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Fracture diagnostics for Single Point Incremental Forming of thin Aluminum alloy foils

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Abstract **– Nowadays many industrial sectors, as automotive or aeronautic industry, use forming processes in order to produce sheet metal components. The most widely used are the stamping process and deep drawing, based on big and costly dies and presses.**
A specific application, the Single Point Incremental Forming (SPIF), for sheet metal forming will be discussed in this paper.
Force estimation on AlMn1Mg1 sheets with 0.22 mm initial thickness is performed by continuous monitoring of servo motor currents.
The aim of this research work is to apply a non-traditional force monitoring on Aluminum alloy foils and detect fracture.

I. INTRODUCTION

Incremental Sheet Forming (ISF) aims at an innovative concept of sheet metal forming in short and medium volume of production, not for long series, where stamping or deep drawing are well established. ISF has two main groups (Single Point Incremental Forming – SPIF – and Two Point Incremental Forming – TPIF) and it is still an interesting research topic because of its extreme and complex mode for deformation, the flexibility of the process and the high forming limits compared to traditional forming processes.
Excessive thinning of the material during forming processes could lead to cracks. To overcome fracture by necking, excessive thinning should be detected in real-time. Some research works are dealing with experimental study on force measurements for SPIF like [1] or [2], but only a couple of them are focusing on sheets with initial thickness less than 0.5mm [3-6]. The goal of this study is to apply a non-traditional force monitoring on AlMn1Mg1 foils to detect necking and cracks.

II. EXPERIMENTS

A set of experiments were carried out on a Rieckhoff CNC milling machine, the forming tool and a fast-clamping system is shown in Fig. 1.

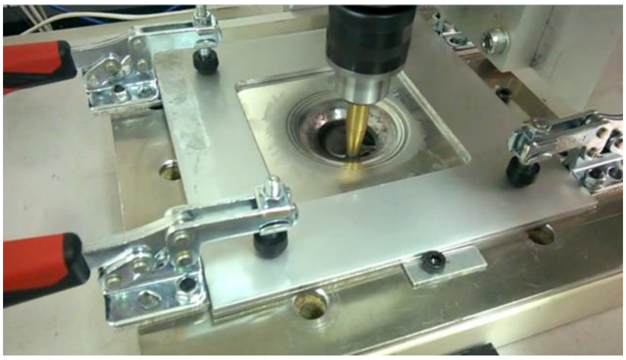

Fig. 1. set-up of SPIF experiments.

The number of experiments required to determine the forming limit of a sheet can be reduced by using a part geometry with variable wall angle as claimed in [7].
For this reason, a conical frustum with circular generatrix was design as shown in Fig. 2.

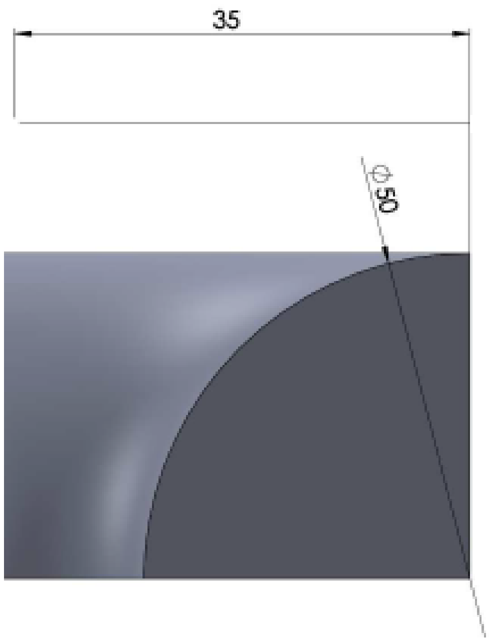

Fig. 2. half of the conical frustum.

A. Control and data acquisition

The CNC Machine control was realised with an open-source Real-Time Control Software called Linuxcnc.
Linuxcnc uses a Real-Time Application Interface (RTAI) with several Modules and a Graphical User Interface (GUI) for motion commands interpretation. Communication is solved through Neutral Messaging Language (NML) channels, except for the Hardware Abstraction Layer (HAL) which allows a number of “building blocks” to be loaded and interconnected to assemble a complicated system. This control allowed to send the tool coordinates to a data acquisition program which collected also the Servomotor data of the Z-axis.

Current measurements were realised with a 0.33 Ohm electrical measurement resistance. From Ohms law the voltages on the Z axis can be obtained.
By using the data of the motor and the drive train, the force applied by the axle as a function of the motor current can be calculated. Z axis loads were obtained to monitor the necking and fracture as in [8]. Similar methodology was used by Rauch et al. [9] to evaluate tool loads in a parallel kinematic machine.

Fig. 3 shows a dataset with at least 30 measurement points per second and a moving average with 16 periods. An arrow is indicating the values of the fracture.

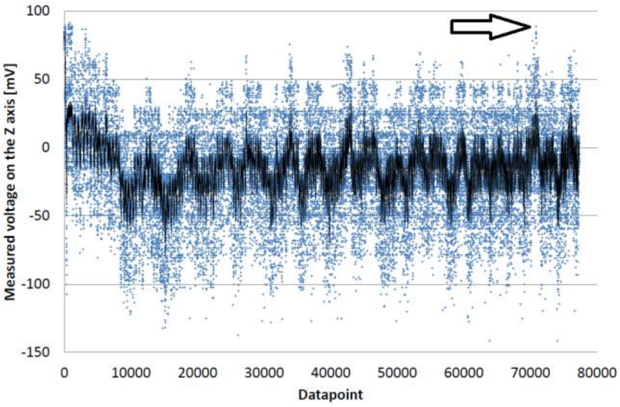

Fig. 3. Measured voltage on the Z axis indicating the values of the fracture.

In some cases, the part can be formed further without removing the end of the geometry. Fig. 4. shows the result of such a forming. An arrow pointing at the fracture.

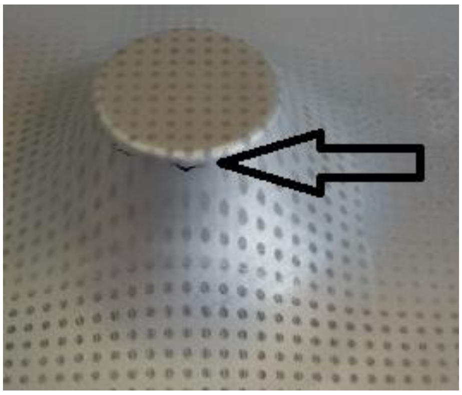

Fig. 4. Result of the forming with fracture.

In this case the forming tool moved further along the programmed tool path and the measured voltage showed no sign of a fracture (see Fig. 5).

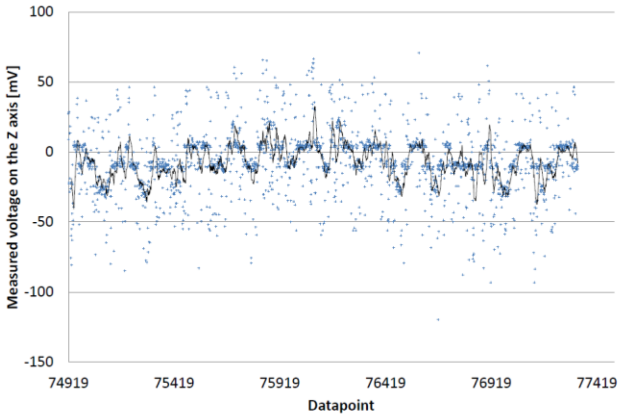

Fig. 5. signals at the end of the forming, after fracture.

ACKNOWLEDGMENT

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