論　文　の　要　旨

題　目　Elimination of Springback of High Strength Steel Sheets Using Additional Bending with Counter Punch

(カウンターパンチによる付加的曲げを利用した高張力鋼板のスプリングバックの消失)

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Elimination of springback is a key issue in press forming of HSS sheets. Although much effort has been made for controlling and compensating springback by proposing several stamping technologies, it is still not so easy to obtain accurate shapes of sheet products. In this thesis, a novel technology to eliminate springback of high strength steels in U-bending process is proposed. These technologies were validated by performing U-bending experiments and corresponding FE simulations. Highlights of the present work are summarized as follows:

In Chapter 1, the background and motivation of the research were presented by giving an overview of previous works on technologies of springback control and compensation. The objective and contents of the thesis were described.

In Chapter 2, outlines of two types of U-bending technologies:　(1) bottom pushing-up; and (2) combined corner bottoming and bottom pushing-up, were presented, and the details of experimental set up, punch shape and process parameters were described:

In Chapter 3, FE simulation for the accurate prediction of springback was described.　Especially the importance of the use of an appropriate material model that describes the Bauschinger effect was emphasized.　Use of the Yoshida-Uemori kinematic hardening model is the best choice because of its high capability of describing plasticity behavior of materials. It was confirmed by comparing the numerical simulation of stress-strain responses of HSS sheet with the corresponding experimental observations.

In the Chapter 4, a new technology of bottom pushing-up with a counter punch to eliminate U-bending springback was proposed. The reduction of springback in this process is attributed to the negative bending moment generated at the bent-corner part of the sheet, which is the driving force of 'spring-go'. It was verified from experiments on 980Y HSS sheet and the corresponding numerical simulations. The present findings are summarized as follows:

(1) In the process of bottom pushing-up without clamping force, springback angle can be reduced to zero, but the geometrical imperfections will appear at the bottom part and the bent corner, i.e. the bottom is not flat enough and the corner radius is too large.

(2) Clamping of sheet plays an important role to improve the flatness of the bottom part of a U-bent product. An appropriate combination of the sheet clamping and the bottom pushing-up force is allow us to eliminate springback entirely and remove the geometrical imperfections.

(3) As for tool desgn, it is important to have an enough deep hollow on the punch head.

(4) For accurate simulation of springback, selection of material models is of vital importance. The Y-U model well captures springback behavior and finding best process parameters the present process, whereas the conventional IH model poorly predicts springback.

In Chapter 5, specifically for a U-shaped product with a small bottom plate, a new technology of combined corner bottoming and bottom pushing-up was proposed to eliminate springback. The mechanism of reduction of springback in this process was discussed based on the FE simulation. The present findings are summarized as follows:

(1) The reduction of springback in the present work is attributed to the decrease of bending moment by corner bottoming and bottom pushing-up. To have a flat bottom plate, the gripping effect by corner bottoming is essential in the pushing-up process.

(2) An appropriate combination of the corner bottoming force and the bottom pushing-up force allow us to eliminate springback entirely and improve the flatness of a bottom plate for 780G and 980Y sheets.

Thus proposed new technologies for elimination of U-bending springback of HSS sheets will be directly applied to real stamping operation in industry. One of the great advantages of the technologies is that it is applicable for any types of HSS sheets (in terms of strength level and sheet thickness) and any shapes (e.g., corner radius, length of bottom plate, etc.) of U-bent products by determining optimum process parameters of corner bottoming and bottom pushing-up forces. The author of the thesis (Lawanwong Komgrit) sincerely hopes that the proposed technologies will contribute to stamping industry greatly.