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Influences of electric-hydraulic chattering on backward extrusion process of 6061 aluminum alloy

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Abstract: The possibility of the electric-hydraulic chattering technology and its application in the cold extrusion were presented. The conventional and electric-hydraulic chattering assisted backward extrusion processes were performed on 6061 aluminum alloy billets at room temperature. The experimental results showed that 5.65% reduction in the extrusion load was attained if the die and ejector were vibrated at a frequency of 100 Hz and amplitude of 0.013 mm in the longitudinal direction. The friction coefficient at the billet and tool system interface determined from the finite element analysis (FEA) decreased from 0.2 without chattering to 0.1 with application of electric-hydraulic chattering. The higher values of instantaneous velocity and direction change of material flow were achieved during the chattering assisted backward extrusion process. The strain distribution of the chattering assisted backward extrusion billet revealed lower maximum strain and smoother strain distribution in comparison with that produced by the conventional extrusion method.

Key words: 6061aluminum alloy; conventional backward extrusion; electric-hydraulic chattering assisted backward extrusion; finite element analysis; material flow; strain distribution

1 Introduction

Vibration assisted metal forming is one of the most recent and beneficial process improvements in which vibration is applied on the billet or the die to improve forming process because of the lower forming load, better surface qualities and higher precision of the parts [1,2]. However, the influence that the extent to which the vibration may be advantageous depends on the type of process, the vibration exciting method, the mode of vibration, and so on [3].

Various types of deformation test have been carried out to investigate the influences of vibration. By using a piezoelectric transducer (PZT), BUNGET and NGAILE [4] superimposed ultrasonic vibration on micro-extrusion setup, and a significant reduction on the extrusion force and an obvious improvement in the surface of the deformed parts were observed. SIEGERT and MÖCK [5] reported similar results during vibration assisted wire drawing process. BAI and YANG [6] superimposed vibration on metal foil surface finishing process and found improvement in the surface roughness. SEO et al [7] developed an audio frequency vibration (AFV) micro-forming system and found experimentally that the formability could be increased. By means of magnetostrictive transducer, SUSAN et al [8,9] applied vibration on ball-bearing steel wire drawing and found the decrease of the friction coefficient between the workpiece and die interface. YAO et al [10] observed the stress decreasing during vibration assisted micro/meso upsetting process. JIMMA et al [11] observed experimentally that higher vibration frequency can lead to higher limiting drawing ratio, greater accuracy and deeper cups by using electrostrictive transducer. It should be noted that the exciting vibration technologies described above were applied only in the metal forming process requiring lower forming load, such as micro/meso forming and wire drawing forming process.

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Additionally, other exciting vibration technologies developed for the metal forming processes with higher forming load are also reported. OSAKADA et al [12] applied vibration on the container using a motor during enclosed-die forging and observed significant decrease in the forming load. CAI and JIANG [13] experimentally found that lower forming force, shorter forming time, and better forming quality can be attained by the hydraulic exciting vibration rotary forging. BOCHNIAK et al [14] superimposed rotary vibration on the punch or the anvil during compression and forging process and found that the lower forging force was required in comparison with the conventional method. MILENIN et al [15] investigated the process of flat rolling with additional vibration of rolls along their axes by using a numerical model. However, lower frequencies and greater amplitudes of the vibration were produced by these exiting vibration technologies. It may restrict the applications of these technologies in the metal precision forming processes. An electric-hydraulic chattering technology was presented to solve these problems [16].

Numerical simulations are often employed for understanding the metal forming process because of the difficulty of performing measurements inside a die. Therefore, the finite element method (FEM) is often used to predict the required forming load, effective strain, stress distribution and temperature gradient at any instant of time during a forming process [17].

The main aim of the present work is to study the differences between the conventional backward extrusion (CBE) and electric-hydraulic chattering assisted backward extrusion (EHCABE) processes in load requirement, material flow and strain distribution. Experiments of both processes at room temperature were performed. Additionally, a commercial finite element analysis software Deform-3D was employed to evaluate the friction coefficient between the billets and die interface, and predict the deformation behavior of the material in the CBE and EHCABE processes such as velocity of material flow and strain distributions.

2 Experimental

To carry out EHCABE process, a special experimental setup with electric-hydraulic chattering was designed and prepared (see Fig. 1). The electric-hydraulic chattering platform was composed of a circular plate used for fixing the die, an upper plate with grooves and a lower plate with oil duct for passing hydraulic oil. Due to the grooves, the chattering of upper plate could be excited by the hydraulic oil controlled by a high frequency exciting vibration valve. The frequency and amplitude of chattering can be adjusted by using a specially designed control test device with a frequency

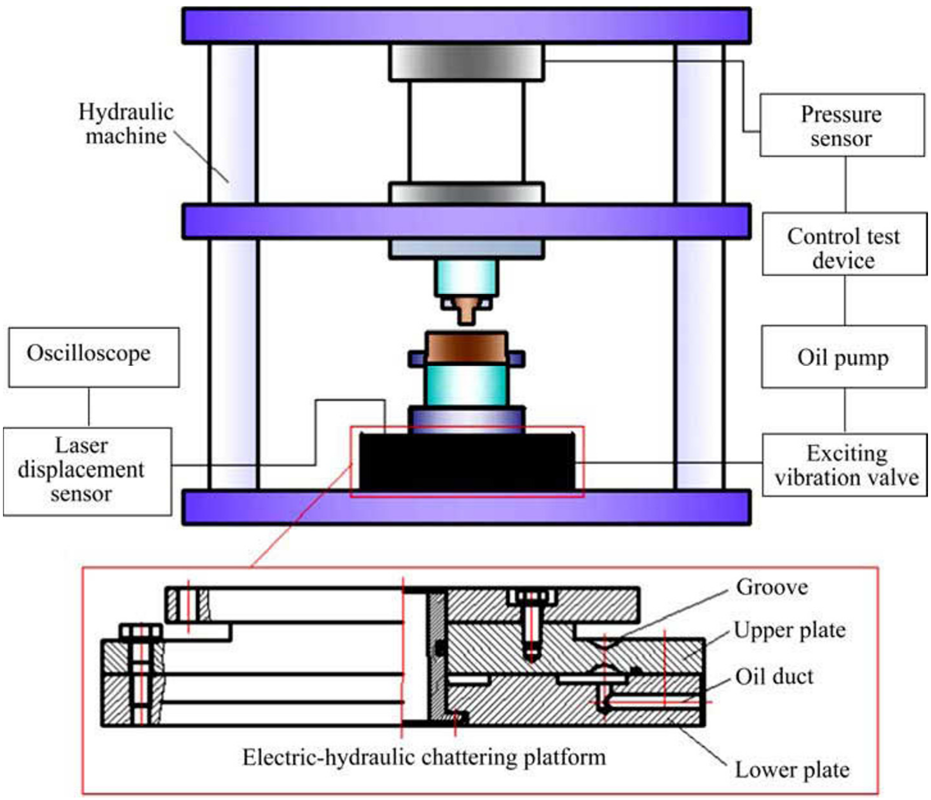

Fig. 1 Configuration of electric-hydraulic chattering assisted backward extrusion (EHCABE) experimental setup