Measurement of hydrogen sorption properties of magnesium-based alloys and zircalloys subjected to severe plastic deformations

Julien Lang[1], Jacques Huot[1] and Roxana Flacau[2]

[1] Hydrogen Research Institute, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada
[2] NRC Canadian Neutron Beam Centre, Chalk River Laboratories, Chalk River, Ontario, Canada

Ex-situ neutron diffraction was used to study the hydrogen sorption in magnesium based alloy ZK60 (~ 94% Mg, 6% Zn, ~0% Zr) and zircalloy subjected to severe plastic deformation (SPD). Two SPD techniques were used: Equal Chanel Angular Pressing (ECAP) and Cold Rolling (CR). In the case of ZK60 both ECAP and CR were used to process the alloy. Both techniques produce textured materials and we wanted to see if this induced texture induced could make the first hydrogenation easier. In the case of Zircalloy aur investigation showed that cold rolling greatly reduce the hydrogenation and dehydrogenation temperatures. As the desorption temperature (1023 K) is too high for the apparatus presently installed on C2 only absorption was investigated. Neutron investigation could give some understanding of the mechanism responsible for this temperature reduction.

ZK60 alloy

Deuterium absorption was made at UQTR using a homemade PCT apparatus. Deuterium was used instead of hydrogen to reduce the incoherent scattering background. The samples were scanned at room temperature on the D2B apparatus, taking scans of 6 hours per detector bank. Figure 1 shows the neutron diffraction patterns from 25 to 50 degrees (2θ) for ZK60 as received ingot, subjected to equal channel angular pressing (ECAP) and cold rolled two times (CR2X). We also show the ECAP and CR2X's partially hydride state in order to see the crystal change at the start of hydrogenation. As seen, cold rolling creates a more textured sample than ECAP due to the mechanical process or cold rolling which 'flattens' the Mg structure along the [002] direction. There is also a slight shift of Mg peaks towards higher angles when deuterium enters the sample. This means that hydrogen is going in solid solution in magnesium. Usually only marginal amount of hydrogen enters in solid solution in magnesium. This could means that severe plastic deformation enhances solid solution of hydrogen in magnesium.

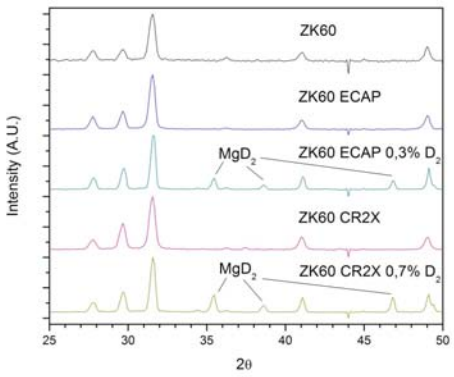

Figure 1 – Neutron diffraction of the ZK60 alloy for different SPD processes and Deuterium contents.

Zircalloy

From X-ray diffraction we saw that after cold rolling the material is highly textured (see fig. 2). Neutron diffraction was performed and are under analysis. The analysis is made harder because of the important contribution of the diffraction peaks from the stainless steel cell.

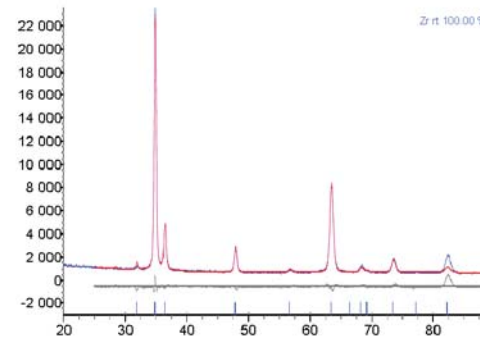

Figure 2 – Diffraction pattern and Rietveld analysis of cold rolled zircaloy-4 chips.