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BOTTOM BENDING PROCESS ASSISTED BY SHORT CURRENT PULSES: CHARACTERIZATION VIA NUMERICAL SIMULATION

Antonio J. Sánchez Egea[1], Hernán A. González Rojas[1], Diego J. Celentano[2], J. Antonio Travieso-Rodríguez[1], Jordi Llumà i Fuentes[3]

[1] Department of Mechanical Engineering (EUETIB), DEFAM group,
Universitat Politècnica de Catalunya, Spain
[2] Departament of Mechanical and Metallurgical Engineering,
Pontificia Universidad Católica de Chile, Chile
[3] Department of Materials Science and Metallurgical Engineering (EUETIB), DEFAM group,
Universitat Politècnica de Catalunya, Spain

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The electroplasticity phenomenon, defined by Troitskii and Likhtman (1963), is linked to thermal and athermal effects. While the physical aetiology of this phenomenon is not fully characterized, experimental studies carried out by Sprecher et al. (1986) have shown that several parameters, such as current density, pulse duration and frequency have an influence on the material's behavior under mechanical efforts. Recently, a large number of experimental publications have proved that electroplasticity has a direct industrial impact and, as stated in Guan et al. (2010), is a suitable tool to assist conventional forming processes by plastic strain or machining. The present study focuses on the influence of the athermal effects of electroplasticity on the bottom bending process when the Joule effect is minimized to negligible values. A short-time current pulse generator, capable of inducing 300A current pulses and a pulse duration of 50μs, was designed and manufactured. The materials studied were sheets of 1050 aluminium alloy (H18 temper). Also, a finite element analysis, based on on that proposed in Celentano et al. (2011), was done in order to characterize the different phases of the mechanical behavior of the test specimen during the bottoming bending process.

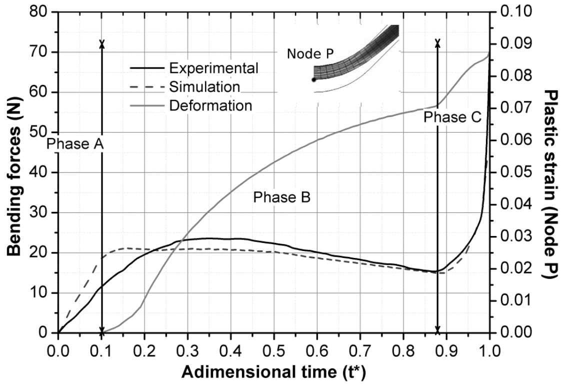

Fig.1: Bottoming bending process characterization.

As plotted in Fig.1, the bending process characterization is defined in four phases. Phase A is characterized by metal-die coupling without noticeable strain. Phase B is marked by metal-die slippery contact and plastic strain initiation. Phase C is characterized by a large plastic strain.

Finally, Phase D is defined by a stress relaxation behavior. The finite element simulation enabled to determine the material's mechanical behavior during the bending process. The preliminary results show that the used current density and frequency have a noticeably influence on the bending forces and the springback effect, as it can be seen in Fig.2 (the error bars correspond to 95% confidence T student test). The average force required to bend aluminum decreases when the process is assisted by high density current pulses. A current density over 25A/mm² reduces up to 18% the necessary force to bend; see Fig.2a.

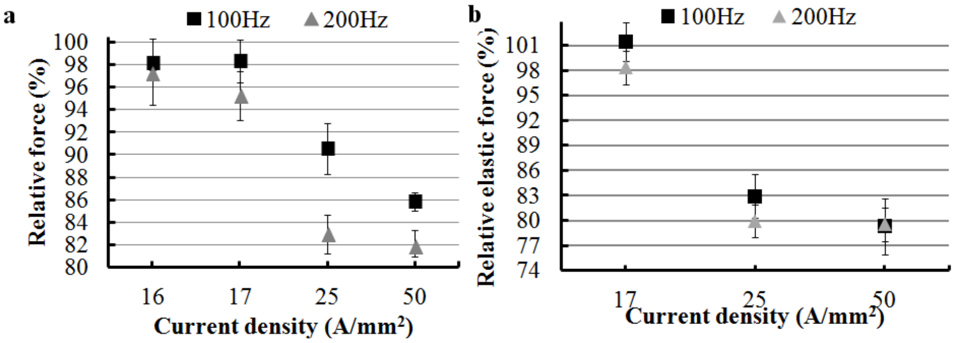

Fig.2: Relative bending forces (a) and relative elastic bending forces (b) on aluminum for the different electrically-assisted configurations.

Fig.2b summarizes the variations in elastic restoring force under different current densities and pulse frequencies. It is showed that just the elastic restoring force is significantly reduced, about 19% average, when current density is nearly and above 25A/mm². Although Salandro et al. (2011) reported up to 77% of springback reduction, it should be noted that their experiments included the influence of the Joule effect. In the present analysis, on the other hand, a value of 21% is reported in the best case but considering a negligible Joule effect which means, therefore, that the reduction in this last case is only attributable to the athermal electroplasticity phenomenon. Therefore, it can be concluded that the mechanical influence of athermal electroplastic effects on the bottom bending process has been addressed on 1050 aluminum and, in addition, the numerical simulation has allowed the characterization of the different phases defining the bending stages.

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