Microstructure of a Two Phase Zirconium-Niobium Alloy after Heat Treatments

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1.INTRODUCTION

Recrystallization in two phase alloys is something more complicate comparing with single phase alloys. In this paper , using transmission electron microscopy , we will present microstructural aspects concerning the recovery and recrystallization in a 60% cold-worked Zr-Nb alloys (Zr with 0.25wt% ; 0.5wt% ; 1.0wt% ; 1.5wt% Nb) . after isochronal heat treatments.One of the principal deal is to correlate the increasing presence of new phases in the metallic matrix (α - zirconium , β - zirconium and β - niobium) , changing recovery and recrystallization processes and also the final microstructure (grain size refinement , presence of fine and coarse precipitates , second phases) .The martensitic transformation from β phase (bcc structure) to the metastable Nb-saturated "transformed α " with hcp structure is the responsible for the increasing of the mechanical properties of these alloys (Holt 1976 ; Lee 1970) .

2.EXPERIMENTAL DETAILS

A serie of retangular sheets of 3 x 0.8 x 0.5 cm was obtained from the Zr-Nb alloy ingots. The samples were annealed at 650 ^{o}C , in an argon atmosphere , for one hour , followed by a cold water quenching and , after a chemical cleaning , the samples were 60% cold rolled (thickness) . Then , the samples were heated , also in an inert atmosphere , in the temperature range 300 - 1050 ^{o}C for one hour and cooled to room temperature .The 3 mm discs for TEM were prepared in a double jet electrolytic polishing machine using 90% methanol + 10% perchloric acid electrolyte at - 15 ^{o}C . TEM analysis of the samples were conducted at 200 kV accelerating voltage in a Jeol JEM 200C microscope (conventional imaging techniques as well as selected area diffration techniques) . Some EDS microanalysis in TEM (JEM 2000FXII) were also utilised to identify the second phase .

3.RESULT AND DISCUSSION

The heat treatments of the cold-worked alloys promote the recovery and

recrystallization processes . The sequence of electron micrographs obtained by TEM (Figs. 1 - 3) shows this evolution . The Fig. 1a shows a microstructure of one of the as-cast Zr-Nb alloys and the Fig. 1b shows a heat-treated (650 ^{0}C for 1h) and 20% cold worked Zr-1.0wt%Nb .The electron micrograph of the Fig. 2a brings a microstructure of the recovery process on a 60% cw Zr-0.25wt%Nb after 450 ^{0}C for 1h .The microstructure of Zr-1.0wt%Nb in the Fig. 2b shows the beginning of the recrystallization process (550 ^{0}C for 1h). The electron micrograph of the figure 3a shows a microstructure of a completely recrystallized Zr-0.5wt%Nb alloy (T= 850 ^{0}C for 1h) . The electron micrograph of the Figure 3b brings a duplex microstructure (α-Zr + β-Zr with Nb dispersion) of the Zr-1.5wt%Nb heat-treated at 750 ^{0}C for 2h .

Figure 1 : a) As-cast Zr-0.5wt%Nb ; α-Zr grains surrounded by β-Zr .
b) Zr-1.0wt%Nb heat treated at 650 ^{0}C for 1h . 60% cold-worked .

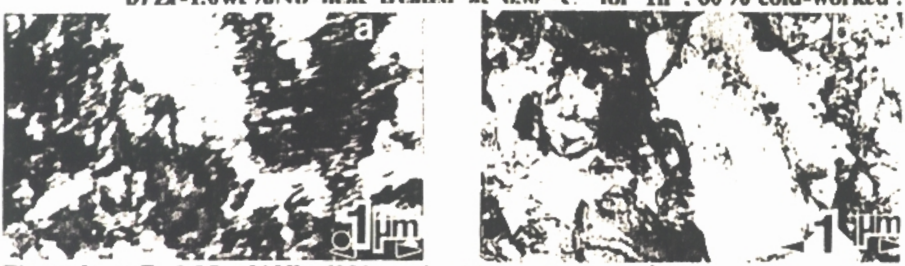

Figure 2 : a) Zr-0.25wt%Nb, 60% cw, heat treated at 450 ^{0}C for 1h; recovery process. b)Zr-1.0wt%Nb , 60% cw , heat treated at 550 ^{0}C for 1h beginning of the recrystallization process.

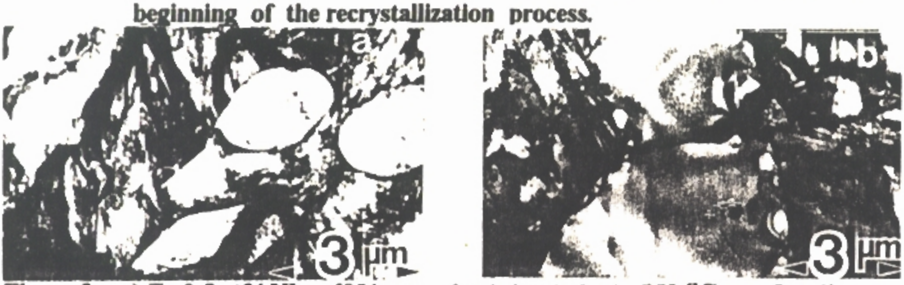

Figure 3 : a) Zr-0.5wt%Nb , 60% cw , heat treated at 850 ^{0}C for 1h ; completely recrystallized with twinned grains due to the β-Zr quenching ; b) Zr-1.5wt%Nb , 60% cw , heat treated at 750 ^{0}C for 2h ; α-grains and "α -transformed " (by quenching)

Holt., R. A. , J. of Nucl. Mat. , 1976 , 59 , 234-242.

Lee, D. , J. of Nucl. Mat. , 1970 , 37 , 159-170.