Magnesium alloys have poor formability at room temperature, due to a limited number of slip systems owing to the hexagonal closed packed structure of magnesium. One possibility to increase the formability of magnesium alloys is to refine the grain size. A fine grain magnesium alloy shows high strength and high ductility at room temperature, hence an improved formability. In addition to grain refinement, the formability of Mg alloys can be improved by controlling crystallographic texture. Severe plastic deformation (SPD) processes namely, equal channel angular pressing (ECAP) and multi-axial forging (MAF) have led to improvement in room temperature mechanical property of magnesium alloys. Further, it has been reported that by adding rare earth elements, room temperature ductility is enhanced to nearly 30%. The increase in property is attributed to crystallographic texture. Many rare earth elements have been added to magnesium alloys and new alloy systems have been developed. Amongst these elements, Ce addition has been shown to enhance the tensile ductility in rolled sheets at room temperature by causing homogeneous deformation. It has been observed that processing of rare-earth containing alloys below 300°C is difficult. Processing at higher temperatures leads to grain growth which ultimately leads to low strength at room temperature. The present thesis is an attempt to combine the effect SPD and rare earth addition, and to examine the overall effect on microstructure and texture, hence on room temperature mechanical properties. In this thesis, Mg-0.2%Ce alloy has been studied with regard to the two SPD processes, namely, ECAP and MAF.

The thesis has been divided into six chapters. Chapter 1 is dedicated to introduction and literature review pertaining to different severe plastic deformation processes as applied to different Mg alloys. Chapter 2 includes the details of experimental techniques and characterization procedures, which are commonly employed for the entire work.

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Chapter 3 addresses the effect of ECAP on the evolution of texture and microstructure in Mg-0.2%Ce alloy. ECAP has been carried out on two different initial microstructure and texture in the starting condition, namely forged and extruded. ECAP has been successfully carried out for the forged billets at 250°C while cracks get developed in the extruded billet when ECAP was done at 250°C. The difference in the deformation behaviour of the two alloys has been explained on the basis of the crystallographic texture of the initial materials. The microstructure of the ECAP materials indicates the occurrence of recrystallization. The recrystallization mechanism is identified as “continuous dynamic recovery and recrystallization” (CDRR) and is characterized by a rotation of the deformed grains by ~30° along c-axis. The yield strengths and ductility of the two ECAP materials have been found quite close. However, there is a difference in the yield strength as well as ductility values when the materials were tested under compression. The extruded billet has the tension compression asymmetry ~1.7 while the forged material has the asymmetry as ~2.2. After ECAP, the yield asymmetry reduces to ~1 for initially extruded billet, while for the initially forged billet the yield asymmetry value reduces to ~1.9.

In chapter 4, the evolution of microstructure and texture was examined using another severe plastic deformation technique, namely multi axial forging (MAF). In this process, the material was plastically deformed by plane strain compression subsequently along all three axes. In this case also two different initial microstructures and texture were studied, namely the material in as cast condition and the extruded material. The choice of initial materials in this case was done in order to examine the effect of different initial grain size in addition to different textures. By this method, the alloy Mg-0.2%Ce could be deformed without fracture at a minimum temperature of 350°C leading to fine grain size (~3.5 µm) and a weak texture. Grain
refinement was more in the initial cast billets compared to the initial extruded billet after processing. The mechanism of grain refinement has been identified as twin assisted dynamic recrystallization (TDRX) and CDRR type. The mechanical properties under tension as well as under compression were also evaluated in the present case. The initially extruded billet has shown low tension compression asymmetry (~1.2) than cast billet (~1.9), after MAF.

Chapter 5 addresses the exclusive effect of texture on room temperature tensile properties of the alloy. Different textures were the outcomes of ECAP and MAF processes. In this case, in order to obtain an exact role of texture, a third of deformation mode, rolling, was also introduced. All the processed materials were annealed to obtain similar grain size but different texture. A similar strength and ductility for ECAP and MAF, where the textures were qualitatively very different, was attributed to the fact that texture of both the ECAP and MAF processed materials, was away from the ideal end orientation for tensile tests. In chapter 7, the final outcomes of the thesis have been summarized and scope for the future work has been presented.