Mechanical and structural aspects of plastic deformation of fine-grained magnesium and it's alloys at low temperature range

Magnesium and its alloys, due to their lower symmetry hexagonal lattice, suffer from the limited number of closed-packed slip systems, which limit ductility and formability of the alloys. However, the alloys exhibit a favorable combination of weight and strength making them promising materials for more energy-efficient and environmentally friendly applications. This perspective becomes a challenge and simultaneously the opportunity for the scientists to develop innovative solutions that would overcome barriers and limitations imposed by Mg-based materials that are subjected to processing and during products' fabrication.

The proposed research program aims to apply conventional processing, i.e.: (i) hot-extrusion, (ii) thermomechanical treatment and non-conventional fabrication technology offered by: (iii) Rapid Solidification (RS) combined with Plastic Consolidation (PC), to develop pure Mg and Mg-alloys with severely refined microstructure, and to study the mechanisms that determine properties and performance of these materials during low temperature plastic deformation. The goal is to advance our understanding of the processes that control the plastic flow, work hardening behaviour and fracture and to identify factors that guide the principles of the microstructure design and process control required in fabrication of Mg-based materials with enhanced mechanical properties including plasticity.

During the research tenure we intend to conduct comprehensive studies of the plasticity of Mg-alloys produced by conventional and non-conventional methods, in a range of temperatures between 4K and 298K. The control of the microstructure during alloy fabrication will allow tunning deformation modes to achieve superior combination of the strength and ductility. We will focus on understanding deformation mechanisms, determination of the critical grain size at which transition in dominant deformation modes occurs, and on understanding the role of grain boundary sliding in plasticity of magnesium alloys. The key question of this research is whether it is possible to obtain synergistic enhancement of the alloy's properties through the microstructure design and process control and identify deformation mechanisms that permit to delay failure while improving strength and ductility.

The proposed research offers development of new fundamental knowledge about the structure, properties and performance of fine-grained Mg and Mg alloys produced by hot extrusion, thermomechanical treatment and RS+PC method, which is not available yet. This new data pertains to the properties of the alloys in a broad range of temperatures, including the regime of very low temperatures, the influence of the temperature and the composition on the work hardening, and the relationship between the microstructure and the mechanical properties of Mg-based alloys. The industry could then use this knowledge to devise alloys with desirable functional properties intended for use in military air systems, space products, electronic systems, and energy efficient vehicles.