Manufacture of miniature parts using micro electro hydraulic forming of thin aluminium sheets

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Summary

Micro electro hydraulic forming of thin aluminium sheet is investigated in this paper both theoretically and experimentally. An electro hydraulic forming apparatus is presented by which miniature parts can be made. The process is first analysed by the FE method. In this paper it will be shown that electro hydraulic forming can be successfully used to manufacture miniature parts with high accuracy. It is shown that thin aluminium sheets can be formed into complex parts such as coin and sculptural features. Effects of part distance from the forming die and air vent of the die cavity are investigated on parts quality.

1. Introduction

Industrial demands on miniature products with high accuracy and complex shapes are increasing. For this reason various methods have been invented to produce these parts. Several non-traditional techniques have been proposed for low volume production of complex miniature parts with high accuracies [1, 2, 3, and 4]. The estimated rise in turnover from 15 to 35 billion US$ in the last 7 years shows a growing demand on micro technical products, which is mainly driven by a rising trend of miniaturization of products [1]. The demand of miniaturization comes not only from consumers, who are wishing more handy electronic devices and more integrated functions, but also from technical applications like medical equipment, sensor technology and optoelectronics [2, 3]. All these products contain mechanical parts such as leverages, connector pins, resistor caps, screws, contact springs and chip lead frames [3]. Significant numbers of micro-sheet components, which are popularly used in the electronics industry, are still produced largely by using various stamping configurations. As demands on the variations of the component-forms and the types of the materials increase, process- and tool-engineers face new challenges. Forming methods under high strain rates, such as Electro Hydraulic Forming (EHF), allows the possibility of significant improvement of formability, because the technique is associated with a high deformation rate of blank materials [5, 6]. Trends towards rapidly growing volumes of small series production are expected to increase the interest of high velocity forming technologies such as EHF [7]. In the EHF process, improvement of ductility in several materials has been observed under high strain rates [8, 9]. High-speed metal forming with liquid shockwaves, generated explosively in a liquid shock tube, is a new field of study. The advantage of forming with liquid shock waves in a shock tube in comparison to explosive forming is better control and increased safety [10]. In this paper it will be shown that electro hydraulic forming can be successfully used to manufacture miniature parts with high accuracy. This system converts electrical energy stored in a capacitor bank into hydraulic pressure. Utilizing this method, parts can be formed from either a tubular or a flat blank. After the blanks are loaded into a forming die, the chamber is filled with deionized water and a pair of electrodes is inserted into the work chamber. The capacitor bank is then discharged through the electrodes and between electrodes gap a spark would initiate. This produces an expanding plasma channel and a high intensity shock wave which combine to force the work piece to move towards the die. The process is investigated both theoretically and experimentally. For safety reasons, stresses in the main parts of system are predicted both theoretically and FE method. In this work thin aluminium sheets are successfully formed with a very good accuracy into complex parts such as coin and sculptural features. Effect of part distance from forming die and air vent from the die cavity are investigated on parts quality. One of the advantages of this proposed method is using a low voltage as compared with voltages usually used in conventional electro hydraulic forming processes. The other advantages of this mechanism are its simplicity and sealing method for production of miniature complex parts.