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Influence of Mandrel's Surface on the Properties of Joints Produced by Magnetic Pulse Welding

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Abstract : Magnetic Pulse Welding (MPW) is a cold solid-state welding process, accomplished by the electromagnetically driven, high-speed and low-angle impact between two metallic surfaces. It has the same working principle of Explosive Welding (EXW), i.e. is based on the collision of two parts at high impact speed, in this case, propelled by electromagnetic force. Under proper conditions, i.e., flyer velocity and collision point angle, a permanent metallurgical bond can be achieved between widely dissimilar metals. MPW has been considered a promising alternative to the conventional welding processes and advantageous when compared to other impact processes. Nevertheless, MPW current applications are mostly academic. Despite the existing knowledge, the lack of consensus regarding several aspects of the process calls for further investigation. As a result, the mechanical resistance, morphology and structure of the weld interface in MPW of Al/Cu dissimilar pair were investigated. The effect of process parameters, namely gap, standoff distance and energy, were studied. It was shown that welding only takes place if the process parameters are within an optimal range. Additionally, the formation of intermetallic phases cannot be completely avoided in the weld of Al/Cu dissimilar pair by MPW. Depending on the process parameters, the intermetallic compounds can appear as continuous layer or small pockets. The thickness and the composition of the intermetallic layer depend on the processing parameters. Different intermetallic phases can be identified, meaning that different temperature-time regimes can occur during the process. It is also found that lower pulse energies are preferred. The relationship between energy increase and melting is possibly related to multiple sources of heating. Higher values of pulse energy are associated with higher induced currents in the part, meaning that more Joule heating will be generated. In addition, more energy means higher flyer velocity, the air existing in the gap between the parts to be welded is expelled, and this aerodynamic drag (fluid friction) is proportional to the square of the velocity, further contributing to the generation of heat. As the kinetic energy also increases with the square of velocity, the dissipation of this energy through plastic work and jet generation will also contribute to an increase in temperature. To reduce intermetallic phases, porosity, and melt pockets, pulse energy should be minimized. The bond formation is affected not only by the gap, standoff distance, and energy but also by the mandrel's surface conditions. No correlation was clearly identified between surface roughness/scratch orientation and joint strength. Nevertheless, the aspect of the interface (thickness of the intermetallic layer, porosity, presence of macro/microcracks) is clearly affected by the surface topology. Welding was not established on oil contaminated surfaces, meaning that the jet action is not enough to completely clean the surface.

Keywords : bonding mechanisms, impact welding, intermetallic compounds, magnetic pulse welding, wave formation
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