SUPERPLASTIC BEHAVIOUR OF A FINE GRAINED TiAl BASED ALLOY TREATED BY MULTI-STEP THERMO-MECHANICAL TREATMENT①

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ABSTRACT A Ti-33Al-3Cr (mass fraction, %) alloy was multi-step thermo-mechanically treated through hot can forging. Samples of the forged plate were tension tested at strain rates of 10^{-5} to 10^{-3} s^{-1} and temperatures between 1 000 ℃ and 1 075 ℃. At 1 075 ℃ and a strain rate of 8×10^{-5} s^{-1}, the maximum elongation(517%) was achieved. The strain rate sensitivity coefficient m was about 0.7 under the conditions of 1 075 ℃ and 6×10^{-5} s^{-1}.

Key words TiAl forging superplasticity

Recently, researches of superplastic forming (SPF) of TiAl based alloys have been carried out in many countries to improve the workability of these materials. It has been found that the optimal temperature for the SPF of TiAl based alloys is above 1 200 ℃. An elongation of 980% was gained by Lombard *et al*[1] when a fine grained Ti-45.5Al-2Nb-2Cr (mole fraction, %) alloy was tested at 1 200 ℃ and an initial strain rate of 1×10^{-4} s^{-1}, and this is the maximum elongation that has been reported up to now. At the same time many efforts have been made to study the superplasticity of TiAl based alloys at lower temperatures. At 1 025 ℃ and a strain rate of 8.3×10^{-3} s^{-1}, an elongation of 250% was obtained by Imayev *et al*[2] in a tensile test of Ti-35.9Al (mass fraction, %) alloy. In another work, an equiaxial fine grained microstructure (average grain size ~ 5 μm) was obtained by thermo-mechanical treatment and the superplasticity of this material reached 275% under the conditions of 1 050 ℃ and 2.5×10^{-4} s^{-1}[3]. Clemens *et al*[4] tested a fine grained (~ d9 μm) Ti-48Al-2Cr alloy at 1 000 ℃ and 1 100 ℃ with a strain rate of 5×10^{-4} s^{-1}, the values of m were reported to be 0.25 and 0.35, and the elongations were 165% and 210%, respecitvely.

In our former study, a new processing technology of TiAl based alloys called multi-step thermo-mechanical treatment(MSTMT) was developed, which can refine the initial coarse lamellar grains of TiAl ingot to equiaxial fine grains with good homogeneity[5]. This study investigated the superplasticity of the material treated by such technology.

A Ti-33Al-3Cr (mass fraction, %) alloy was vacuum arc melted, homogeneously treated at 1 040 ℃ for 48 h, isostatically hot pressed to seal casting porosity and then forged by MSTMT. Tensile specimens with a gauge section of 6 mm × 3 mm × 2 mm were cut from the forged pancake by electrical discharge machining. The surface of each specimen was mechanically ground and the gauge section was covered

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by coating to prevent it from oxidizing. High temperature tensile tests were performed on Shimadzu AG-100KNA machine.

The elongation-to-fracture of this material at different temperatures between 1 000 ℃ and 1075 ℃ was investigated. Under the conditions of 1075 ℃ and $8 \times 10^{-5} s^{-1}$, a maximum tensile elongation of 517% was obtained. The strain-rate-incremental tests showed a m of 0.7 at 1075 ℃ and a strain rate of $6 \times 10^{-5} s^{-1}$. The elongation of tensile tests at 1 000, 1 025 and 1050 ℃ were 467%, 483% and 500% respectively at a strain rate of $2 \times 10^{-4} s^{-1}$. These results show that this TiAl based alloy treated by MSTMT technology has good potential of SPF. The test temperatures being lower than 1 100 ℃ are also of practical importance for the industrial application of TiAl based alloys. And it can be anticipated that this material will show much better superplasticity at higher temperatures and in inert atmosphere.

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