Study of friction extrusion and consolidation

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Abstract

Friction extrusion and consolidation was invented by The Welding Institute (Cambridge, UK) in the early 1990’s. It is related to simple extrusion processes with the primary difference being that the extrusion die rotates about the extrusion axis and the die is required to impart substantial deformation to the initially, finely divided charge (like metal waste or chips) in order to consolidate it prior to extrusion. It can produce high quality wire and fully consolidated bulk material from low cost precursors like metal chips or powders. The advantages lie in that it is a direct method to recycle metal chips or scraps and considered as more convenient, economical and “green” process when compared with conventional recycle processes involving melting and casting. This is a novel process believed to have huge potential for producing high quality wire products with customized chemical composition for fusion welding and additive manufacturing with relatively simpler devices and less time/labor/energy requirements.

This dissertation work aims to develop insight understanding of the underlying physics of friction extrusion and consolidation processes and enable its use for a wide range of high value added manufacturing applications, like additive manufacturing. The specific works are listed as follow: The thermal-mechanical progression of friction extrusion and consolidation process was studied experimentally and numerically. The deformation and material flow were revealed via a marker insert technique, thus strain in friction extrusion wire is deduced. Relationship between
control parameters (like extrusion/consolidation force and die rotational speed) and responses (like torque, extrusion rate, grain size and features of marker pattern etc.) were analyzed. Electron backscatter diffraction result showed that there is no strong texture preference in friction extruded aluminum wire. Using friction extruded aluminum alloy wire, wall samples were built via wire and arc additive manufacturing. Finite element simulation helped predict heat transfer and temperature field during the additive manufacturing process. Post-analysis indicates that good mechanical properties can be achieved if favorable thermal management was provided.