Electromagnetic pulse generator: analytical and numerical study of Lorentz force in tube crimping operation

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Abstract

This work discusses the application of Lorentz force in electromagnetic pulse welding, forming and crimping operations. In this paper, we used an analytical method based on mutual inductance development and mutual force between two circular coils. First, we introduced the process of tube crimping by an intense current pulse of hundreds of kA generated in a massive coil of copper alloy. The magnetic field produced by this process can reach a few tens of Teslas [1]. This operation is used for different materials of the workpiece and the generator is generally represented by an RLC circuit. For different voltage, we developed an analytical method using a model of two circular coils, the first one represents the inductance of the massive coil attached to the RLC circuit, and the second represents the inductance of the tube in the short circuit. This model is used to determine the magnetic flux density in the coil-workpiece region and conclude the mutual Lorentz force. Obtained results from the analytical method are compared with performed numerical simulation. Magnetic flux density, self-inductance and Lorentz force are obtained by the numerical analysis using finit element method. Finally, we performed experimental measurments to calculate mutual inductance and lorentz force in the coil-workpiece region.

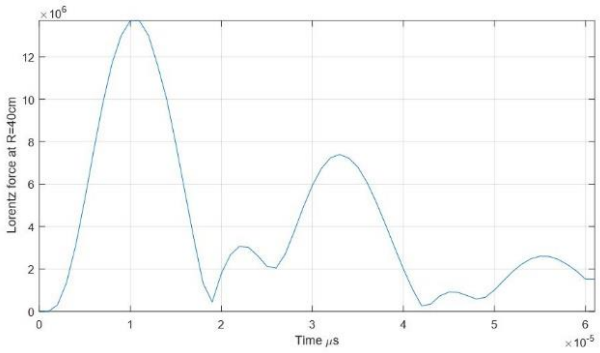

Figure 1: Lorentz force density

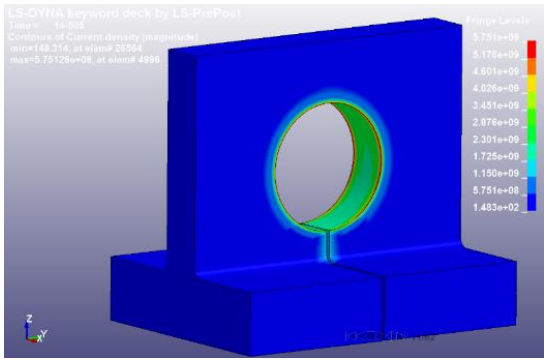

Figure 2: Current density in the coil at 10 μs

[1] V. Psyk, D. Risch, B. L. Kinsey, A. E. Tekkaya, and M. Kleiner, “Electromagnetic forming - A review,” J. Mater. Process. Technol., vol. 211, no. 5, pp. 787–829, 2011.