

A Review on the Response of Equal Channel Angular Pressed Composite

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Abstract—SPD(Severe Plastic Deformation) methods are used to convert coarse grain metals and alloys into ultrafine grained (UFG) materials. Obtained UFG materials then possess improved mechanical and physical properties which destine them for a wide commercial use. This paper, in one direction, looks into historical development of ECAP(Equal Channel Angular Pressing) method of SPD process and its effect at obtaining fine crystalline structure and on the other side also partially focuses on further development of UFG structure by any secondary operation like Rolling.

Keywords—Severe plastic deformation, ultrafine grained materials, Equal Channel Angular Pressing, Rolling.

I. INTRODUCTION

Equal channel angular pressing is a severe plastic deformation technique (SPD) used to impart a large amount of plastic strain to bulk metallic materials. ^[1] This technique is capable of producing large fully dense samples containing an ultrafine grain size in the sub micrometer or Nanometer range. ^[2] A special die, which consists of two channels of identical cross section intersecting at an angle 2Φ , is used for this purpose. Basically the specimen is pressed from one channel to the next by a punch; ideally deformation takes place by shear at the intersecting plane. The main advantage of SPD processed materials, compared to other nano structured materials processed by gas condensation or ball milling with subsequent consolidation, is that it is possible to overcome a number of difficulties associated with residual defects and powder contaminations in the compacted samples. Among the various SPD processes, ECAP is a convenient procedure for obtaining ultrafine grained materials by extruding metallic materials through specially designed channel dies without a substantial change in geometries. ^[2] Though ECAP method is substantially used to refine grain size of metals, a very few studies have been made on composites subjected to ECAP.

A recent study has shown that ECAP is a viable method for Metal Powders Compaction and sintering. It was found that high mechanical strength could be achieved effectively due to the well bonded powder contact surface during ECAP process of gas atomized Al-Si powders. ^[2]

Further a simple method of producing long metal strips with fine and ultra-fine grain structure (UFG) has been developed to implement in metallurgical industry where a volume of fine and ultra-fine grain structure is produced by ECAP and then long nano structured strips are produced by cold rolling. The results so obtained showed that there was a significant increase in yield strength, ultimate tensile strength and toughness. There was a significant effect of cold rolling on the metal subjected to ECAP. ^[1]

II. METHODOLOGIES OF ECAP CONVENTIONAL ECAP

The ECAP die is formed from two channels of same cross-section, intersecting to form a corner as shown in Fig 1. The cross-sectional area can be square, rectangular or circular in shape. The inner surfaces of the die are highly polished and lubricated for easy flow of material and to reduce surface defects due to friction. The channel angel (ϕ) and the curvature angle (ψ) play an important role in inducing strain in the material. Mostly the channel angle of 90 or 120 degree is used. The material to be processed is made similar to the cross-section of the channel. The material is inserted in the inlet channel and extruded out from the outlet channel. The deformation occurs at the die corner as the billet is pressed. The ECAP technique is always conducted with the high plunger speed. In case of hard materials, the billet is preheated to enable easy deformation and to reduce the plunger force. The ECAP is now being used for manufacture of ultrafine grained structures of different materials. The products made from ECAP process include fasteners, plates etc.

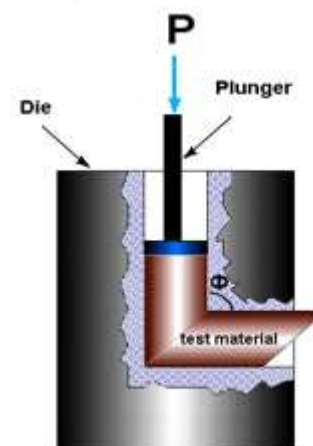


Fig 1: Conventional ECAP process

Langdon et al ^[7] studied the effect of various routes on the processing of the material in ECAP and it was found that, type of route plays an important role in evolution of grains. Nakashima et al ^[8] performed experimentation on commercially pure aluminum in ECAP and studied the effect of channel angle on grain characteristic. It was found that the better grain size and orientation was obtained with the channel angle close to 90 degree. Yamashita et al ^[9] conducted tests on various samples of

aluminum alloys to study the effect of pressing temperature on material characteristic. It was found that the measured grain size tend to increase with increasing pressing temperature

III POST ECAP PROCESS-ROLLING

In metalworking, rolling is a metal forming process in which metal stock is passed through one or more pairs of rolls to reduce the thickness and to make the thickness uniform. The concept is similar to the rolling of dough. Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature, then the process is known as hot rolling. If the temperature of the metal is below its recrystallization temperature, the process is known as cold rolling. In terms of usage, hot rolling processes more tonnage than any other manufacturing process, and cold rolling processes the most tonnage out of all cold working processes. Roll stands holding pairs of rolls are grouped together into rolling mills that can quickly process metal, typically steel, into products such as structural steel (I-beams, angle stock, channel stock, and so on), bar stock, and rails. Most steel mills have rolling mill divisions that convert the semi-finished casting products into finished products^[10].

There are many types of rolling processes, including ring rolling, roll bending, roll forming, profile rolling, and controlled rolling.

Hot rolling

Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material. After the grains deform during processing, they recrystallize, which maintains an equiaxed microstructure and prevents the metal from work hardening. The starting material is usually large pieces of metal, like semi-finished casting products, such as slabs, blooms, and billets. If these products came from a continuous casting operation the products are usually fed directly into the rolling mills at the proper temperature. In smaller operations the material starts at room temperature and must be heated. This is done in a gas- or oil-fired soaking pit for larger workpieces and for smaller workpieces induction heating is used. As the material is worked the temperature must be monitored to make sure it remains above the recrystallization temperature. To maintain a safety factor a *finishing temperature* is defined above the recrystallization temperature; this is usually 50 to 100 °C (90 to 180 °F) above the recrystallization temperature. If the temperature does drop below this temperature the material must be re-heated before more hot rolling.

Hot rolled metals generally have little directionality in their mechanical properties and deformation induced residual stresses. However, in certain instances non-metallic inclusions will impart some directionality and workpieces less than 20 mm (0.79 in) thick often have some directional properties. Also, non-uniform cooling will induce a lot of residual stresses, which usually occurs in shapes that have a non-uniform cross-section, such as I-beams. While the finished product is of good quality, the surface is covered in mill scale, which is an oxide that forms at high temperatures. It is usually removed via pickling or the smooth clean surface process, which reveals a smooth surface.

Dimensional tolerances are usually 2 to 5% of the overall dimension.

Cold rolling

Cold rolling occurs with the metal below its recrystallization temperature (usually at room temperature), which increases the strength via strain hardening up to 20%. It also improves the surface finish and holds tighter tolerances. Commonly cold-rolled products include sheets, strips, bars, and rods; these products are usually smaller than the same products that are hot rolled. Because of the smaller size of the workpieces and their greater strength, as compared to hot rolled stock, four-high or cluster mills are used.^[10] Cold rolling cannot reduce the thickness of a workpiece as much as hot rolling in a single pass.

Cold-rolled sheets and strips come in various conditions: *full-hard*, *half-hard*, *quarter-hard*, and *skin-rolled*. Full-hard rolling reduces the thickness by 50%, while the others involve less of a reduction. Skin-rolling, also known as a *skin-pass*, involves the least amount of reduction: 0.5-1%. It is used to produce a smooth surface, a uniform thickness, and reduce the yield point phenomenon (by preventing Lüders bands from forming in later processing). It locks dislocations at the surface and thereby reduces the possibility of formation of Lüders bands. To avoid the formation of Lüders bands it is necessary to create substantial density of unpinned dislocations in ferrite matrix. It is also used to break up the spangles in galvanized steel. Skin-rolled stock is usually used in subsequent cold-working processes where good ductility is required.

Other shapes can be cold-rolled if the cross-section is relatively uniform and the transverse dimension is relatively small. Cold rolling shapes requires a series of shaping operations, usually along the lines of sizing, breakdown, roughing, semi-roughing, semi-finishing, and finishing.

IV Conclusion

In this paper the conventional ECAP process and ROLLING process was studied. It was found that there has been lot of works carried out on composites to get UFG structure by ECAP method of SPD. Also many researchers have improved UFG of metals and composites by ROLLING process. It was observed that both ECAP and ROLLING processes are reliable methods to improve grain structure of composite materials; however it can be observed that less works have been carried out on ECAP-composites to be ROLLED.

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