Friction-Stir Processing

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Friction-stir processing (FSP) is an emerging surface-engineering technology used to locally eliminate casting defects and refine microstructures, thereby improving strength and hardness, increase resistance to corrosion and fatigue, enhance formability, and improve other properties. FSP can also produce fine-grained microstructures through the thickness to impart superplasticity. The technology involves plunging a rapidly rotating, non-consumable tool, comprising a profiled pin and larger diameter shoulder, into the surface and then traversing the tool across the surface. Large surface areas can be traversed rapidly by using the appropriate tool design accompanied by rastering. Frictional heating and extreme deformation occurs causing plasticised material (constrained by the shoulder) to flow around the tool and consolidate in the tool's wake.. FSP zones can be produced to depths of 0.5 to 50mm, with a gradual transition from a fine-grained, thermodynamically worked microstructure to the underlying original microstructure.

FSP has been applied to Al, Cu, Fe, and Ni-based alloys with resulting property improvements. Details of the benefits and limitations of FSP, along with examples of current and potential applications, will be presented. Some examples of benefits are: (i) a doubling of strength of cast nickel-aluminium-bronze, (ii) a five-fold increase in ductility of Al alloy A356, (iii) depending on the microstructure, a 3 to 20 times increase in the corrosion resistance of a Cu-Mn alloy, and (iv) bending of 25 mm thick 2519 Al plate to 85˚ at room temperature without surface cracking. The additional advantages of low-plasticity burnishing (LPB) following FSP, to change any residual near-surface tensile stresses introduced by FSP to compressive residual stresses, are also discussed.