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Research Paper

FLOW ANALYSIS OF PURE ALUMINIUM IN MODIFIED ECAP

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Equal Channel Angular Processing (ECAP)is a novel technique for producing ultra-fine grain structures in submicron level introducing a large amount of shear strain into the materials without changing the billet shape or dimensions. This process well suited for aluminum alloys. We can apply ECAP technique to 99.99% pure aluminum. In this work, ECAP process has been performed on commercial pure aluminum to passes in a defined route. After Verification of FEM analysis, by the influences of die channel angles, strain distribution is produced. By increasing the strain, the Grain sizes changes and become more strength. The results are compared with already existing results available on pure aluminum. Analysis is taken after strain displacement

Keywords: Component, Aluminium, ECAP, FEM analysis

INTRODUCTION

Light metals with high strength are the intermediate and future requirements for aerospace as well as automotive industries. Grain refinement is one of the techniques, which provides finer grains and hence ultrahigh strength can improved by changing the grain size by the ECAP process.

Equal channel angular pressing is one of the techniques which are developed for producing ultrafine grain structures in smaller levels by introducing a large amount of shear strain into the materials without changing the billet shape or dimensions. ECAP technique is done in 99.99% pure aluminium. Current Period attempts to apply ECAP technique to 99.99% pure aluminium and characterize the resulting aluminium by optical microscopy.

EXPERIMENTAL

The dimensions for ECAP die for 10mm square work-piece are designed with $f_1 = 120^0$ and $f_2 = 150^0$, y_1 and y_2 (angle subtended by the arc of curvature at the point of intersection)= 60^0 and 30^0. Figure 1 says that schematic of ECAP and photograph of the fabricated ECAP die fitted on the hydraulic press of 25 tonnes capacity, respectively.

The material used in this work was commercially available 99.99% pure aluminium

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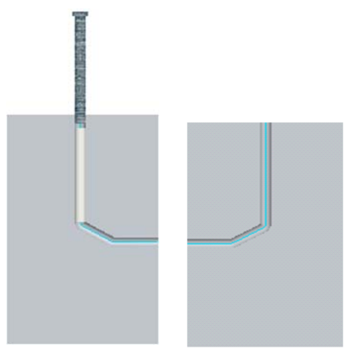
with a composition given in the table. The experiment were carried out by using the samples cut from an ingot and machined to the size of 250´150´96 mm and the angles are $f_1 = 120^0$ and $f_2 = 150^0$, $y_1 = 60^0$ and $y_2 = 30^0$. The experiments can be carried out by using the route, up to number of passes at room temperature, which is preferred route for achieving equi-axed grains.

Small samples were prepared for optical microscopic and atomic force microscopic studies. The following table shows the chemical composition of 99.99% of pure aluminium. The material of the die is h11 tool steel which is higher is strength compare to aluminium.

Table 1: Chemical Composition Of The 99.99% Pure Aluminium

S No	Element	Composition (%)
1	Silicon(Si)	0.07
2	Iron(Fe)	0.34
3	Titanium(Ti)	0.001
4	Vanadium(V)	0.008
5	Copper(Cu)	0.001
6	Manganese(Mn)	0.004
7	Aluminium(Al)	99.57
8	Others	0.002
	Total	99.99

Figure 1: ECAP Die Assembly Fitted With Plunger



EQUAL CHANNEL ANGULAR PRESSING (ECAP)

Process

The ECAP die is composed of two channels with identical rectangular cross sections connected through the intersection at a specific angle, usually $f_1 = 120^0$ and $f_2 = 150^0$. The cross section can also be circular or square (we used circular cross section). The workpiece is machined to fit within the channel and extruded through channels path with the same cross section using a plunger (Figure 1).

During the ECAP process, adequate lubrication is essential because of frictional influences, tool wear and the loads necessary for plastic deformation. One important advantage of the ECAP process is that it can be repeated several times without changing the dimensions of the workpiece, and the applied strain can be increased to any level; these advantages mean that the severe strains that can be applied and a simple shear deformation mode contribute to the strong and unusual properties of the material produced.

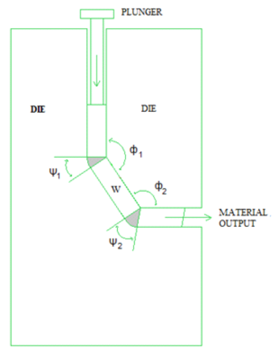
FACTORS THAT INFLUENCE GRAIN

Refinement in ECAP

Routes By Which The Material Processed

In ECAP the material is made to flow through the path and made stress at the bending angles (i.e.,$f_1 = 120^0$ and $f_2 = 150^0$, $y_1 = 60^0$and $y_2 = 30^0$). Due to the angles, shear acts and changes the grain sizes and increases the number of grains. While sending through the paths, lubricant is used to reduce the friction. One of the great advantages of the ECAP process is, it can able to send more number of times through the same path.

Figure 2



Super Plastic Behaviour

Ultra-fine grained materials exhibit superplastic behavior.Super plasticity is the capability of some polycrystalline materials to exhibit very large tensile deformations without necking or fracture. As grain size decreases, the temperatureat which super plasticityoccurs decreases, and the strain rate for the occurrence of super plasticity increases. This superplastic behavior is often observed in ultra-fine grained and nanocrystalline metals and alloys when the temperatures are low and the strain rates are high.

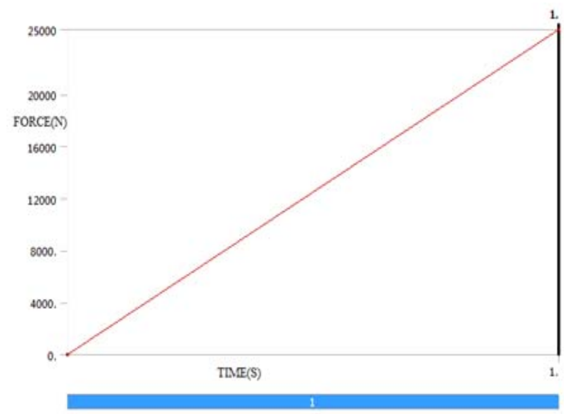
EXPERIMENTAL PROCEDURE

The ECAP die used for the experiment was a two-piece split die housed in a round channel with a diameter of 10 mm. The angle between the channels was $f_1 = 120^0$ and $f_2 = 150^0$,$y_1 = 60^0$and $y_2 = 30^0$.The die consisted of a highly polished smooth plate bolted to a second polished plate. The inlet and outlet channels had nearly the same dimensions.

Figure 2 ECAP die assembly fitted with plunger is used for the analysis. The ECAP process was performed on pure aluminium samples into diameters of 10 mm and lengths of 100 mm. The chemical composition of the pure aluminium is given in Table 1. In practical the samples were well lubricated with molybdenum disulphide based solid lubricant (MoS). The process can be performed using a 25-ton hydraulic press at room temperature, using route and up to 4 consecutive passes. Optical electron microscopy using a Nikon eclipse L150 was performed for microscopic observations. The grain size can be measuredon the cross section and the aggregate of grains were analyzing using software (ANSYS 14).

The Vickers hardness value can be determined using a Rockwell-type hardness testing machine.

Figure 3: Static Structural > Force VS Time



Pressing Speed

The pressing speed in ecap die made in gradual way with respect to time.25 tonnes of load is applied in hydraulic press over the plunger.due to the load the material flow through the cavity of the die.

SIMULATION-FEM ANALYSIS

New design of the ECAP die made up of h11 tool steel in PTC (Creo parametric) and analysis is done through the ansys14(workbench).

In the ANSYS, total deformation, directional deformation, equivalent elastic strain equivalent stress solutions were found and listed below.

Figure 4: Directional Deformation

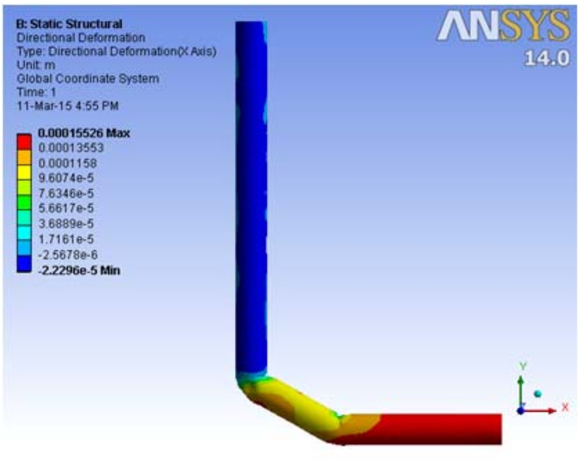


Figure 5: Equivalent Elastic Strain

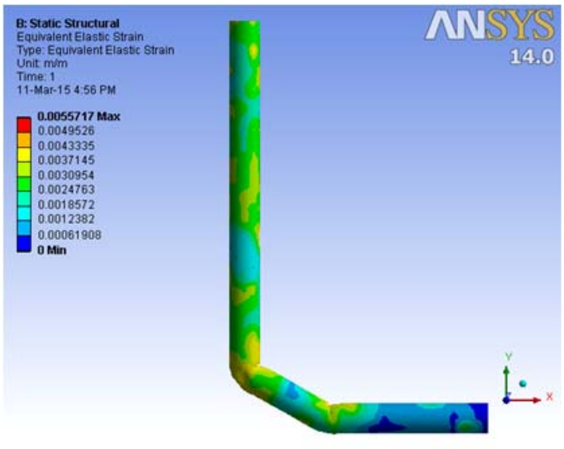
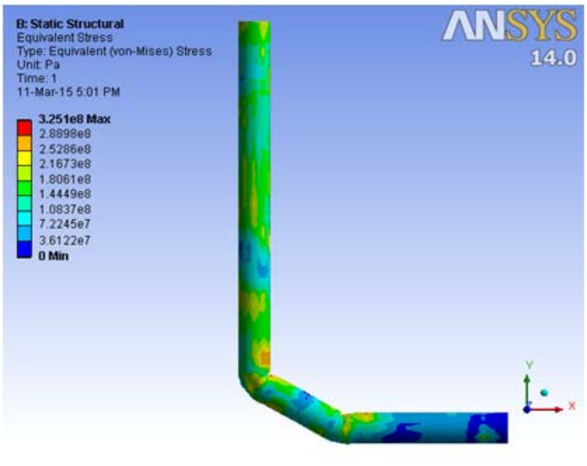


Figure 6: Equivalent Stress

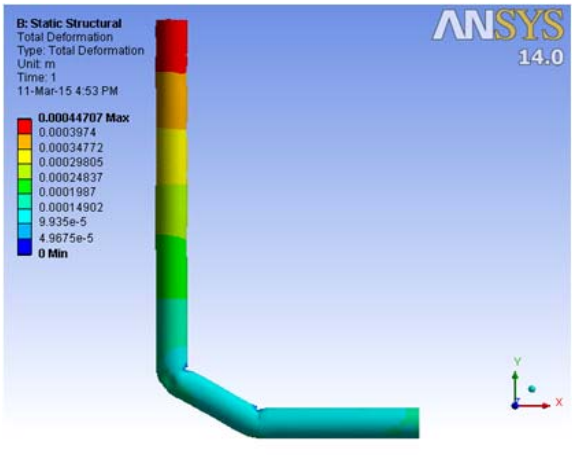


Figures 4,5,6,7 shows the total deformation, directional deformation, equivalent elastic strain equivalent stress at $\phi_1 = 120^0$ and $\phi_2 = 150^0$, $\psi_1 = 60^0$ and $\psi_2 = 30^0$ angles in ECAP die.

To Find Out the Strain Values:

$$\epsilon_{eq} = N/\sqrt{3}\left[2cot\left(\frac{\Phi+\Psi}{2}\right)+\Psi cosec\left(\frac{\Phi+\Psi}{2}\right)\right]$$

Figure 7: Total Deformation

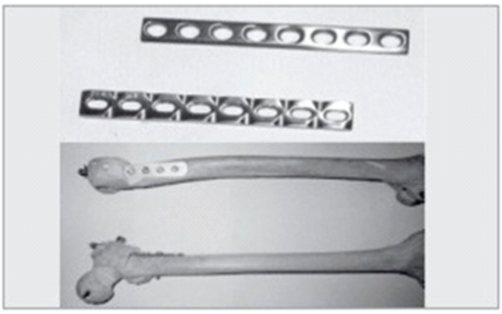


APPLICATIONS

These ultra-fine grained materials can be used in the manufacturing of semi-finished products.

It is used in the power applicants, aerospace, medical and automotive industries.

Figure 8: Medical Applications Of Equal Channel Angular Pressing Include The Manufacture Of Commercially Pure Titanium Instruments For Osteosynthesis



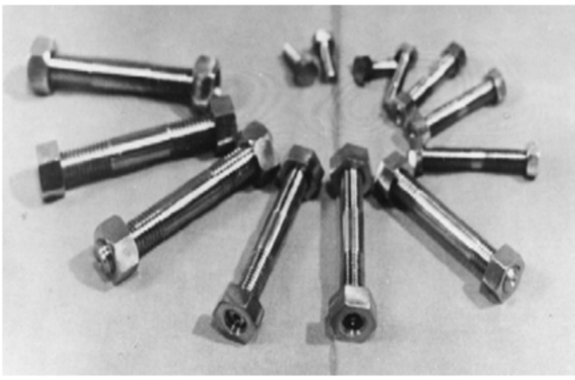
Source: Furukawa et al.

COMPARISION

Compared with 90^0 Die, $f_1 = 120^0$ and $f_2 = 150^0$, $y_1 = 60^0$ and $y_2 = 30^0$ ECAP die is more easy for pressing. Tonnage required for this die low compared with 90^0 die.

Since it is a two angle die, the grain size can be easily reduced.

Figure 9: High-strength Thread Articles Manufactured From A Titanium Alloy By Severe Plastic Deformation



RESULTS AND DISCUSSION

The Figures 4,5,6,7 shows deformations of pressed 99.99% pure aluminium. Initially, the unpressed material can be composed of large grains. After ECAP process, original grains are uniformly elongated.This dislocation density increases and grains become extremely fine.

Further this ECAP method can be proceeded by practically and the grain size of various passes can be found by Optical electron microscopy using a Nikon eclipse L150 and various microscopic behaviors can be found.

With the help of furnace setup in ECAP process, such as pure copper, copper composites, aluminium composites, etc., can also be done.

CONCLUSION

By this process we can change the metal behavior of the pure aluminium and make it as more stronger with out changing its properties. The main objective of this project is to reduce the grain size of the aluminium.

Further by this process we can make with more composites with out changing its billet shape and its properties.

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