

# Friction Spot Welding of Thermoplastics and Composites

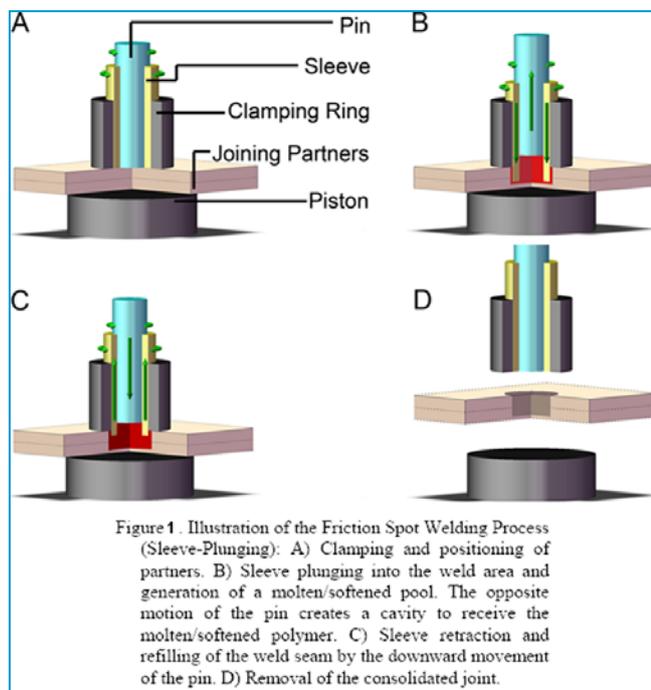
S. Amancio

## Challenge

Due to the increasing importance of thermoplastics and lightweight alloys in industrial applications, such as for the automotive and aircraft industries, efforts have been made to develop new joining methods for similar and dissimilar polymer and composite joints. While similar welds of thermoplastics can be welded by different technologies, there is a lack of process and properties understanding and availability of adequate technologies for dissimilar thermoplastic welding, especially if they are immiscible and/or incompatible. Moreover thermoplastic fiber reinforced composites (TPC) are difficult to weld or bond by traditional joining processes. Therefore there is an open niche to be filled by the research and development of alternative joining technologies.

## Technology

The FSpW is a new technology for producing similar and dissimilar overlap joints in thermoplastic and thermoplastic fiber-reinforced composites. Figure 1 illustrates the steps of the process. The FSpW tool is non-consumable and cylindrical, composed of three pieces assembled co-axially, as shown in Figure 1A. There are two process variants: Sleeve-Plunge and Pin-Plunge. In the Sleeve-Plunge variant the parts are initially fixed by a pneumatic-piston in the welding machine (Figure 1A). Thereafter, sleeve and pin start to



rotate in the same direction under a preset speed, and the sleeve (Figure 1B) is forced against the upper joining partner, generating frictional heat and a volume of softened/molten material. Simultaneously, the pin is retracted, creating a cavity that the softened/molten material will flow into. When a preset plunge depth is reached, the sleeve and the pin return to their original positions (Figure 1C); forcing the softened/molten material trapped in the

cavity to refill the keyhole left by the sleeve. Finally the FSpW tool is removed and the joint consolidates under pressure, to prevent thermal shrinkage (Figure 1D). In the Pin-Plunge variant, the pin is inserted into the joining partners while the sleeve is retracted, in order to create the cavity for receiving the plasticized material. The remaining process phases are to the same as those found in the Sleeve-Plunge technique. The main advantage of the Sleeve-Plunge compared to the Pin-Plunge variant is the generation of larger welded areas, resulting in stronger joints.

The main improvement of FSpW over the Friction Stir Spot Welding (patented by The Welding Institute – TWI, England) is the absence of the keyhole in the spot seam; this usually leads to higher joint strengths due to reduction of the geometrical notch effect of the keyhole. The positive characteristics of FSpW, such as short joining cycles, no need for filler materials or expensive surface treatment, the low-cost of the machinery and easy operability, indicate the good transfer potential of these new technologies as alternative fabrication methods. Figure 2 shows some examples of friction spot welded polymeric materials.

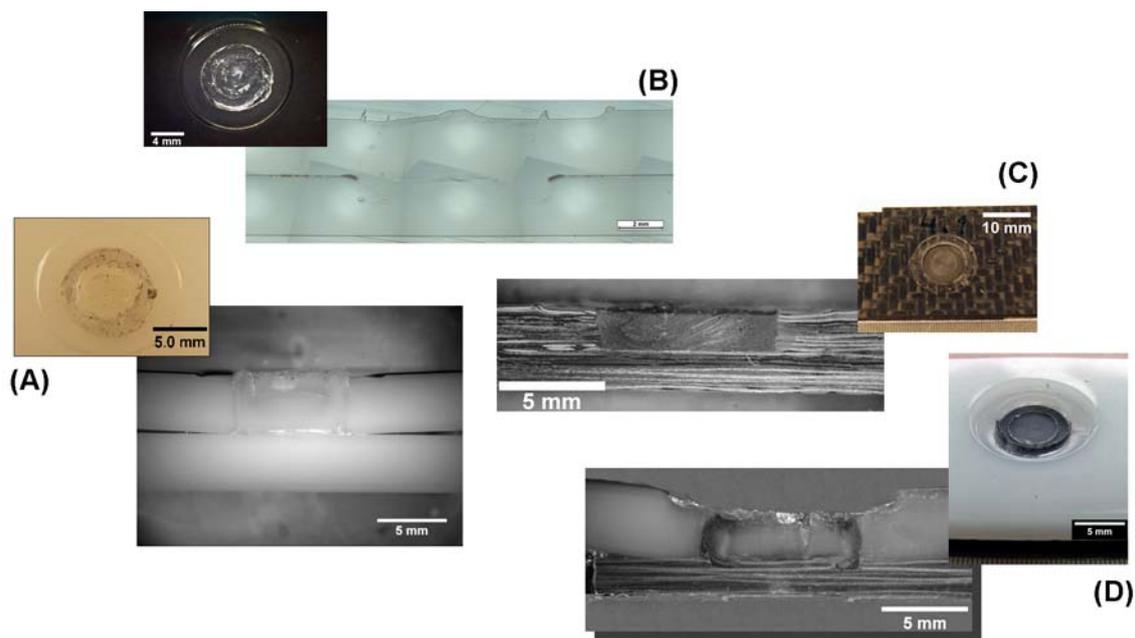


Figure 2: Example of friction spot welds: A) PA6 / PA6. B) PMMA / PMMA. C) CFRP / CFRP. D) PA6 / CFRP.