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Theoretical and experimental analysis of the dieless incremental sheet forming process

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Abstract

Incremental sheet forming (ISF) is a very promising technology to manufacture sheet metal products by the CNC controlled movement of a simple forming tool. Although it is a slow process, the cost reduction linked to the fact that punches or dies are avoided, makes it a very suitable process for low series production, in comparison with the traditional stamping or drawing processes. Nevertheless, the process still needs a further optimization to guarantee the reliability required for industrial applications. Process analysis based on experimental tests and modelling is required to analyse the effect of process parameters on the characteristics of incrementally formed parts and to go deeper in the understanding of the process itself. Therefore, this paper shows preliminary results obtained with experimental tests and a simple FEM model which gives accurate prediction of some characteristics of the formed parts.

Keywords: Incremental forming; Sheet metal; Process modelling; FEM; Process parameters; CNC machine

1. Introduction

Sheet metal industry often employs different forming methods which are based on the usage of punches and dies with the accurate geometry of the part to be formed. These methods are normally used for mass production, since the high cost of the dies can be shared among a large number of products. However, when a short series production is required, the conventional methods based on dies, like stamping or drawing are not usable anymore and, therefore, new production methods have to be developed in order to fulfil the requirements imposed by the low series production industries. Nowadays, the production of small batch series is required by many industrial sectors (rapid prototyping, automotive and aeronautic industries, biotechnology, design furniture, . . .) and reaches a market volume over €4000 million/year, which requires an important scientific and technological effort to develop new production methods suitable for low series production. Among the different possibilities, incremental sheet forming (ISF) has proved to be a very reliable solution as shown in many different works carried out by Kim and Park [1,2], Ceretti et al. [3], Ambrogio et al. [4] and Kopac and Campus [5]. This method is based on the forming of a metal sheet by means of a CNC controlled tool which plastically deforms the blank according to the desired shape. The tool trajectory is directly taken from the CAD file of the part to be formed. The process can include a basic geometry supporting die ("positive ISF") or no dies at all ("negative ISF"), depending on the complexity of the part. Due to the flexibility of incremental sheet forming, this method is especially adequate for low volume production in order to save the high cost and long processing time needed with other manufacturing processes as stamping or drawing. On the other hand, this process is very slow compared to the traditional ones, which makes it only usable when a low series production is required. The economical characteristics of the process and the volume range in which it can be profitably used have been intensively studied by many authors [6–9]. In this scenario of industrial interest in the technology, scientific effort is required in order to optimize the process, overcome the present limitations, and make it a useful tool for the industry. In this sense, it is very important to increase the knowledge on the incremental forming procedure through an experimental study which gives information on the effect of process parameters on the characteristics of the formed parts, together with the development of accurate process models which may improve the understanding of the process itself (see, e.g. the work developed by Hirt et al. [10,11]). Therefore, this paper summarizes

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