Contribution ID: **1011** Contribution code: **WED-PO2-306-07** Type: **Poster**

Numerical simulation and experimental study on the composite process of electromagnetic and electro-hydraulic tube forming

Wednesday 17 November 2021 10:30 (20 minutes)

High-speed forming can greatly improve the forming performance of lightweight sheet and tube components, and has broad application prospects in aerospace and automobile manufacturing. Electro-hydraulic forming (EHF) and electromagnetic forming (EMF) are two common high-speed forming processes. EHF utilizes the underwater discharge to produce a shock pressure as the driving force, while EMF utilizes the pulsed Lorentz force induced in the workpiece as the driving force. In previous studies, these two types of forming processes are typically adopted independently to form lightweight components.
In this work, the two high-speed forming processes were combined to improve the forming capability of aluminum tubes furtherly. Specifically, during the EHF process, additional axial Lorentz forces were generated by the EMF process to control the material flow of the tube, which was achieved by placing two coils at the end of the tube. A coupled numerical model was established to design the system parameters and understand the composite forming process. On this basis, an EMF system with high-strength coils and adjustable pulse width was established, which can provide sufficient and flexible controlled axial Lorentz forces during the EHF process. Then the effectiveness of the developed forming method was verified by conducting a series of experiments on annealed state 6061 aluminum tubes. It was found that compared with the single EHF process, when the composite process of electromagnetic and electro-hydraulic tube forming was used, the bulging depth of the tube was improved by about 25%, while the wall thickness reduction was reduced by more than 30%. Furthermore, the underlying mechanism of the new forming process for improving the forming peformance of tubes was also revealed by numerical simulations.

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Session Classification: WED-PO2-306 Resistive and Pulsed High-Field Magnets