. Further, the mechanical properties have been investigated for a series if processing parameters and finally, a detailed study of the texture development and deformation mechanisms have been made. In the present work, the main focus has been to gain a better understanding of the deformation mechanisms operating in the ECAP process, which leads to the observed intense grain refinement. In this process, a vast amount of EBSD measurements was carried out, including two processing routes (route A and B) and four accumulated strain levels, corresponding to four ECAP passes. Due to the enormous amount of collected data, it proved impossible to collect all results and observations in this thesis; therefore, the main focus was set on the early stages of grain subdivision, i.e., the first two ECAP passes by route A. However, some results obtained at higher strains, i.e., higher number of passes, are included, such as grain size and misorientation distributions. The most important results on the microstructural development at higher strains will be published in international journals after the submission of the present thesis.

II. METHODOLOGY

ECAP method is that the most standard process route developed via the severe plastic deformation method 2 channels of equal crosswise area utilized as a die, and therefore the block is ironed between these dies, manufacturing desired strain on the fabric.

Defining the objective of the work

- Literature review
- Study and selection of various parameters affecting ECAP
- Finite Element Analysis by considering defined parameters.

III. TERMINOLOGY OF ECAP

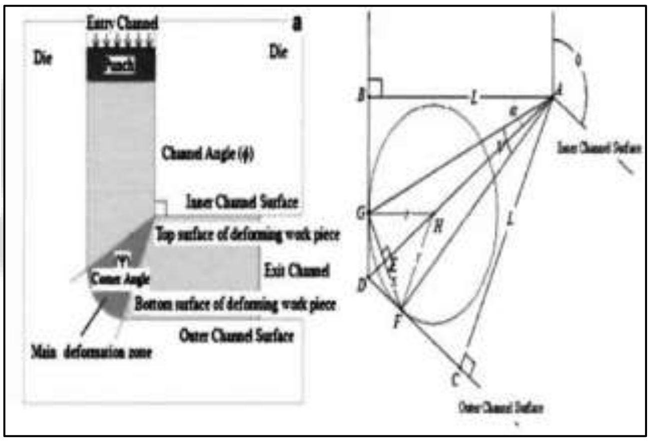

Fig. 3.1: shows terminology of ECAP

- Channel angle (Φ): It is the angel between two channels of die. It may be acute angle, right angel or obtuse angel.
- Corner angle (Ψ): For any given channel angle (Φ), the minimum and maximum value of a corner angle (Ψ) can take as 0 and π- Φ, respectively.

IV. EFFECT OF PARAMETERS ON ECAP

1) With increasing corner angle, the strain at all-time low surface of the deforming work piece exhibiting strain hardening, organic material behaviour decreases until a corner angle 45 degree and will increase thenceforth. this can be attributed to synergistic result of mixed mode of deformation and uneven nature of the corner gap.
2) With low corner angles (Ψ <=40o), process of materials with high proportion of flow softening. characteristic is troublesome. Friction has a pronounced result on the deformation behaviour, with increasing friction during a die with none corner angle, a strain hardening material sticks to the outer channel surface forming a dead metal

zone and also the strain distribution becomes nonuniform.

3) If a corner angle is provided, the results of friction area unit reduced and also the strain distribution becomes homogeneous regardless of the organic material behaviour.
4) Providing fillet at the inner channel surface junction wherever the 2 straight channels meet helps to method materials with high proportion of flow softening.
5) The optimum corner Angle and inner fillet radius for deforming a range of engineering materials with behaviour travel kind strain hardening to flow softening through an ECAP die with a channel angle of 90 degree was found to be 40 and five millimetres, severally.

V. SCOPE AND OBJECTIVE

There exists a spread of ways to impose giant plastic strains on materials so as to supply fine-grained microstructures. Forging, extrusion, drawing, and rolling are used for this purpose, however all of them have vital drawbacks. Multiple reductions of the initial billet crosswise restricted by the geometrical amendment of the work piece, require high hundreds, and end in a non-uniform deformation. In the gift work, by considering the die utilized in ECAP and analysing the die for stress variation beneath completely different operating conditions of higher than consolidation of MMC method and showing the stress variation on die beneath many parameter variations. The deformation behaviour of sq. cross sectional sample of an ECAP die with a channel angle 90 degree and corner angle 40 is simulated victimisation ANSYS.

VI. EXPERIMENTAL PROCEDURE

The dimensions of the die used in consolidation of aluminum alloy are taken from the journals on ECAP; they are mentioned in reference section. The overall dimensions are shown in fig.

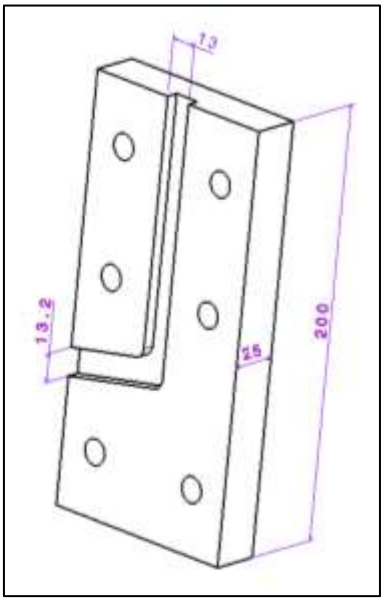

Fig. 6.1: Die Structure and Its Dimentions

For analysis in ANSYS the model is assumed to be a second drawback with no thickness. The corner angles for various channels area unit calculated by the equation several parameters had to be taken into thought relating to sample form, sample size, working, and most work load. we have a tendency to set to use a 90° die with an oblong section of two hundred x one hundred metric linear unit2 cross section and sample length of eighty mm that ought to be capable of a most work of 20KN. and also the outer fillet radius is 15mm and Inner fillet radius is five metric linear unit. Cross section of Channel is within the sq. form the size area unit 12x12 metric linear unit.

$$\varphi = 2tan^{-1}\left[\frac{rcos\left(\frac{\emptyset}{2}\right)\sin\left(\frac{\emptyset}{2}\right)}{L - rcos2\left(\frac{\emptyset}{2}\right)}\right]$$

Where,

φ=corner angle (0º to 90º)

Φ =channel angle (90ºto120º)

r= corner radius (5mm)

L= width of channel (12 mm)

Calculation for corner radius which is used in analysis.

Channel Angle	Corner Angle	Corner Radius
At <D= 90	'P = 0	R = 0 mm
	'¥ =45°	R = 5mm
	'¥ =90°	R = 10 mm
At <p=100	'P = 0	R = 0 mm
	'¥ = 45°	R = 5mm
	'¥ = 90°	R = 10 mm
At <p = 120	'P = 0	R = 0 mm
	'¥ = 45°	R = 5 mm
	'¥ = 90°	R = 10 mm

Table 1: Corner radius for various channel angles.

VII. ECAP PROCESSING

For analysis in Ansys the model is assumed to be a second drawback with no thickness. The corner angles for various channels area unit calculated by the equation several parameters had to be taken into thought relating to sample form, sample size, working, and most work load. we have a tendency to set to use a 90° die with an oblong section of two hundred x one hundred metric linear unit2 cross section and sample length of eighty mm that ought to be capable of a most work of 20KN. and also the outer fillet radius is 15mm and Inner fillet radius is five metric linear unit. Cross section of Channel is within the sq. form the size area unit 12x12 metric linear unit.

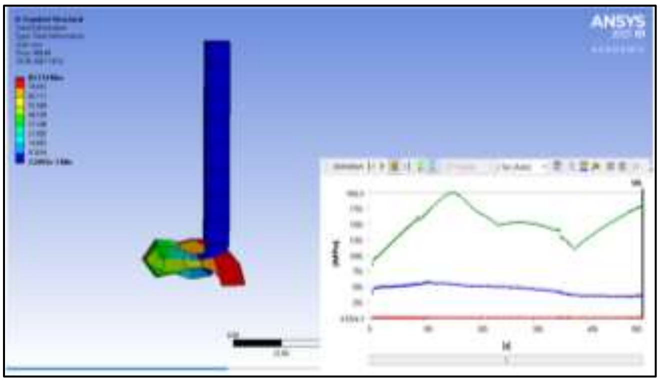

Fig. 7.1: ECAP Analysis Deformation

VIII. ECAP PROCESSING ROUTES

By changing the orientation of the specimen between successive presses, complex microstructures and textures can be developed. For attaining profound grain refinement (to ECAP Processing Routes nanoscales), the development of optimal routes for microstructure control, by changing the orientation after each pass, is critical. Three fundamental ECAP routes are defined and utilised to obtain different textures and microstructures.

Route A is when the orientation of the specimen remains unchanged after each pass.

Route B is when the specimen is rotated around its longitudinal axis after each pass. If the rotation is always performed in the same direction, it is called route BA, and if the rotation direction is alternated between counter clockwise and clockwise, it is called route BC.

Above figure shows all four routes (Routes A, BA, BC and C) for conducting ECAP passes. The differences between Routes A, B and C are the shearing direction and the shear plane orientation. Some of the experiments performed have demonstrated that Route BC is an excellent processing route for producing ultra-fine microstructures.

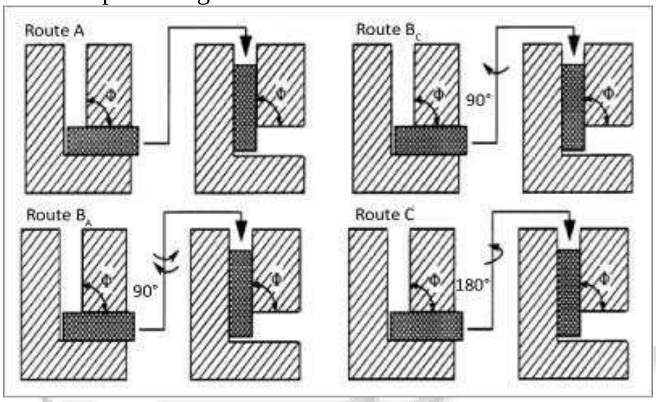

Fig. 8.1: ECAP Route Processing

IX. FUTURE PLAN

1) To eliminate the discontinuities of the evoked strain within PDZ.
2) To generate a PDZ, whose form and size can match higher the important conditions of the deformation, wherever the hardening/softening properties, that square measure manifesting at the outer- corner of the ECAP die, the friction, or the shear localization, that square measure manifesting at the inner corner of the ECAP die square measure taken into consideration.
3) To embody the yield property of the hexagonal-closed packed (HCP) structures within the definition of the equivalent strain.
4) To realize an analytical flow-line model to predict the experimental knowledge obtained for the shear- strain mapping. The results obtained on the deformation textures of the studied Mg alloys square measure a valuab0le information for conducting the in-detail visco-plastic consistent simulations, and to use the plastic spin theory to ECAP deformation. The texture-mapping procedure, that was fortunate in deciding through an experiment the lattice rotation throughout one pass of ECAP.

X. CONCLUSION

Form the whole analysis we can made this conclusion:
If we change the channel angle by keeping velocity of the input material same then stress value is accrued.

From the analysis we can say that die have following design parameters that considered as optimal design.

Channel angle = 120 Degree
Corner angle = 0 degree

REFERENCES

[1] Vasile Danut Cojocaru, Donia Raducnu , Nicolae Serban, Icon cinc, Rami Sban, Mechanical behaviour comparison between unprocessed and ECAP 6063 t835 alluminium alloy, U.P.B sci. Bull., Series B, vol. 72, Iss. 3, 2010.
[2] W.Z. Han , Z.F. Zhang, S.D. Wu S.X. Li Investigation on the geometrical aspects of deformation during ECAP Extrusion in an AL-MG-Si alloy.
[3] Gleiter H. Nanocrystalline materials. Progress in materials science 989;33:223-315.
[4] Langdon TG. Processing by sever plastic deformation : Hestorical developments and current impacts. Matewrial science forum.2011;667-669:9-14
[5] V. M. Segal, V. I. Reznikov, A. E. Drobyshevskiy, V. I. Kopilov, Russ. Metall. 1 (1981) 99.