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RESEARCH ARTICLE OPEN ACCESS

Process design based on FE simulations and experiments of forging a complex-shaped magnesium alloy adaptor

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Abstract – High-strength magnesium alloys show great potentials for aviation and aerospace applications due to their special strength and low density, but these are difficult to form because of the poor formability and narrow, feasible forging-temperature ranges. Isothermal forging is an effective method to manufacture complex-shaped components with a magnesium alloy, in which the avoidance of forming defects and improvement of mechanical properties are of great concern. The process design of complex-shaped MB26 magnesium alloy adaptor based on finite element (FE) simulations and forging experiments was conducted in this study. A combined female-die was used in order to remove the adaptor forging with three branches. Different forming schemes were analyzed and compared through finite element method (FEM) simulations and forging experiments. The results showed that, compared with a one-step forging process, two-steps forging was more appropriate for forming the adaptor, which not only improved the filling quality but also reduced the forging load. In addition, the aging treatment after hot forging could only slightly improve the mechanical properties of the MB26 adaptor forging, because of the minor addition of rare earth (RE) elements.

Key words: Magnesium alloy adaptor, Forging process design, FE simulation, Forging experiments

1. Introduction

Magnesium alloys are light-weight and high-strength structural materials, which have great potentials in the application of aviation, aerospace and automobile industries [1]. However, magnesium alloys exhibit low workability due to the limited number of slip systems associated with hexagonal close packaged (HCP) crystal structure. Currently, most of magnesium alloy components are used in the as-cast condition, which are hard to meet high performance service requirements [2]. Compared to the castings, magnesium alloys subject to plastic deformation exhibit improved strength and ductility, loading bearing capacity, shock resistance ability, etc. Therefore, hot precision forging of magnesium alloys are garnering increasing attention in recent years [3, 4]. In particular, isothermal precision forging is extensively utilized to manufacture complex-shaped structural components of hard-to-deform metals, such as magnesium, aluminium and titanium alloys [5–8]. For instance, Yan et al. successfully produced magnesium alloy upper housing of helicopter through isothermal precision forging process [9]. A. Dziubińska et al. adopted semi-open die forging to form AZ31 magnesium aircraft brackets [10]. Rabori et al. studied on the microstructure and superior mechanical properties of a multi-axially forged WE magnesium alloy [11]. He et al. performed the simulation and experimental research on isothermal forging of large AZ80 magnesium alloy support beam [12]. However, the isothermal forging process of complex-shaped component is not easy to determine since magnesium alloys have narrow forging temperature range and poor deformability.

In the present study, the forging process of a MB26 magnesium adaptor with three branches is designed with combined female die. Different forging schemes are compared and the defect mechanisms are analyzed through finite element (FE) simulation and process experiment, based on which the two step forging process was determined to form the adaptor component. Besides, the microstructure and mechanical properties of the MB26 adaptor are analyzed during isothermal forging and post-forging heat treatment.

2. Material and forging schemes

2.1. Materials and target component

The material used in the present investigation is MB26 magnesium alloy, belonging to Mg-Zn-Zr alloy with minor addition of rare element Y. The chemical composition of the

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Table 1. Chemical composition of MB26 magnesium alloy (wt.%).

Zn	Zr	Mn	Al	Fe	Si	Cu	Y	Mg
6.33	0.79	0.01	0.004	0.003	0.002	0.002	0.93	Balance

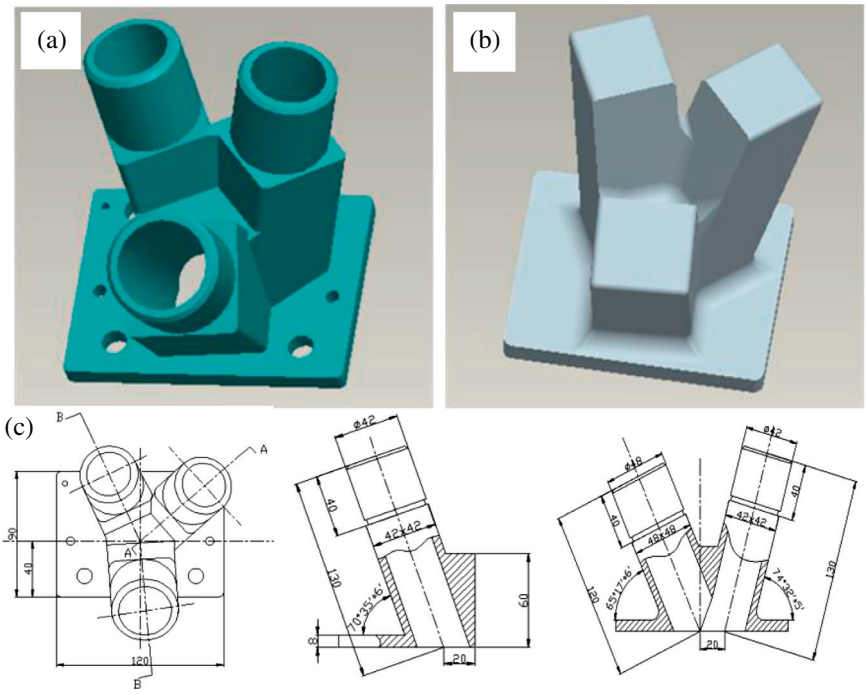

Figure 1. 3D solid modeling drawing of the MB26 magnesium adapter: (a) component, (b) forging billet, (c) 2D dimension of adaptor.

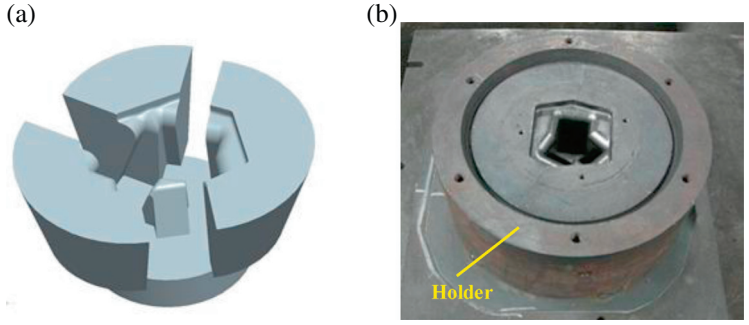

Figure 2. (a) 3D solid modeling drawing of combined die and (b) photo of female die.

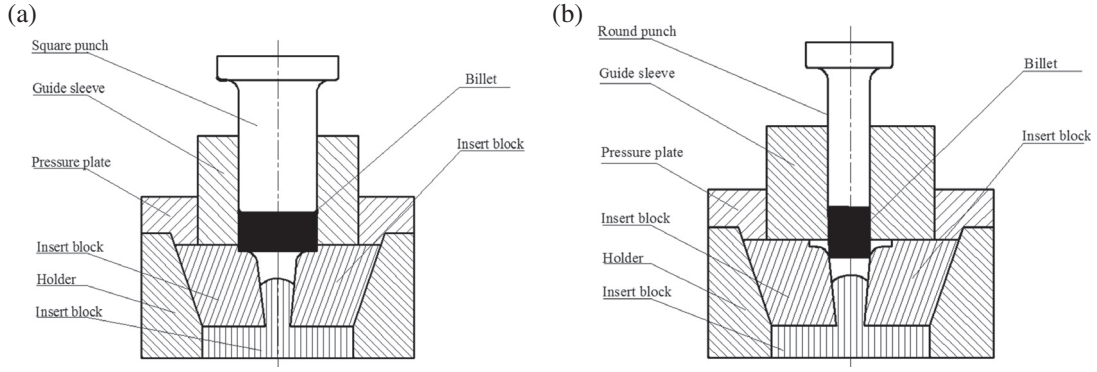

Figure 3. One-step forging scheme. (a) Scheme A, (b) Scheme B.