Application of temperature-controlled friction stir welding process to Al-Cu joints with complex geometries

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Abstract. Multi-material joints, for instance of aluminium and copper, are of great industrial interest for the production of components used in modern electrical applications. Conventional fusion welding techniques are not suitable to weld such joints as a multitude of brittle intermetallic phases are formed upon joint solidification. Friction stir welding (FSW) is a promising solid-state process for producing mixed material joints. Here, the layer thickness of the intermetallic compound (IMC) is reduced to nanometre scale. The IMC layer thickness depends on the welding temperature and can be correlated with the joint´s properties. Temperature-controlled FSW has been shown to produce welds with homogeneous and repeatable intermetallic layers for simple geometries in lap-joint configuration. However, in real applications, the components may have complex geometries or non-linear welding paths may be employed. This can lead to heat accumulation and inconsistent weld properties. The implementation of a temperature-controlled FSW process is a promising method to improve the weld homogeneity in such workpieces.

In this study, aluminium and copper were welded in lap-joint configuration. A complex part geometry was designed in order to induce heat accumulation in designated areas during a conventional FSW process. Initial experiments were performed using a fixed rotational speed. The variance in the stir zone temperature was measured in-situ by a thermocouple placed in the probe. Subsequently, the degree of heat accumulation was determined. Next, joints of the same geometry were welded using a temperature-controlled FSW process set to five different welding temperatures. The control system adjusts the rotational speed of the tool to maintain a constant welding temperature. It was shown that the set temperature in the weld zone was held constant, even in parts with complex geometries. The weld seams were examined by shear tensile tests, optical microscopy and scanning electron microscopy (SEM) of the interface.