Conference Paper

Superplastic Deformation Behavior of High-Temperature Titanium Alloys VT8 and Ti6242S

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Abstract

Superplastic forming (SPF) is an effective process that allows for forming the sheet metal parts of complex configuration. Superplastic deformation behavior of conventional sheets of a high temperature titanium alloys VT8 и Ti6242S was studied by constant strain rate tests in a temperature range of 850–950 °C. The research identified the optimum superplastic temperature of studied alloys in a constant strain rate of 3×10^{-4} s^{-1} with elongation above 150 %.

Keywords: superplasticity, titanium alloys, stress, elongation.

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1. Intorduction

Titanium and its alloys are widely used in aviation and aerospace industry due to their high strength/density ratio, composite compatibility, corrosion resistance, elevated and cryogenic temperature capabilities [1]. Two-phase α/β titanium alloys VT8 and Ti6242S are widely used for elevated temperature applications. However, there still existed limitations to manufacture the thin-walled or complex structural components using this alloys, owing to its poor cold formability at room temperature. Superplastic forming is an effective process that allows for forming the sheet metal parts of complex configuration. Superplasticity is the ability of polycrystalline materials to exhibit very high value of strain (tensile elongation can be even more than 2000%), appearing in high temperature under exceptionally low stress which is strongly dependent on strain rate [2, 3]. Superplasticity allows uniform thinning of the workpiece during deformation, which is extremely important for production of parts. Among the key attributes for a good SPF material are practical SPF temperatures, low flow stress at the forming temperatures and high strain capability. Initial microstructure also plays an important role on SPF behavior of titanium alloys. The greater part of the literature on superplastic deformation of titanium alloys pay particular attention to α+β type alloys, especially Ti6242S [4, 5]. There is not much literature on the superplasticity of the VT8 titanium alloy. Therefore, the purpose of this work was to obtain new experimental data on the superplastic deformation of VT8 titanium alloy [6], and to compare its deformation behavior with the most popular high temperature resistance titanium alloy Ti6242S.

2. Materials and Methods

The annealed sheets of VT8 and Ti6242S titanium alloys from commercial mill products of PSC VSMPO-AVISMA Corporation were used in this work. The microstructure of the specimens was observed by scanning electron microscope (SEM) Quanta 3D FEG which was operated at 5 kV with a probe current 8 nA. The specimens for mechanical testing made from transverse direction of sheets. SPF testing was implemented in accordance with standard ASTM E 2448 by MTS Insight 100. High temperature tensile tests were conducted by Zwick Z100 at temperature 550, 625, 685 °C and 30 minutes preheating prior to deformation.

3. Results and Discussion

In the study comparison of mechanical properties of alloys was performed on sheets with globular structure, Fig. 1. As it follows from the SEM data, after rolling and heat treatment the sheet component of Ti6242S practically totally transforms into a globular one. The average size of globular grains of the primary α phase after heat treatment is about 8 μm. The microstructure of alloy VT8 indicates the development of partly spheroidization of the lamellar constituent and acicular secondary α phase. The primary α grains of VT8 are elongated along the deformation direction. Their size in normal direction of the sheet is about 2-3 μm and length in the structure is about 10-12 μm.

It is seen from Fig. 2 that the value of yield stress of VT8 alloy at T=550 and 625 °C is higher as compared to Ti6242S. The difference in the yield stress values of the investigated alloys is primarily conditioned by a difference of initial microstructure of the alloys. There are many factors that allow for increased strength in α/β titanium alloys, such as increased amount of barrier for dislocation motion by grain refinements and strengthened by the formation of secondary phases. The technological parameters limits alpha grain size in α+β processed materials and can increase, on average, the number of barriers to slip in microstructures. An increase test temperature to 685 °C resulted in the dissolution of acicular secondary α phase in structure of VT8 during preheating prior to deformation. As result, decreased the yield stress of VT8.

The obtained strain curves in SPF mode for the VT8 and Ti6242S alloys are shown in the Fig. 3. The present work revealed that the flow stress of VT8 was significantly lower than that of Ti6242S. At a temperature of 900 °C, the deformation of the VT8 alloy is carried out in a stable mode, ensuring a uniform flow without the formation of areas with local thinning on the samples than at 850 °C.

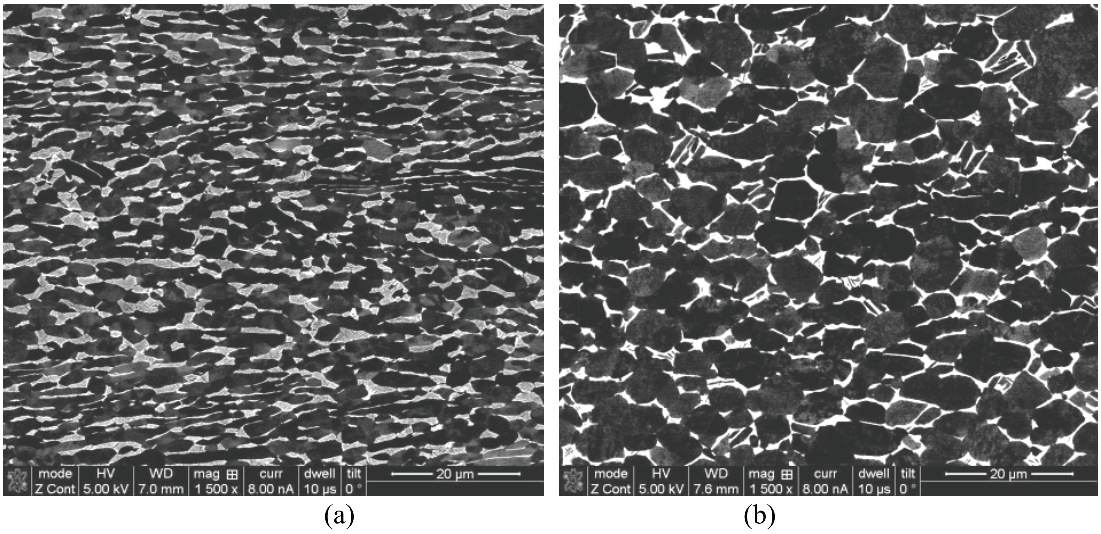


Figure 1: Starting microstructure of alloys (transverse direction TD) used for SPF experiments. Microstructure of VT8 (a) and Ti6242S (b) titanium alloys.

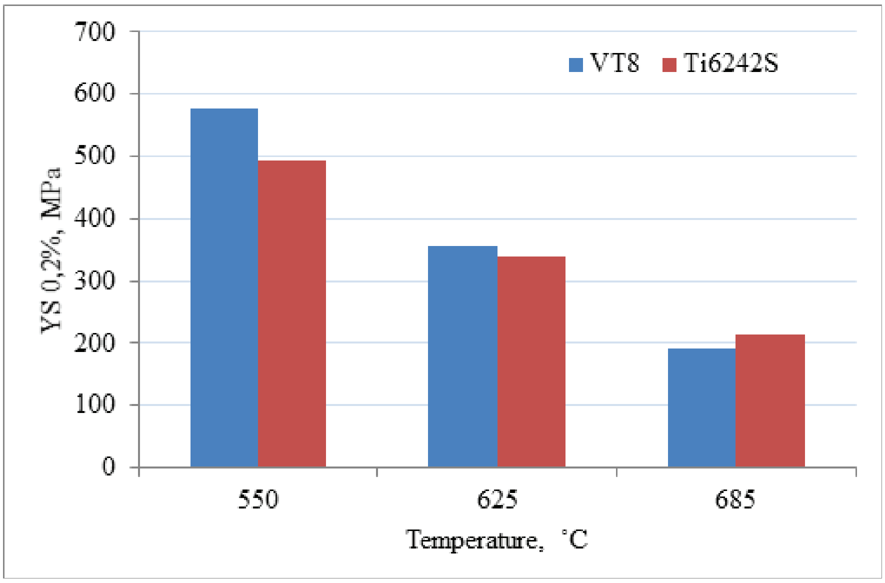
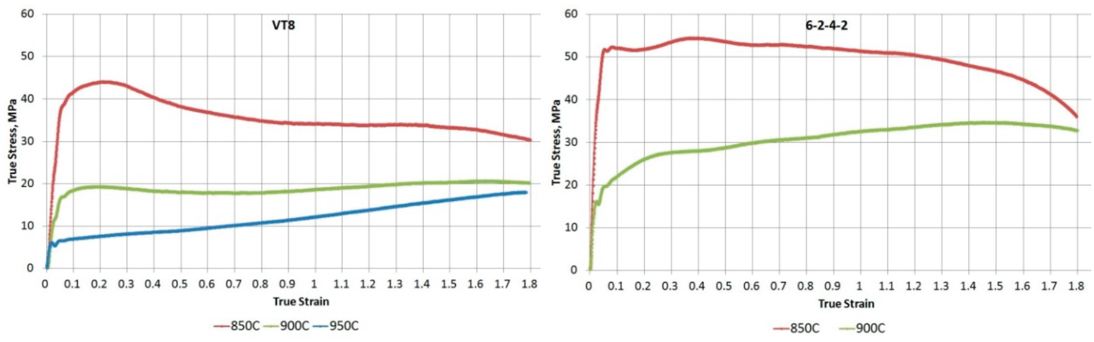


Figure 2: Tensile properties at elevated temperature of VT8 and Ti6242S alloys.

The VT8 and Ti6242S alloys at the early stage of deformation (e≤0.05) at T = 900 °C have a true stress less than 20 MPa. With further deformation, the true stress of the



(a) (b)

Figure 3: True stress – true strain curves of alloys VT8 (a), Ti6242S (b) obtained at 850, 900, 950 °C and strain rate tests at $3*10^{-4}s^{-1}$.

Ti6242 alloy increases to 35 MPa, while the VT8 alloy remains at the same level of 20 MPa. Parameters of microstructure such as grain size, shape and volume fraction phase components in the alloy affects its superplasticity. Obtained behavior of alloys at investigated temperature can be explanation by difference of grain size and volume fraction of β phase.

4. Conclusion

VT8 titanium alloy in the investigated condition can be formed in the superplasticity mode with flow stress is approximately 30 % lower than that of Ti6242S mill annealed sheet. The optimum temperature for superplastic deformation of the VT8 was obtained at the strain rate of 3×10^{-4} s^{-1} and 900 °C.

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