High temperature compressive deformation of the activated sintered W-powder compacts

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Abstract

A small amount of iron group metals added to tungsten powder as a sintering activator increases drastically the sinterability of the W-powder compact. Such an activated sintering method allows a lower sintering temperature of about 1200 – 1400 °C and shorter sintering time than the conventional PM processing, which can ultimately lead to cost benefits for the commercial application. However, the presence of the activating metals has a negative effect on the mechanical properties of the activatedly sintered W-compact, causing extreme brittleness. Therefore it can hardly be worked into the desired form by plastic forming process. However, there is rarely found any investigations which have quantitative analyzed the plastic deformation behavior of the activated sintered W-compact at its hot working temperature. In the present study it is aimed to analyze the stress-strain relationship through compressive testing at the hot working temperature in order to provide the useful mechanical data for further working.

A wide range of compression test of the Ni-doped W sintered compact was carried out under controlled temperature conditions between 900 and 1100 °C and a constant true strain rate of $1 \times 10^{-3} - 1 \times 10^{-0}$ /s by use of "Thermecmaster-Z". The sintered microstructure of the test specimen as well as the morphology and the chemistry of the fracture surface was appropriately analyzed by using OM, porosimeter, SEM and AES.

A moderate true strain up to 0.6 was obtained without fracture at the testing temperature of 900 °C irrespective of the strain rate for the Ni activated sintered W specimen of an appropriate porosity and controlled grain size, being comparable to that of pure W specimen. The relationship between the brittle features and the segregated Ni phase was discussed on the basis of the microstructural analysis and the deformation behavior.

The thickness of the Ni-rich phase seems to be an important factor to overcome the brittleness of the Ni-activated sintered W compact. The Ni-rich phase was redistributed or decomposed from the triple or quadruple point among W- grains to the surface plane between W grains at a higher temperature of 1000 °C by results of the AES analysis on fracture surface. The Ni-doped W compact showed a pertinent true strain up to 0.6 at 900 °C, because the stability of the Ni-rich phase could remain under the relatively higher strain rate and lower testing temperature.

In addition to Ni, Co and Fe were added as an activator for the sintering of W compact. The order of the activator which influences positively on the deformability (maximum true strain) of the activated sintered W-compact is Ni, Co and Fe, as similar to the order of the activator in sinterability. The maximum true strain of the Co activated sintered W-compact was attainable by an appropriate control of the microstructure of testing specimen and testing condition. The similar discussion on the relation between deformation behavior and the testing condition was also carried out for these Co (or Fe) activated sintered W-compacts.