SET UP OF U-Mo POWDER PRODUCTION BY HMD PROCESS

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ABSTRACT

An industrial process for the fabrication of U-Mo powder have been set up with the development of the massive hydryding of uranium-molybdenum alloys in gamma phase at low temperatures and pressures. The brittleness of the hydride allows performing conventional milling and dehydryding for obtaining U-Mo powder. This process is known as hydryding-milling-dehydriding (HMD).

The whole process involves the melting of the alloy, fractionating the alloy into lumps, two steps hydriding, size reduction of hydride by crushing, low impact milling, dehydriding and a very high temperature treatment. All this processes are performed in a licensed facility with the capability of working with enriched uranium.

The different steps in the process have been holly understood and optimized. Melting of the alloy can be done in an arc furnace to reduce scrap and eliminate the fractionating step. The capability of massive hydriding in the gamma phase essentially depends on the previous introduction of hydrogen in traps and performed at a slightly higher temperature than the intersticial filling. Previous crushing of the hydride is needed for the introduction of controlled size particles to the low impact mill. One pass threw the atmosphere controlled low impact mill produces specification size powder. A controlled temperature and pressure dehydriding is performed to avoid flying powder. A final step of high temperature treatment is performed to reduce even more remnant hydrogen, reduce oxide layer, homogenize composition, eliminate interior defects, sinterize cracks, increase density and with cooling, passivate the final product.

Known data of the whole process is presented so as to thoroughly evaluate fabrication capabilities, performance and costs.

1. Introduction

Uranium-molybdenum (U-Mo) alloys can be hydrided massively in metastable gamma phase.

The brittle hydride can be milled and dehydrided to acquire the desired size distribution needed for dispersion nuclear fuels.

This process is called hydriding-milling-dehydriding (HMD process) [1, 2, 3].

2. Development

The whole process involves the melting of the alloy, fractionating the alloy into lumps, two steps hydriding, size reduction of hydride by crushing, low impact milling, dehydriding, and a very high temperature annealing treatment for increasing density.

The capability of massive hydriding in the gamma phase essentiaqlly depends on the previous introduction of hydrogen in traps that is performed at a slightly higher temperature (325 °C, 1 atm. H_2, 1 hr.) than the interstitial hydrogen filling (120 °C, 1 atm. H_2, 36 hrs.). After total hydriding, hydrogen traps are evacuated (375 °C, vacuum, 15 min.).

The obtained hydrided material (figure 1) is crushed in a two rods mill to size particles smaller than 2 millimeters in a glow box with a depleted oxygen atmosphere ($[O_2] < 4\%$). This particles are reduced to specified dimensions (< 100 µ) in a low impact gyratory crushing mill embedded in an argon atmosphere.

Figure 1. One kg batch of just hydrided and passivated U-Mo material.

A controlled temperature (25 – 400 °C) and pressure (< 1 atm.) dehydriding is performed to avoid powder flying into the vacuum pump zone. Figure 2 shows the evolution of gas as temperature is increased in the dehydriding chamber. The peak at 325 °C corresponds to low bounded hydrogen allocated in traps. Beyond 400 °C a burst of interstitial hydrogen is liberated that can be auto-controlled by pressure increment.

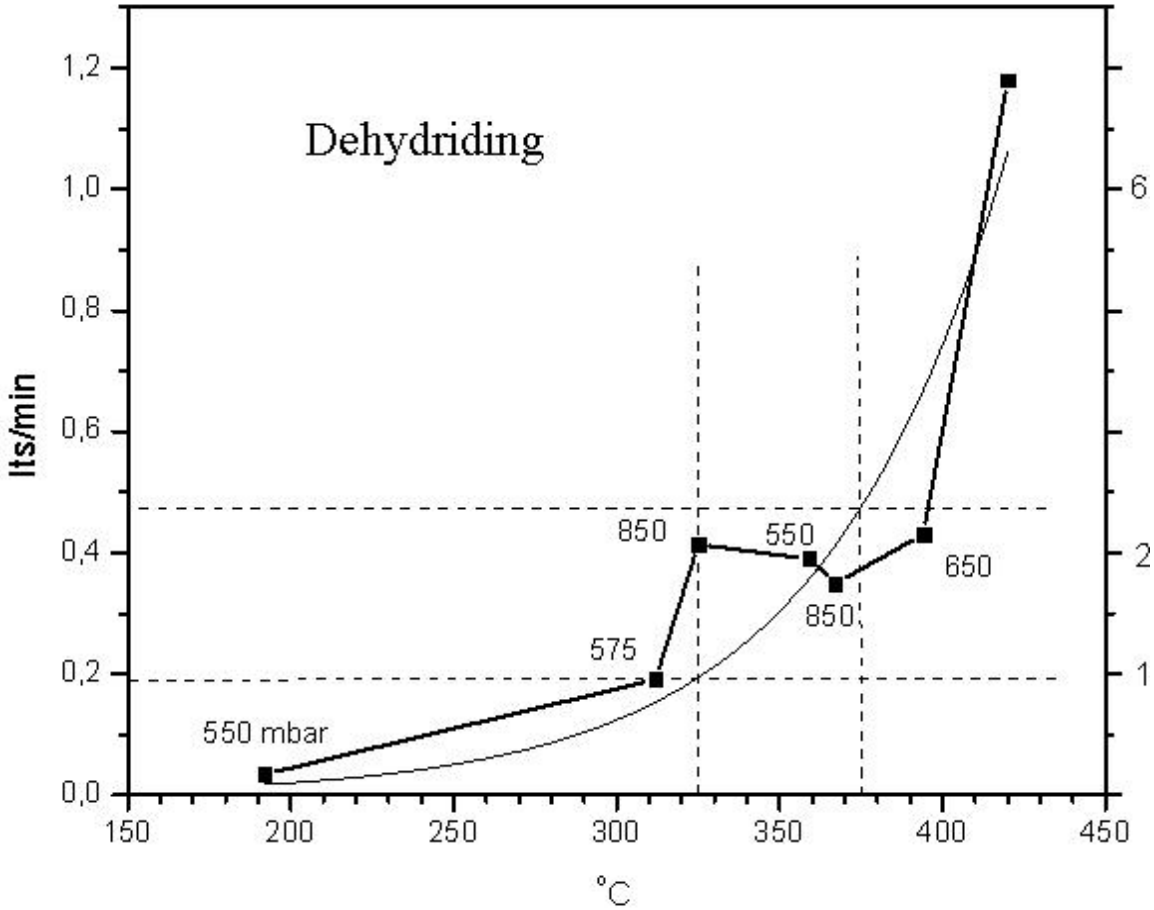

Figure 2. Rate of hydrogen liberation in a heated batch of hydrided U-Mo powder.

A final heat treatment, of more than 8 hours at 1000 °C and diffusion pump low pressure atmosphere, is performed in a moving chamber that avoids powder sintering. The powder is deoxidized in the low oxygen pressure atmosphere and cracks are sintered with the possibility of controlling interior porosity (figure 3).

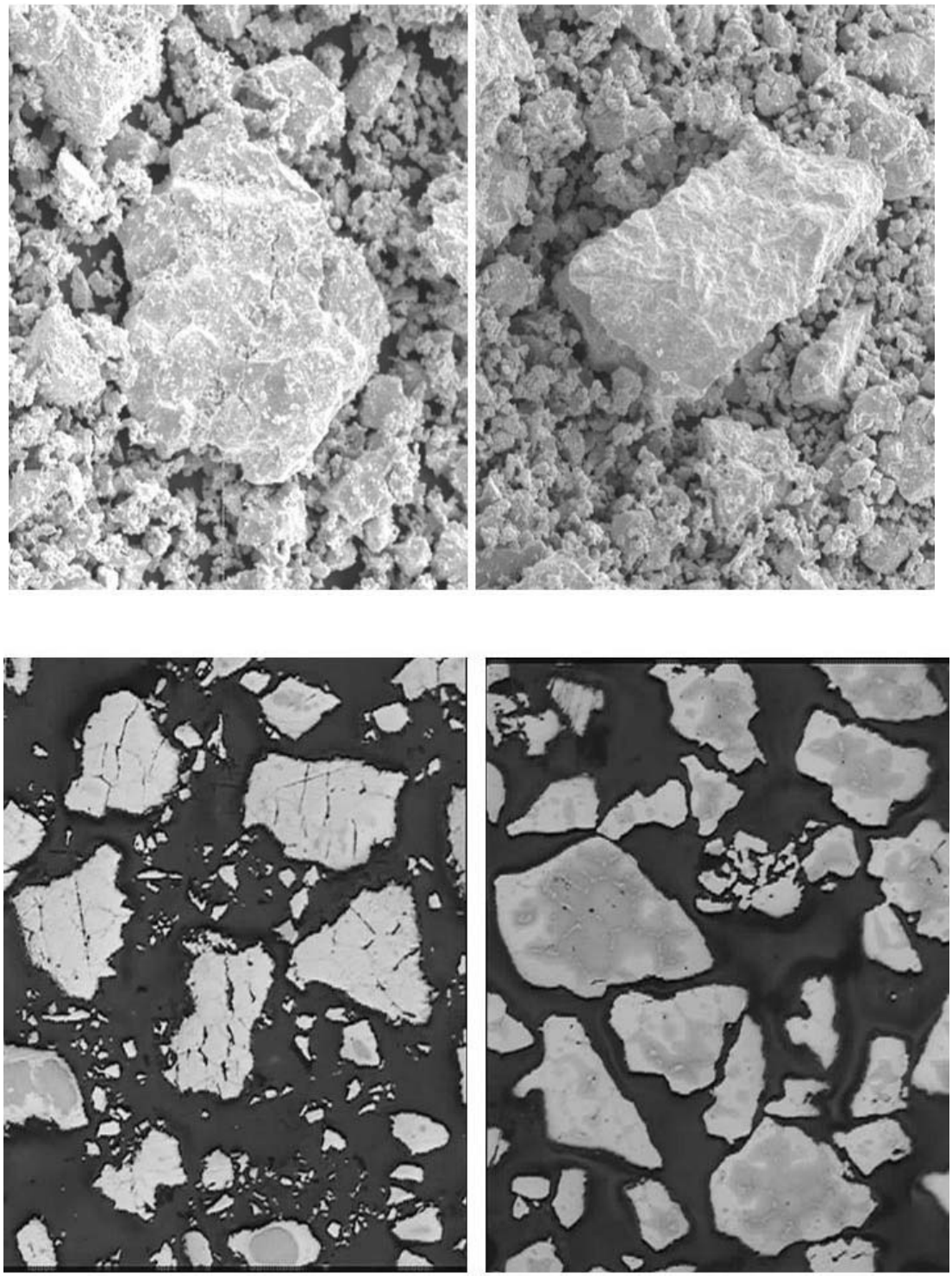

Figure 3. SEM (first row) and metallographies (second row) of U-7Mo powder before (left column) and after (right column) heat treatment at 1000 °C in a vacuum atmosphere. Big particles are approximately 100 μ size.

3. References

1. E. E. Pasqualini, J. Helzel Garcia, M. López and E. Cabanillas. AATN, Buenos Aires, Argentina. Noviembre 2001.
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