INCREMENTAL SHEET FORMING: A NOWADAYS VISION

O. Fruitos, A. Maymó, A. Ferriz

International Center for Numerical Methods in Engineering (CIMNE)
Campus Norte UPC, 08034 Barcelona, Spain
e-mail: metalform@cimne.upc.edu

Key words: Incremental sheet forming, ISO format, Numerical methods, CAM trajectory, Results visualization, Springback.

Abstract. *The incremental sheet forming (ISF) is a rapid prototyping forming technique that has a high efficiency, quick and low cost process. In this paper, fundamental characteristics of real and simulated execution (numerical simulation -CAE- from CAD geometries and CAM trajectories) are described. The integration degree, results correspondence, treatment in GID platform and development lines are analyzed.*

1 INTRODUCTION

The ISF process consists in a sheet metal forming by means of a spherical punch placed on the head of conventional drilling tool machine controlled by 3 axes CNC or specific designed machine for ISF processes. The final shape will be determined by the trajectory (defined in CAM) and the die-support if would be necessary.

With ISF is possible to obtain complicated geometrical pieces that with a traditional method would have prohibitive price for only one piece or short series.

The main advantages of this kind of processes are:

- Process can be done with die less depending of the shapes. Sometimes, support surface is needed. This support could be made of wood, resin, aluminium, steel, etc.

- In most cases a special tool machine is not needed. Pieces can be formed with a three axis drilling machine controlled by CNC with accessories (clamped blankholder) to subject the sheet. The 3D trajectory is defined by commercial CAM programs.

- Cost, wearing and fracture of the tools are low. If more than one tool were needed, to define final radius for example, only differs in its diameter.

- The dimensional accuracy, surface finish and reproducibility are function of the

trajectory and friction conditions control.

However, there are also some disadvantages:

- The fabrication process is unitary. One tool machine creates one piece at the same time.
- The production is limited to short series.

2 REAL PROCESS DESCRIPTION

In this paper a real process execution, done in RWST-IBF institute [i], is described. This piece (see figs. 1 and 2) has been done with a carbide (Widia®) spherical punch of Ø10mm. The sheet is sustained by a support with rounded edges that prevent the sheet movement (see figure 3). The sheet fixation is supported with a blankholder that clamps the sheet.

Pieces of aluminium 1050 and mild steel DC04 have been done.

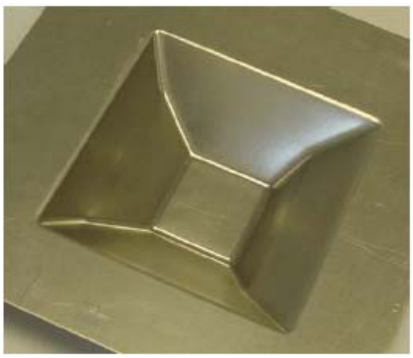

Figure 1: Real piece (Courtesy of RWTH-IBF)

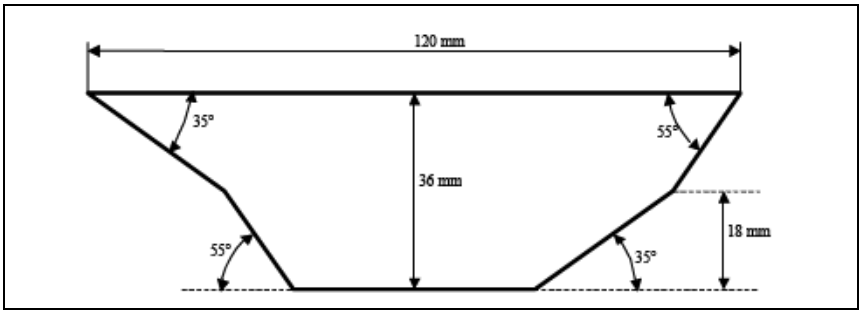

Figure 2: Lateral view and dimensions (Courtesy of RWTH-IBF)

3 COMPUTER SIMULATION PROCESS

For the virtual simulation is using the software oriented to sheet metal forming based in STAMPACK®. This development is doing in the FLEXFORM project context (financed by EC, Collective Research Proposal nº 030273). The specific and friendly user interface is based in GiD platform.

The movement of the virtual spherical punch and the sheet fixation is done at the same way that in the real process. Interface allows the user to transfer from CAM environment the trajectory in ISO format. Specific dialogue menus have been developed with TCL-TK programming language. The numerical treatment of ISO information, to generate the velocity

vs. time trajectory description, is done with a specific algorithm implemented in C++ [ii]. It is integrated in interface too. In the figure 4 is shown the tool trajectory.

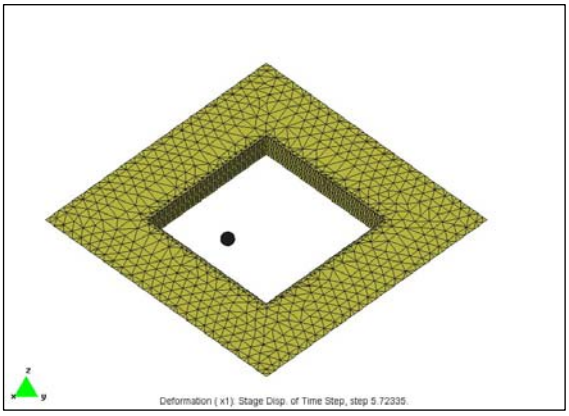

Figure 3: Mesh of support and spherical tool

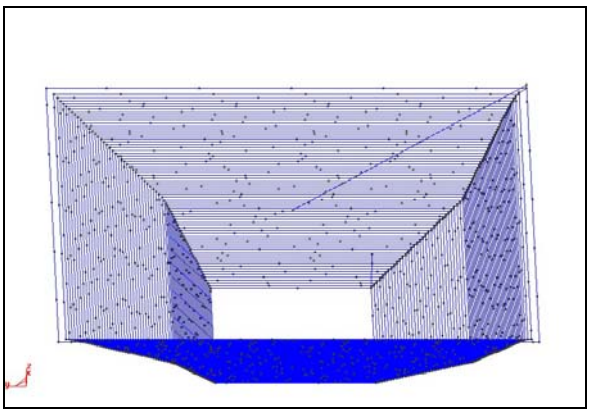

Figure 4: Trajectory generated in CAM and processed in the FEM program

The main process difficulty lies in the treatment of the contact forces, between the tool and the sheet. The high velocities and accelerations produced in the contact zone and its surrounding area are also principal objects of study.

3 EXPERIMENTAL AND SIMULATED RESULTS COMPARISON

To evaluate the software capacity, in development, to reproduce the ISF processes the next aspects are measured:

- Trajectory reproduction: the correspondence between real trajectory and simulated trajectory is high. The absolute error is below 0.01mm.
- Reproduction of the strains in the sheet: In the figure 5 the main strain at the end of the process for aluminium 1050 is shown.

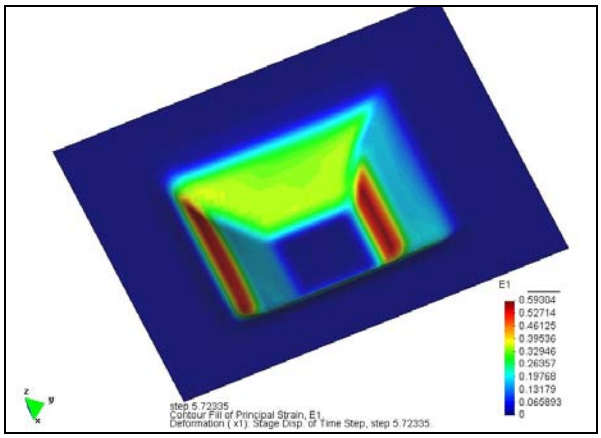

Figure 5: Major strain (at the end of the process for aluminium 1050)

The simulation results have been compared with experimental results and simulated results obtained with LS-Dyna® [i]. Figure 6 shows the comparison.

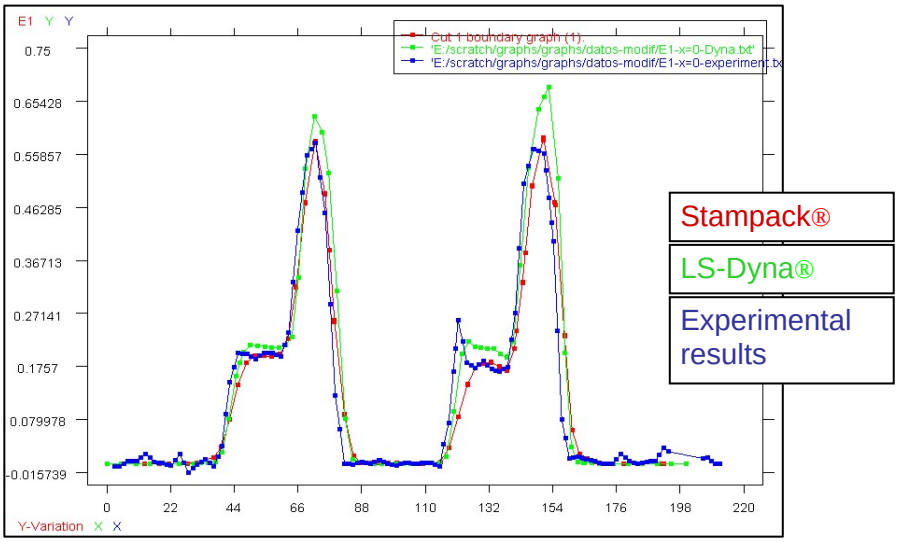

Figure 6: Experimental and simulated major strain comparison

Numerical simulations of cut and springback have been done too. The visualization of numerical results is shown in figures 7 and 8.

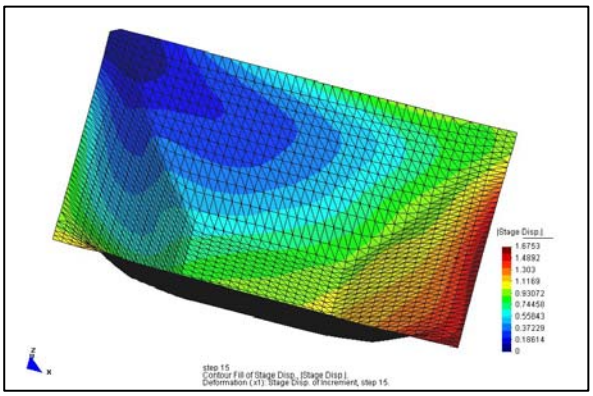

Figure 7: Cut of the remaining sheet

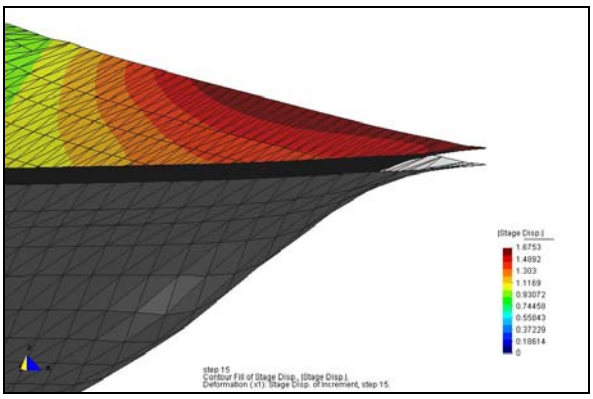

Figure 8: Springback after the end of the process

To do the springback some points have to be fixed. In the case of the figure above three points of the corner were fixed and the rest of the sheet was free.

12 CONCLUSIONS

- The discrepancy between the trajectory defined in CAM and the trajectory obtained by CAE simulation (error < 0.01 mm) is compatible with the industrial requirements.
- The discrepancy between experimental results and the simulations obtained in terms of main strains and stresses are inferior to 2%.
- With the specific user friendly interface, based in GiD platform, complete and complex processes of ISF can be simulated.

REFERENCES

[i] RWTH-IBF, Deliverable1-5_FLEXFORM project, Parameters for the FEM-simulation, May 2007.

[ii] Márquez, J., et. al, Estudio de procesos de deformación incremental de chapa, Informe técnico CIMNE IT s/n, Barcelona, Junio 2007.

[iii] CIMNE, Activities progress report M1-M12, FLEXFORM project, Barcelona, Oct 2007