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ScienceDirect

Procedia Engineering 184 (2017) 35 – 42

Procedia Engineering

www.elsevier.com/locate/procedia

Advances in Material & Processing Technologies Conference

Effect of Hole Lancing on the Forming Characteristic of Single Point Incremental Forming

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Abstract

In the single point incremental sheet forming (SPIF) process, the part accuracy and maximum forming angle are limited in comparison with conventional stamping method. The blank sheet boundary is fixed to prevent it from drawing in during the forming process. In addition, the maximum forming angle is reached when the sheet is deformed into critical thickness as described by sine law in the SPIF. This study gives another view on the role of blank shoulder area by hole lancing before forming process. The experiments showed that the hole lancing not only improve the formability but also part accuracy. The springback prediction by artificial neural network (ANN) were performed to clarify the springback dependence on the forming parameters and hole lancing. The 0.8 mm-thick AL5052-O metal sheet was used for all experiments.

Peer review under responsibility of the organizing committee of the Advances in Materials & Processing Technologies Conference

Keywords: Single point incremental forming, AL5052-O, hole lancing, springback optimization;

1. Introduction

Since the pioneering work of Iseki [1] on incremental sheet forming (ISF), many experimental and numerical studies have been performed to identify the effect of various process variables on formability and minimizing springback, which is inevitable in ISF and large compared with that in press forming. Many different ISF processes such as single-tool ISF, double-tool ISF, negative ISF, and positive ISF have been developed. Due to forming mechanism, ISF is used for producing sheet parts without using presses recently, prototypes of large-sized parts as the nose of a high speed train, electric home appliance cases as well as small-sized parts as camera case and

Peer review under responsibility of the organizing committee of the Advances in Materials & Processing Technologies Conference
doi:10.1016/j.proeng.2017.04.068

healthcare products. In single point incremental forming (SPIF), a sheet is clamped around its periphery by a blank holder and the forming tool moves along a trajectory on the convex surface of the part, from the top to the bottom of the desired geometry (Fig. 1).The deformation mechanisms are stretching ε_{11} and shear γ_{13} in the plane perpendicular to the tool movement direction. These strain components increase on successive laps. But the most significant component of strain is shear γ_{23} in the plane parallel to the tool movement direction [2].

(a) single point incremental forming (b) forming parameters

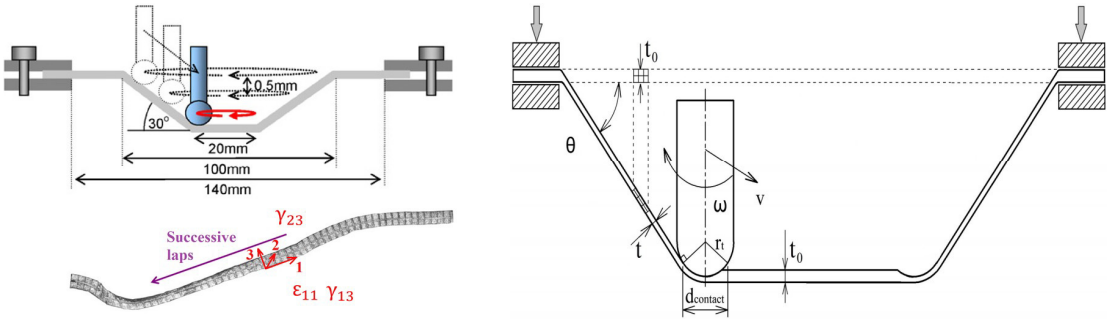

Fig. 1. Single point incremental forming and forming parameters [2].

The forming parameters includes forming angle θ, tool diameter (radius r_t), vertical step size p_z, horizontal step size p_x, tool rotation speed ω, feed rate v, initial sheet thickness t_0, and temperature (see Fig. 1b). Selection of the forming parameters results in final part appearance. The forming angle strongly affects part accuracy, forming step size decides the part surface quality, and tool speed is related to heat generation. The part accuracy is defined by springback amount caused by rebound phenomena after each forming step and clamping release after forming completion. After the forming tool is moving on the contacting area, this area is going under plastic deformation. After the forming tool is moving out, this area is released and going under elastic deformation. The total springback amount is very large and measured by the difference of formed part profile and designed part profile [4, 5]. Springback minimization based on the forming parameters is very critical in SPIF.

(a) forming forces in the ISF (b) hole lancing on the blank shoulder of pyramidal part

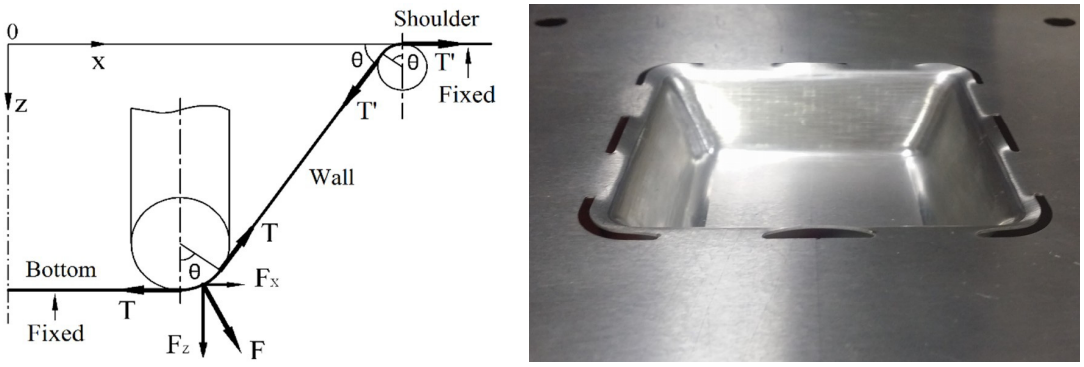

Fig. 2. Forming forces in the ISF and hole lancing on the blank shoulder of pyramidal part.

Additionally in the SPIF process, the blank shoulder area is fixed by holder. So the material in the wall area is stretched by the force T. Meanwhile the same force value T applied to the bottom area tends to put this area under tension [1]. The similar force T' also tends to stretch the blank shoulder area. But the blank shoulder is fixed and