SPRINGBACK AND SIDEWALL CURL CORRECTION ON DP600 AND TRIP 700 U-CHANNELS BY ELECTROMAGNETIC PULSES

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LABEIN Tecnalia
• Introduction
• Electromagnetic Forming: Basic concepts
• Springback
• Springback correction
  – Control of corner springback
  – Reshaping sidewall curvature
• Concluding remarks
Labein is part of
TECNALIA Technology Corporation
Labein Tecnailia - Automotive Unit

INTRODUCTION

Labein is one of Europe’s most active organizations participating in European Union R&D Programs

Operating in 5 markets:
- Iron and steel
- Automotive sector
- Energy sector
- Building
- Regional Development

Bilbao, Spain

www.autosteel.org
Application Fields

- **Forming Processes**: sheet metal deep drawing, tube forming (hydroforming), forging, punching / blanking, hot forming & electromagnetic forming.

- **Functional development of components** in chassis mechanics and fluid automotive systems

Automotive suppliers
800 Ton Hydraulic Press
with hydroforming system

Capacitor Bank
Magneform ESCU 60 kJ
Biggest in Europe for R&D
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Primary current induces secondary current (in the part) and the two fields repel causing part expansion.

Tube expansion
Electromagnetic Forming (EMF)

Basic concepts

PROCESS CHARACTERISTICS:

• Deformation velocities achieved are: 50 - 250 m/s

For aluminium-steel and steel-steel couples impact pressures of 500 Mpa and 1.4 Gpa are generated at velocity impact of 50 m/s.

• Strain rate in order of $10^3$ & $10^4$ s$^{-1}$

• Total process time 200 µs
Electromagnetic (EM) Forming

EM formed parts

EM Assembly

Tube Compression Set up
Electromagnetic Forming (EMF) Tube compression

Solenoidal coil + AA6063 Tube

Primary & Induced Currents running in the coil and part
Electromagnetic Forming (EMF)  
Tube expansion

Numerical simulation gives force profile during time interval defined by transient pulse

Current distribution on coil and tube

Force exerted in the piece

Force acting on tube
Electromagnetic Forming (EMF)
Sheet Metal Forming

Pressure distribution comparisons

3-bar coil

uniform pressure coil

Arrows indicate current direction

pancake coil

Energy: 0.8 kJ
Material: 0.13 mm Cu
Electromagnetic Forming (EMF)
Sheet Metal Forming

Finite Element Analysis:
Evolution during Forming
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Two channels made sequentially in the same die. Source www.worldauto.org
Angular change is caused by the stress difference in the sheet thickness direction when a sheet metal bends and unbends over a die radius.

Complex stress state on the sheet thickness.
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Springback correction
Original idea

Why?

The inertial ironing moves the neutral fiber out, controlling the springback.

through thickness deformation
(inertial ironing)

localized area

independent

EM pulse
EXPERIMENTAL STUDY (I)

Material:
- AA-5754 (1 and 2 mm thickness)
- DP-600 (0.8 and 1.95 mm thickness)

Blank measures: 100 X 170 mm
RESULTS

Energy vs. Springback angle

- AA5754 - 1mm
- AA5754 - 2mm
- DP 600 - 0.8mm
- DP 600 - 1.95mm
Springback correction
Control of corner

89°/ 1.6 kJ

90°/ 0.8 kJ

99°/ 0 kJ

88°/ 2.4 kJ

AA5754 of 1mm thickness.

93°/ 9.6 kJ

91°/ 12.8 kJ

90°/ 14.4 kJ

97°/ 0 kJ

DP600 of 1.95mm thickness.
MAIN PARAMETERS:

- **CONDUCTIVITY** OF THE MATERIAL. Aluminum’s conductivity is higher than steel’s. This is a **key factor** in the EMF.
  
  The higher the conductivity of the sheet metal, the higher efficiency the system reaches → higher peak currents obtained with the same input energy level.

- **THICKNESS**. As the area of the pressure is constrained by the actuator’s geometry, the thickness of the material is an important parameter.

- **STRENGTH**.
Springback correction
Reshaping sidewall curvature

EXPERIMENTAL STUDY (II)

SIDEWALL CURL

Materials:
- DP-600 (1mm)
- TRIP-700 (1mm)

Blank measures: 100 X 300 mm

EM pulses to the sidewall curls as a second corrective step

Test configuration
Springback correction
Reshaping sidewall curvature

14.4 kJ pulse

90°

91°

Original sidewall curl

Applying EM pulse only in one sidewall

Material: TRIP 700; 1mm thickness
Springback correction
Reshaping sidewall curvature

Applying EM pulses in both sidewalls
Material: TRIP 700; 1mm thickness
RESULTS: energy levels vs. angles

Plot comparing the different energy levels, averaged angles and materials
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Concluding remarks

- Springback can be corrected effectively on HSS by EM pulses
- The application of this innovative technique is very flexible and independent to other areas of the part.
- The tooling for this method is relatively simple and possible to couple it into an industrial system
Thanks for your attention!

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