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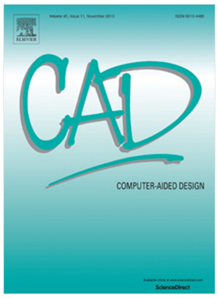

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Zhen Wang, Qiuchong Zhang, Yuqi Liu, Zhibing Zhang

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A robust and accurate geometric model for automated design of drawbeads in sheet metal forming

Zhen Wang; Qiuchong Zhang; Yuqi Liu; Zhibing Zhang*
(State Key Laboratory of Materials Processing and Die & Mould Technology, Huazhong University of Science and Technology, Wuhan, 430074, People's Republic of China)
*Corresponding author, E-mail address: zhangzb@mail.hust.edu.cn; Telephone and fax: +86-027-87558193.

Abstract: A robust and accurate geometric model of real drawbeads that can be used for the automated design of drawbeads is presented in the paper. A three-dimensional geometric drawbead is a lofted surface, of which the section curves are constructed parallel to the stamping direction on the control points. Adaptive control point interpolation is introduced to simplify the management of the drawbead geometry and avoid unexpected shapes. Given primitive control points on a drawbead curve, dominant control points are adaptively obtained with the shapes of both the drawbead curve and the binder considered. An a priori heuristic parameter adjustment strategy is proposed to correct the parameter errors of section curves, which improves the accuracy and consistency of the drawbead geometry. By incorporating the proposed geometric drawbead with a previously developed intelligent drawbead optimization algorithm, a fully automated design process for drawbeads is realized that includes geometric modeling, finite element analysis, intelligent optimization of the drawbead geometry, and die manufacturing. Finally, a fender example is presented to verify the feasibility and validity of the fully automated drawbead design process. The simulation results with the optimized geometric drawbeads and equivalent drawbeads are compared with the experimental results. The proposed geometric drawbead shows remarkable practicability and accuracy in the automated design of drawbeads in sheet metal forming and demonstrates good consistency with the experimental results while the equivalent drawbead model introduces unneglectable deviations.

Keywords: Lofted surface; Drawbead; Intelligent geometry optimization; Automated die design; Sheet metal forming

1 Introduction

Drawbeads are rib-like projections mounted on binder surfaces that restrict and control the material flow in the sheet metal forming process [1]. Drawbeads force the sheet metal to bend and unbend before entering the die cavity. This action creates a restraining force on the sheet metal, which causes the material to enter the die cavity at both a reduced rate and a reduced volume [2]. The drawbeads are one of the most important parameters to control the material flow and the part quality in the sheet forming process. Powerful restraining forces prevent the sheet from drawing-in and may cause necking, but insufficient forces may lead to wrinkling [3]. Restraining forces of the drawbeads are mainly related to the geometry of the drawbeads, so the quality of sheet metal forming can be improved by changing the shape, size, and location of the drawbeads [4].

In recent years, significant developments have been made in sheet forming finite element simulation. Finite element analysis (FEA) is extensively used for drawbead design in sheet metal forming. However, drawbead design is still a highly-iterative process and requires repeated manual adjustment of the geometric parameters. To avoid the disadvantages of the trial and error process, such as low efficiency and dependence on operator experience, FEA combined with optimization methods are often used to perform automated drawbead design. Guo et al. [5] developed a numerical procedure based on the combination of a simplified finite element method called inverse approach (IA) and a sequential quadratic programming method to perform shape optimization of blank