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Study of the Tool Geometry Influence in Indentation for the Analysis and Validation of the New Modular Upper Bound Technique

Carolina Bermudo *, Lorenzo Sevilla, Francisco Martín and Francisco J. Trujillo

Civil, Material and Manufacturing Engineering Department, University of Malaga, Malaga 29071, Spain; lsevilla@uma.es (L.S.); fdmartin@uma.es (F.M.); trujillov@uma.es (F.J.T.)

* Correspondence: bgamboa@uma.es; Tel.: +34-951-952-427

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Abstract: Focusing on incremental bulk metal forming processes, the indentation process is gaining interest as a fundamental part of these kinds of processes. This paper presents the analysis of the pressure obtained in indentation under the influence of different punch geometries. To this end, an innovative Upper Bound Theorem (UBT) based solution is introduced. This new solution can be easily applied to estimate the necessary force that guarantees plastic deformation by an indentation process. In this work, we propose an accurate analytical approach to analyse indentation under different punches. The new Modular Upper Bound (MUB) method presents a simpler and faster application. Additionally, its complexity is not considerably increased by the addition of more Triangular Rigid Zones. In addition, a two-dimensional indentation model is designed and implemented using the Finite Element Method (FEM). The comparison of the two methods applied to the indentation process analysed—the new Modular Upper Bound technique and the Finite Element Method—reveal close similarities, the new Modular Upper Bound being more computationally efficient.

Keywords: incremental forming; indentation; Finite Element Method (FEM); Modular Upper Bound (MUB); Upper Bound Element Technique (UBET); punch geometry; plastic deformation

1. Introduction

The application of incremental bulk metal forming processes is gaining growing interest in the current industry. These processes are being investigated due to their advantages, widely discussed in literature by different authors [1–6]. The incremental method is frequently used since it offers load reductions and workability increments in comparison with other processes. It also allows forging materials that present high resistance to deformation, obtaining large final shapes. Another important issue is the tools simplicity—normally a simple punch—and their exchangeable capability. This gives flexibility to the production, a very important feature nowadays. Finally, the high smoothness of the final workpiece deformed by these processes, the material economy and the aptitude for a complete management with Computer Numerical Control (CNC) machines can also be noted. To this end, having these processes implemented in the current industry plays an important role in achieving a competitive production.

Consequently, the indentation case study as a fundamental part of these incremental bulk metal forming processes, is considered as a necessary step in the metalworking industries. Applying indentation to a workpiece, the final shape is progressively obtained by repetitive compressions. Thus, the indentation process is no longer considered as a secondary manufacturing process. On the contrary, it is presented as an alternative to traditional plastic deformation processes. It is not difficult to find works that extensively explore possible applications related with indentation processes,

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