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A die design method for springback compensation based on displacement adjustment

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ABSTRACT

Springback is a major problem in sheet forming processes. This problem can be corrected by adjusting the tooling shape to the appropriate shape and/or active process control. In this paper, the focus will be on tooling shape design, of which compensation magnitude and compensation direction are the two important aspects. A new method, which takes compensation direction into account based on displacement adjustment, has been developed. The method, which we call "comprehensive compensation method" (CC) is general for it considers the fact that large rotation and displacement would occur during springback, which is more common for automotive panel stamping due to the application of advanced high strength steels (AHSS) and the complexity in automotive panel structure. An angle compensation factor was introduced to determine the compensation direction. Compared to the three existing methods, which compensate in different directions, the new method has a higher precision especially for complex panel with advanced high strength. Additionally, the suitability and application of those four methods is also discussed, along with the origin of the differences.

1. Introduction

Springback can be considered a dimensional change which happens during unloading, due to the occurrence of primarily elastic recovery of the part. It causes deviation from the designed target shape and produces downstream quality problems and assembly difficulties. To reduce springback, several approaches have been employed. Most of them focus on adjusting the main process parameters such as blankholder pressure, optimizing drawbead geometrical parameters, etc., to increase sheet tension during bending; some other approaches may also be taken to utilize sheet material properties to its advantage, such as changing the one-step stamping scheme to multi-stage stamping scheme, optimizing material properties of the sheet, etc. These approaches are effective with the advantage of not being required to adjust the tooling shape, but they cannot altogether eliminate springback completely, and may create other problems such as tearing or wrinkling; also based on trial-and-error method, they are found to be time-consuming. To limit trial and error procedures, numerical simulation methods have been used in sheet metal stamping in a wide range to evaluate springback and optimize the design [1–4], although strong nonlinear behavior in sheet metal stamping process makes it a problem to predict springback accurately. Improving the accuracy of springback prediction is an important topic that is beyond the scope of this paper.

Instead of reducing springback, the other approaches tend to adjust tooling shape to compensate for springback. Compared with those approaches mentioned above, which aim to eliminate springback, these approaches of adjusting tooling shape compensates springback to gain the desired product, it means that springback remains large, but with the modification of the die-face, the final product shape would closely approximate that of the desired product. It is more cost effective and has the potential to compensate springback completely for even complex parts.

Traditionally, springback compensation would be made using handbook tables based on analytic results for simple 2D formation or has to be carried out by trail-and-error for complex 2D shape and 3D shape, which is also time-consuming. To improve efficiency of springback compensation, Karafillis and Boyce [5,6] proposed the "Force Descriptor Method (FDM)" which is based on finite element simulation with an iterative scheme. However, its application suffers from lack of convergence unless the forming operation is symmetric or has very limited geometric change during springback [7,8], and the result is a little conservative [9,10]. In three dimensional formation processes, buckling can occur and in some cases the FE calculation will also fail to converge [10]. The "Displacement Adjustment (DA) method", of which compensation magnitude and compensation direction are

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