




Study of the effect of ECAPed Method on the Mechanical Properties of AA 5083: An Overview

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Abstract

The geometrical structuring of a material to increase both physical and mechanical qualities is known as Severe plastic deformation (SPD). To obtain superior mechanical qualities, the co-channel angular plastic deformation (ECAP) approach, which is an alternative to conventional plastic deformation, is applied and developed. When compared to previous procedures, a substantially smaller grain size is obtained as a result of applying large unit deformation to the part in one go and rearrangement of dislocations. The method that has the most potential to find itself as a field of application today is ECAP, which of the extreme plastic processes is the most well-known, giving the combination of ductility and high strength, which is a rare attribute in materials. The effect of ECAP, a type of extreme deformation of plastic, on the mechanical characteristics of 5083 aluminium alloy was examined in this work.

1. Introduction

Many small granular and nanocrystalline materials are produced in the procedures, indicating a significant rise in research. SPD is a metallic forming method that involves the application of a plastic stress to a size of order of metal to generate UFG. The Severe plastic deformation technique is designed to create parts that are ecologically benign, high-strength, and lightweight (Kamaruddin, Shahira, and Katimon). Extreme plastic deformation methods are the most effective among the plastic deformation processes for generating high strength increases using relatively simple moulds and mould layouts, especially in grain size refinement. ECAP's poly-crystalline materials feature a unique microstructure and excellent mechanical characteristics. The materials that

have been treated have ultra-high strength, ductility, and super-plastic forming behaviour. ECAP materials' exceptional strength and ductility call into question what we know about the micro-structural characteristics of metals treated by extreme plastic deformation (Sadasivan, Balasubramanian, and Rameshbapu)

Nanocrystalline grain sizes in multi-grained materials range from 1 nm to 110 nm. If the grain size is between 150 and 550 nanometers, it is considered ultra-fine grain. grain size 0.8 μm - If the grain size is in the range of 12 μm , it is fine-grained; if the grain size is higher than 12 μm , it is coarse-grained. For various materials, plastic deformation, structure alteration, and property enhancement are possible. It's a good way to get things done. Traditional metal forming procedures including extrusion, forg-

ing, and rolling have been employed to attain this goal until now. The original billet cross-section drops too much during these processes, requiring high pressures, and stress-strain anomalies emerge during operation. Often, high-capacity machinery and pricey tools are necessary, is audible These are significant difficulties to overcome when making high-quality and large-scale products (Singh et al.)

This situation demonstrates that traditional processes are inefficient, and that sophisticated technology should be used to produce special deformation methods. When creating nanostructured development in materials, some conditions should be considered while using high plastic deformation procedures. First and foremost, Grain morphologies with ultra-fine grain boundaries and high angle grain boundaries are crucial. To ensure that the processed materials' characteristics remain steady, nanostructured must be generated consistently throughout the sample volume. There should be no mechanical damage or cracks when the samples are subjected to significant plastic deformations. Rolling, drawing, and extrusion are examples of plastic deformation techniques that do not match these requirements (Eivani et al.) . The largest distinguishing aspect of Equal Channel Angular Pressing is that it maintains the material's random sample after the procedure. As a result, high-stress plastics without cross-sectional change deformation are achievable. Multiple passes may cause substantial deformation in a specimen in order to enhance plastic stress (Beyerlein, Lebensohn, and Tome)

2. Equal Channel Angular Pressing Method (ECAP)

Segal and her colleagues at the Institute in Minsk in the 1970s and 1980s, Soviet Union, initially created ECAP, also known as (ECAE). The major goal was to create shear stress to the metal rods by delivering a large amount of force in order to shape the metal materials. The goal was accomplished, however the ECAP approach received insufficient the scientific community is paying heed. In the 1990s, things began to shift. ECAP products have been shown in reports and studies to have the capacity to manufacture ultra-fine grain and submicron metals with new and distinctive characteristics. The ECAP approach became an industrial application as a result of useful outcomes and studies. Angular pressing process

with equal channels, it entails pressing a material into a mould having two channels and a specific cross-section. As shown in Figure 1, the die has a channel angle (Φ) and an exterior curvature angle (Ψ) that defines the arc of curvature at the outer point of the junction region of the two channels (Silva)

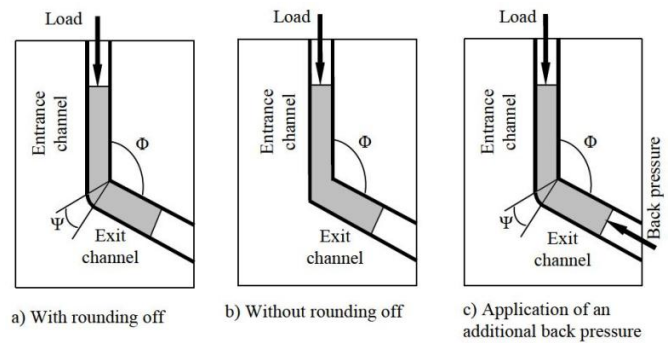


FIGURE 1. ECAP method basic mould design and process parameters

The sample only goes through simple shear deformation and retains its section shape. It is possible to repeat the transitions in the pressing process in sequence to improve grist size up to the size specified by the material's property. Multi-pass products can produce extremely large effective deformation. The method also results in a material with a significant crystallographic texture (Ebrahimi, Pashmforoush, and Gode)

3. ECAP Process Parameters

The ECAP procedure takes into account basic process variables such as die angles, pressing speed, process routes, pressing temperature, back pressing (back pressure), material to be pressed, and the number of passes. In ECAP, the amount of stress applied to a sample during transit is determined by the angle (Φ). The tension is also affected by the exterior curvature angle (Ψ). Micro-structures created using the ECAP technique have been documented in the literature. Several papers have been published that describe. In the majority of these tests, an Equal Channel Angular Pressing mould along a 90° angle of the channel was used. When utilizing a die along an angle of the groove (Φ) when the angle is more than 90 degrees, pressing gets easy. As a result, metals that are difficult to deform and have poor ductility are more easily pressed. According to the findings of the research, the figure of 90° is the ideal channel angle that should be used in all

studies (Bagherpour et al.) . In ECAP operations, hydraulic presses with high speeds are commonly used. Press speeds typically range from 1 to 24 mm/s. The equilibrium size of the very small particles created in the ECAP process is unaffected by press speed (Aal, Ibrahim, and Sadawy)

In the ECAP press, there are several processing options. The changes in the sample's processing direction and rotation are indicated in Fig 2. Typically, these are without the samples spinning (Route A)

- Rotate the sample 90 degrees (Route B) - Rotate the sample plus 90 degrees (Route C) (Route B_C)

- Rotate the sample 180 degrees to operate (Route C).

Figure 2 depicts an analysis using the usual procedure (between 90° and 0°).

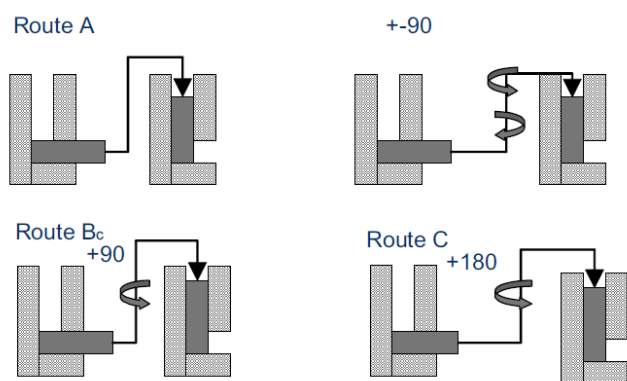


FIGURE 2. Various Processing Routes

Low-temperature pressing, where grain production is regulated, is clearly successful in lowering grain size in Equal Channel Angular Pressing (Sklenicka et al.) . Temperature is one of the most explored ECAP elements in the ECAP procedure. Extrusion at high temperatures benefits materials with low ductility. Because of the significant shear stress that is generated, the samples may shatter. Increases in processing temperature promote an increase in grain size in aluminium alloys, according to studies. Back pressure has been successfully used in the ECAP process to reduce simple shear irregularity and eliminate sample mistakes. Depending on the breadth of the deformation zone, applying counter pressure minimizes the overall stress necessary to establish a homogeneous ultra-fine grain structure. Back pressure guarantees that the outer corner is filled during the ECAP process, resulting

in the elimination of the dead zone (Samsudin, Kurniawan, and Nor) . Materials with varied cross-sectional areas were used in a study, it was determined that as the amount of stress increases, so does the quantity of hardness, and in all dimensions, the hardening process is relatively comparable. After the ECAP process, grain size decreased to an average of 0.8 μm , with cumulative stress of 5.0 or larger in materials of varied cross-sections, according to the same study (Samuel) . In the ECAP procedure, the number of passes through the die is proportional to the overall stress given to the sample.

4. Experimental Study

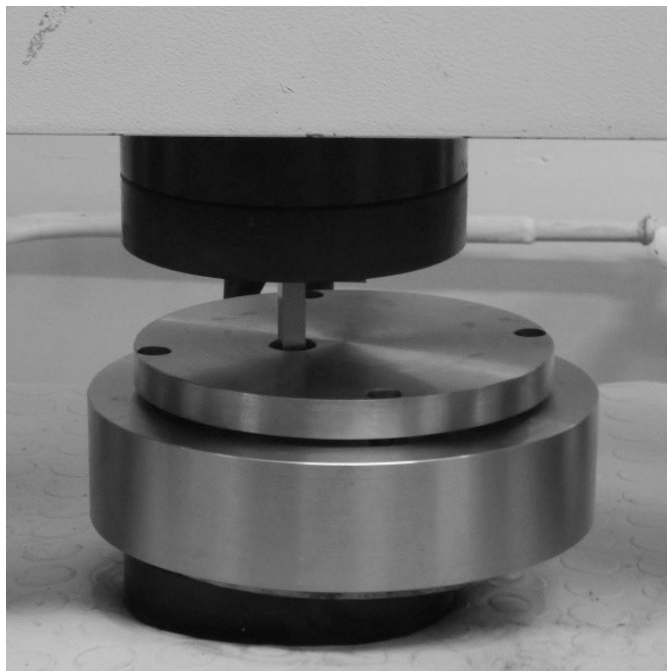
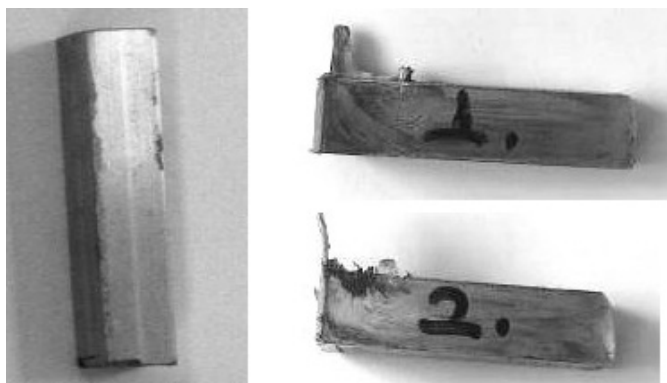
Square section samples made from Aluminum 5083 alloy, whose chemical make-up is shown in Table 1, were employed in this experimental component of these investigation. Table 1 shows the chemical make-up of the 5083 aluminium alloy utilised in the tests. At room temperature, the Equal Channel Angular Pressing tests were performed. Molds along a channel angle of 90 degrees and an outside curvature angle of 0 degree were employed in the studies. The samples were deformed in a universal tensile-compression test system along a strength of 120 tonnes and a pressing speed of 15 mm/min using the mould whose photograph is shown in Figure 3 (Rifai) . Route A was used to carry out the operation. The pressing is speed and load controlled, and the pressing stamp is a 10x10 mm² cross-section 64 HRC hardened HSS rotating tool (Sanusi and O) . Figure 3 shows a sample material with dimensions of 10 mm x 10 mm x 55 mm and a heat treatment of "O."

During the application, MoS lubricant was applied to the sample, mould surface, and channels. As indicated in Figure 4, problems arose during the procedure. Two transitions were successfully completed when the problems were resolved. In the centre (core) of the deformation zone and other areas of the mould, no cracks, fractures, or deformations occurred. The material flowed freely through the channel, and the mould performed as expected (Mousavi et al.)

Using Aluminum 5083 material, an ECAP test rig was successfully set up and put into action in this investigation. After successfully completing two passes, it was discovered that the compressive strength value had increased. Following the opti-

TABLE 1. The hardness variation for 5083 Aluminum alloy based on the number of passes

Number of Passes	Purchased As	Single Pass	Two Pass
Brinell Hardness (Depth Based)	78	88	92

**FIGURE 3.** ECAP moulds and test piece that were utilized in the experiment**FIGURE 4.** Single (1) and Double (2) passes yielded test pieces

mization testing, it was discovered that the pressing force varied between 170 and 210 kN, and the hardness value varied between 170 and 210 kN, as shown in Table 2 for MoS₂ as channel lubricant, 90° channel angle, and 10 mm/min pressing speed. The hardness values of the pieces are visually represented in Figure 5 the number of passes as a function of the number of passes. With the application of ECAP, the material's hardness increases quickly (18%), then drops. This result is in line with what has been found

in the literature on the issue. It is reasonable to conclude that the study's technique and mould setups were successful.

5. Result

Two passes were performed using a multi-piece ECAP mould and hardness variation was applied in the provided experimental investigation, which was previously carried out at our university and developed to alleviate the problems experienced in the moulds in the works. measured. It is the first of a series of experimental studies conducted as part of a Master's Thesis. Our article, which is being provided in order to share the findings on a scientific platform, our institution's studies in this area have been further developed. It's a sign that the experimental infrastructure is gradually improving. Fatigue will be tried to acquire the change in qualities by developing the work and doing more than two consecutive passes.

6. Conclusion

Severe plastic deformation operations are metal forming procedures that apply an ultra-large plastic strain to a bulk material in order to generate ultra-fine grained metals. Metals that have been SPD-processed have a high strength, and typical cold forming methods are combined with Severe Plastic Deformation processes to increase the strength even further. Because metal ductility is reduced by relatively modest strain, annealing is used after the Severe Plastic Deformation process to enhance ductility. The metals treated by the Severe Plastic Deformation techniques have great strength and ductility, resulting in good fatigue characteristics. On the separated dies, no corner cracking has been seen. In order to reduce testing time and boost automation capabilities, some more developments in die arrangement and fixing are required. The study can be considered effective based on the experimental results, and dies can be used securely.

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