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Technical Report

The workability evaluation of wrought AZ80 magnesium alloy in hot compression

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ABSTRACT

Workability, an important parameter in metal forming process, can be evaluated by means of processing maps on the basis of dynamic materials model (DMM), constructed from experimentally generated flow stress variation with respect to strain, strain rate and temperature. To obtain the processing maps of wrought AZ80 magnesium alloy, hot compression tests were performed over a range of temperatures 523–673 K and strain rates 0.01–10 s^{-1}. As the true strain is 0.25, 0.45, 0.65, 0.85 respectively, the response of strain-rate sensitivity (m-value), power dissipation efficiency (η-value) and instability parameter (ξ-value) to temperature and strain rate were evaluated. By the superimposition of the power dissipation and the instability maps, the stable, metastable and unstable regions were clarified clearly. In further, in the stable area the regions having the highest efficiency of power dissipation were identified and recommended. The optimal working parameters identified by the processing maps contribute to designing the hot forming process of AZ80 magnesium alloy without any defect.

1. Introduction

Since 1990s, there is an appearance of high-strength magnesium matrix composites as lightweight advanced structural materials for automotive, and aerospace. Magnesium alloys are considered as possible replacements for aluminum, plastics, and steels, primarily because of their higher ductility, greater toughness, and better castability [1,2]. Recently, although the casting process using the magnesium alloys has been widespread in manufacturing the complex-shaped parts due to its good castability, the mechanical properties of the part made by casting process may not meet industrial requirements [3]. Thus, an alternative process like forging has been required to improve the mechanical characteristics. However, magnesium alloy has the hexagonal close-packed crystal structure whose dominant slip system at room temperature is basal slip. This is not sufficient for homogeneous deformation of polycrystalline material. Fortunately, the warm or hot working condition offers the chance to improve the workability of magnesium alloy through the activation of non-basal slip plane [4]. The workability of alloy refers to the plastic deformation ability that a metal can be deformed easily without fracture during bulk deformation process such as forging, extrusion and rolling. The workability consists of two independent parts: state of stress (SOS) workability and intrinsic workability. The SOS workability is governed by the geometry of deformation zone and the externally imposed stress state, both of which vary with the different metal deformation processes. The intrinsic workability is decided by the microstructure evolution under certain deformation conditions (different temperature, strain rate, and strain) which is implicitly in the flow stress curves of material [5,6]. As one of the important performances, the intrinsic workability can be indicated by using a processing map based on dynamic materials model (DMM). The DMM model was proposed firstly by Prasad et al. in 1984, and then its variant was carried out by Murty [7–9]. Although there are some differences between Prasad's model and Murty's model, the results evaluated by these two models are similar for investigating deformation behavior of metals and alloys [8,9]. Hitherto, the processing maps based on both these two DMM models have been widely used to characterize the forgeability, optimize hot working process and control microstructure of aluminum alloys, magnesium alloys, titanium alloys, zircaloy alloys, copper alloys, etc. [9].

How to evaluate the process and improve the mechanical properties of wrought magnesium alloys are of greatly scientific significance. Therefore, the aim of the present investigation is to study the hot deformation behavior of AZ80 magnesium alloy using the processing map so as to optimize its hot workability. With the help of processing maps, it is possible to arrive at the optimum parameters for designing a metal working process without resorting to expensive and time-consuming trial-and-error methods.

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