Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 174 (2017) 171 – 178

Procedia Engineering

www.elsevier.com/locate/procedia

2016 Global Congress on Manufacturing and Management

A Study on Forming for Plate-Type Heat Exchangers of the Ti Material

Byeong-Ju Jin[a], Jong-Pyo Lee[a], Min-Ho Park[a], Tae-Jong Yun[a], Youg-Ho Song[b], Ill-Soo Kim[a]*

[a]*Mokpo National University, 1666 Yeongsan-Ro Chonggye-Myun Muan-Gum Jeonnam. Muan 58554, Korea*
[b]*DHP Engineering Co., Ltd, G, 105, 1022 beon-gil, Gimhae-daero, Hallim-myeon, Gimhae-si, Gyeongnam, Gimhae 50850, Korea*

Abstract

Generally, the heat transfer performance of plate-type heat exchanger has been shown lower than other heat exchangers. Recently titanium material that has high formability and performance has been payed attention to a plate material of the plate-type heat exchange. However, the material has a spring-back due to the high strength as well as the mold design for die and punch processes determined by the operator's experience. Furthermore, the factors that affect the sheet forming are too large and complex to describe by mathematical method so that it is quite difficult for the exact design by experimental methods. Since the chevron shape and pattern are important factors in the performance of the plate-type heat exchanger, the heat exchanger that has the same performance with the targeted one has been manufactured in conjunction with mold design. This design has been employed to predict and determine performance of plate-type heat exchanger. If the mold design of the plate-type heat exchanger has considered to the spring-back phenomenon, the design of two-dimensional shape should necessarily be required. Therefore, the compatibility and adequacy of mold design in the plate-type heat exchanger which is used in the industries, can be verified using three-dimensional(3D) Finite Element Method(FEM). In this paper, a forming analysis of a plate-type heat exchanger with its numerical simulation has been carried out. The optimization of mold design in plate-type heat exchanger that has the complex shape has been proposed using the computer simulation. Since the high-tensile steel plate such as Ti material has high stability when designing a metal mold in the new product, an optimization in the quality of plate-type heat exchanger using the developed numerical model has been proposed.

Peer-review under responsibility of the organizing committee of the 13th Global Congress on Manufacturing and Management
Keywords : Plate-Type Heat Exchanger, Finite Element Method(FEM), Forming Analysis, Sheet Metal Forming, Mold Design

* Corresponding Il-Soo Kim. Tel.: +82-061-454-3455; fax: +82-061-452-6376.
E-mail address: ilsookim@mokpo.ac.kr.

Peer-review under responsibility of the organizing committee of the 13th Global Congress on Manufacturing and Management
doi:10.1016/j.proeng.2017.01.197

1. Introduction

Recently, there is a tendency that has developed heat exchanger to consider various environments, such as high pressure. The plate-type heat exchanger should also be required to reduce volume and weight as compared with the other types of heat exchanger. Furthermore, it might be demanded the high performance which predicted the formability of the inner pattern using a FEM and the forming performance of the heat exchangers because the heat exchanger is composed of complex patterns. One of the problems in the forming analysis has considered a dimensional change, which happens during unloading due to the occurrence of primarily elastic recovery of the part as a spring-back phenomenon of high strength material. Spring-back, an elastic material recovery after the unloading of stamping tools caused variations and inconsistencies of final part dimensions. It has not only caused to errors from the designed target shape, but also produced quality problems and assembly difficulties. To reduce spring-back, several approaches have been employed[1-16]. Most of them have focused on adjusting the main process parameters and optimizing geometrical parameters to increase sheet tension during bending[2]. While some other approaches may also be taken to utilize sheet material properties to its advantages such as changing the one-step stamping scheme to multi-stage stamping scheme and optimizing plate-type heat exchanger[3]. The techniques that based on trial-and-error method, are effective methods which not being required to adjust the tooling shape and eliminate spring-back completely. However, there were other problems such as tearing or wrinkling as well as time-consuming. In order to deal with the those problems, numerical simulation methods have been employed for sheet metal stamping in a wide ranges to evaluate spring-back phenomenon and optimize the design [4]. Until now, many industries have be figured out these problems mainly by compensating the shape of the die even if this procedure takes a lot of the times and moneys[5]. To set the process of spring-back compensation on solid physical and mathematical grounds, Cimolin et al.[6] proposed a new method, in which a set of shape function bases has been employed to express the displacements of both the die and the sheet. The proposed technology reduced the size of the inverse problem to deal with. However, the number of function evaluations is too high for complex geometries[7-10]. In particular, heat exchangers with complex shapes such as plate-type heat exchangers have paid many times and moneys for modifying the mold design. Even if initial mold design has mostly designed with the operator experience, the operator experience to a complex mold design has not settled down with the prototype.

The objectives of this paper have focused on the numerical techniques to analyze the optimization of plate-type heat exchanger and to investigate the possibility for simulating this process by using the commercial FEM code PAM-STAMP. Through the developed FEM model, different eight patterns have applied for the optimal design for plate-type heat exchanger to use compensated method. Finally, the FLD(Forming Limit Diagram) curve has compared with the formability between the initial and optimized plate-type heat exchangers. With the compensation of the mold design, the final product shape would be closely approximate that of the desired product. The developed technology has employed to effective tool to compensate initial mold design completely for even complex parts.

2. Development of the FEM model

2.1. Simulation process

In general, the forming analysis of plate-type heat exchanger has been performed in several processes. For example, drawing for plate-type heat exchanger should be required to 3D modeling, analysis and positing process. In addition, the design for plate-type heat exchanger may be remained problems before the forming process has been optimized due to have the complex shape and pattern. Since mold design for plate-type heat