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ScienceDirect

Procedia Engineering 207 (2017) 383–388

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on the Technology of Plasticity, ICTP 2017, 17-22 September 2017, Cambridge, United Kingdom

A novel backward extrusion process through rotating die and open punch

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Abstract

In this study, a new method of backward extrusion through rotating die and open punch, named rotating backward extrusion (RBE), is proposed. In this new process, a torque is imposed on the die that drives billet rotating. The rotating billet was backward extruded with the use of the punch with end face groove. To investigate the capability of this process, the experiment and finite element (FE) analysis were carried out for AZ80 magnesium alloy used as experimental material. The effects of rotating speed on the effective strain and process load were analyzed. The effective strain of the final part and process load were compared for cup extrusion by both the conventional and the new process respectively. The results showed that the average effective strain through the processed sample was approximately higher in 3 times the value of the sample processed via the conventional backward extrusion. The reduction of process load is about 20% in maximum in comparison with the conventional backward extrusion process. This new process has proven to be promising for the hollow parts production because of lower process force and imposing higher effective strain. The potential for grain refinement and mechanical properties improvement are required to fully evaluate for the new process.

Keywords: Rotating backward extrusion, Open punch, Press load, Effective strain

Introduction

Nowadays, the extrusion process has a great important role in the manufacturing industries. Between various conventional deformation processing methods, the backward extrusion (BE) method has become one of the most promising manufacturing processes in usage, due to its material savings and high surface quality [1, 2]. Moreover, backward extrusion has formerly been used in steel, aluminum and magnesium alloys forming for the production of hollow-shape symmetric and cylindrical products. Due to the evolution of the microstructures and mechanical properties of the deformed materials being directly related to the amount of plastic deformation, the phenomenon a-

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10.1016/j.proeng.2017.10.792

-ssociated with strain development is very important to be understood [3]. This is even more distinct, considering the fact that most existing backward extrusion procedures suffer from a smaller deformation percentage of the imposed effective strain within the processed work pieces [4, 5]. This, consequently, may lead to an unfavourable microstructure inhomogeneity and poor overall mechanical performance of the products [6].

Recently, extensive studies have been performed for various new techniques, based on the extrusion process for imposing a higher effective strain and a better strain homogeneity, to be developed. A repetitive indirect extrusion technique, known as accumulative back extrusion (ABE), was developed for the first time in 2009 [7]. ABE is a kind of severe plastic deformation （SPD）process in which back extrusion (BE) and compression are executed cyclically. Certain studies are presented regarding this method for aluminium [8, 9] and magnesium alloy [10, 11]. A new backward extrusion utilizing a small diameter billet was described recently, as a technique for grain refinement [12]. A novel low-temperature indirect extrusion process utilizing artificial cooling was devised and the effects of artificial cooling during indirect extrusion on the microstructure and tensile properties of an extruded commercial AZ31 alloy were studied [13].

In this study, a new backward extrusion method through rotating die and open punch, named rotating backward extrusion (RBE), is proposed. The capabilities of this process are investigated by the experimental and finite element (FE) methods. The description of this novel rotating backward extrusion process, emphasizing the effective strain and process load, is presented.

Principle of the RBE process

Schematic illustration of the rotating backward extrusion is shown in Fig.1. The facility consists of an innovative punch with transverse groove at the end face and a die with longitudinal groove in the inner wall, as can been shown in Fig.2, in order to apply pressure and torsional straining to the sample. In this new process, a torque is imposed on the die that drives billet rotating. In other words, the die and billet are rotated with respect to the punch at a rotation speed. The rotating billet is backward extruded with the use of the punch with end face groove. The billet, in the form of a solid cylinder, is placed into the die cavity. With the rotation of the die and billet, the billet is pressed by the punch in order for the material to be back-extruded into the gap between the punch and the die. During the rotating backward extrusion process, material is pressed into the groove and flattened continuously.

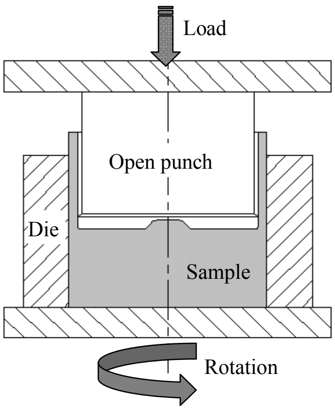

Fig.1. Schematic illustration of the RBE facility

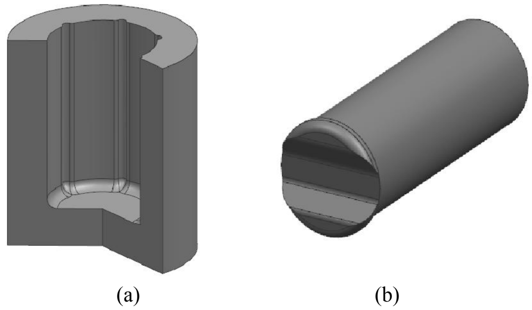

Fig.2. Die (a) and punch (b) for RBE process

In the present experiments, initial diameter of cylindrical billets are 22 mm, and initial height/diameter ratio, h0/d0, is 1.0. The diameter of punch is 12.7mm. The die rotation angular velocities are 0, 0.04, 0.08 and 0.12 rad/s, respectively. When the rotation angular velocity is 0rad/s, it is evidently conventional backward extrusion. The constant extruding speed is determined to 0.05mm/s. The numbers of revolution (*N*) are 2, 4 and 6 turns respectively corresponding to the die rotation angular velocities of 0.04, 0.08 and 0.12 rad/s. The specimen shape is changed from the initial configuration shown on the left in Fig.3 to the final configuration shown on the right after rotating backward extrusion.