Modeling of inertia friction welding in nickel-based superalloys by 2.5D finite element approach

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Friction welding of nickel-based superalloys has traditionally been a process where welding parameters were developed through an experimental approach. However, a more fundamental understanding of friction welding can be gained through numerical simulation, where evolution of welding temperatures, formation of flash, and upset curves can be predicted based on material properties, applied loads, and flywheel energy or applied rotational speed. A 2.5D axisymmetric finite element approach was used to model friction welding for alloy IN 718, where all three velocity components were included in the computation, but where the model was restricted to a 2 dimensional geometric section plane, thus significantly reducing the degrees of freedom needed, compared to a full 3 dimensional approach. A viscoplastic friction law was used to model the shear stresses at the welding interface, including the associated heat generated by frictional sliding. The resulting thermo-mechanical simulation was validated for two different welding approaches. The first was a traditional inertia friction welding process, where a rotating flywheel was used to create frictional heating at the joint interface. The second was a computer numerically controlled (CNC) approach, where the rotational speeds were programmed and applied to the parts as a function of time. The model was able to accurately predict the run down curve for the inertia friction welding process, while providing good predictions of welding temperatures and upset loads for the CNC case. Flash formation was also predicted with reasonable accuracy by the model.