Solid state additive manufacturing of light alloys by Friction Stir Extrusion Additive Manufacturing (FSEAM);
The relation between process parameters, microstructure and mechanical properties

Additive manufacturing of high strength aluminium alloys by fusion based approaches is often limited by the occurrence of solidification related defects. Solid based approaches form a worthwhile alternative where the temperature during deposition remains below the melting point. This may lead to lower heat input and to a fine microstructure positively influencing the mechanical properties (strength, toughness) of the manufactured product.

In recent years the solid state Friction Surface Cladding (FSC) technology has been developed within the Production Technology chair. Various aluminium alloys can be deposited well with this technology that is based on metallurgical bonding through friction and plastic deformation. Homogeneous clad layers without porosity, cracks or other defects can be made within a relatively broad process window.

Recently, a new prototype setup has been developed based on the same principles, but with the advantage that material can be supplied in a more or less continuous fashion. Recent work by various master students has shown that with this screw extrusion based approach similar conditions can be achieved as necessary for deposition and bonding employing FSC.

In this master thesis work the emphasis is on the further exploration of the new, screw extrusion based, printing approach for additive manufacturing applications. The work concentrates on the relation between the process conditions, the microstructure and the mechanical properties of the parts printed. The following aspects should be included:

(i) Perform a literature study towards FSC and related solid state approaches. Discuss feasibility and applicability of the various solid state additive manufacturing approaches and compare with common fusion based approaches.

(ii) Determine the relation between process conditions, microstructure and mechanical properties. Set up a realistic experimental program and select appropriate combinations of process variables. Analyze the results of the printing experiments employing microstructural analysis and mechanical testing. Improve the setup where necessary.

(iii) Support the analysis of the results with a thermal model that provides a relation between the process conditions, the process temperature and the material’s microstructure and properties.