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Cu-based shape memory strips elaborated by one-step rapid solidification techniques: structural and functional properties

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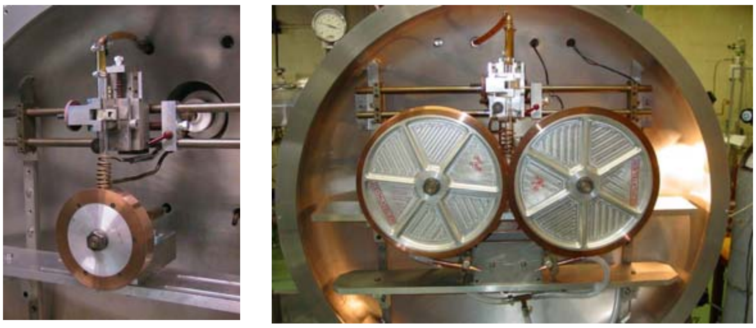
Abstract – Rapid solidification techniques are particularly useful for certain Cu-based alloys for which shaping is difficult because of their inherent lack of ductility. Applied to shape memory alloys, the Twin Roll Casting and Planar Flow Casting techniques allow to obtain in one step materials with forms suitable for practical applications (as ribbons and strips) with reduced grain size. Optimum conditions in processing parameters such as roll speed, melt temperature, melt flow, ejection pressure were established to obtain thin foils that are not brittle, with a smooth surface and free of cracks and holes. Martensitic transformation temperatures, phase stability and shape memory properties will be examined in relation with the microstructures developed by this techniques and specific thermal treatments.

Rapid solidification techniques were first used to obtain amorphous or microcrystalline metallic materials, which required high quenching rates (10^4 -10^6 $K.s^{-1}$). By a suitable combination of processing parameters a series of Cu-Al-Ni thin tapes were produced directly from the melt. Melt spinning (Figure 1-a) allows to obtain ribbons of 8 mm width and 30-50 μm thickness while twin roll casting, where the melt is cast through a nozzle and solidified between the gap of two rollers rotating in opposite directions (Figure 1-b) [1], resulted a successful method to obtain strips of 40 mm width and 450 μm thickness (Figure 2-a). The average size of the grains is 2-3 μm for the as-cast specimens when Ti is added as grain refiner.

Due to directional heat flow during solidification, such processes generate new textured microstructures with respect to conventional casting and the martensitic transformation characteristics can be deeply modified. As a consequence of the rapid solidification the martensitic transformation temperatures are depressed mainly due to quenched-in disorder and a high level of residual stresses in reduced size grains. The values corresponding to the bulk form are restored by adequate thermal treatments. Measurements of length change under uniaxial tensile load shows fully recoverable strains $\varepsilon^{A\rightarrow M}$ up to 4 % (under 90MPa) on cooling through the martensitic transformation (Figure 2-b).

Non conventional production technologies based in rapid solidification methods appear as an effective approach to overcome the brittleness of some Cu-based alloys and to obtain shape memory alloys with remarkable functional properties.

1-a 1-b



2-a 2-b

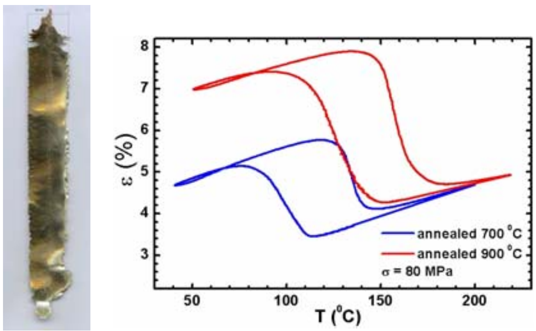


Figure 1: Rapid solidification set-up **a)** Planar Flow Casting **b)** Twin Roll Casting

Figure 2: a) Cu-Al-Ni strip obtained by TRC
b) Length change under tensile load on cooling and heating through the martensitic transformation in a twin-roll cast strip

References

[1] H. S. Chen, C. E. Miller, *Rev. Sci. Instrum.*41(1970) 1237