Laser Beam Melting as manufacturing process for the realization of complex nuclear fusion and high heat flux components

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The development of fabrication technologies for fusion related Blanket concepts for ITER and DEMO is an activity of the KIT since more than a decade. A variety of fabrication technologies has been developed and qualified in strong collaboration with industry. Besides the standard technologies such as welding, machining and electrical discharge machining, in 2014 an activity has been launched based on national funding to explore the capabilities of generative fabrication procedures.

To manufacture components for Test Blanket Modules (TBM) and DEMO Breeder Blankets with internal cooling channel structures by Laser Beam Melting (LBM), "EUROFER-like" powder had been procured as a mixture of different metal powders, resulting in a chemical composition equal to EUROFER (a Reduced Activation Ferritic Martensitic RAFM steel applied e.g. in ITER).

With this powder, test parts have been fabricated with progressing complexity of requirements (e.g. geometry specifications and dimensions). Recently, blanket relevant part segments (e.g. for the Stiffening Plates) with meandering cooling channel structures in real scale dimensions have been fabricated.

In the frame of the EUROFUSIUON project first preliminary qualification activities have been concluded using test procedures applied e.g. for the qualification of welding seams such as Tensile – and Charpy tests, makro- and micro structure investigation or hardness measurement. The findings have been compared to standard material properties of EUROFER in order to quantify the fabrication results. Material properties of ~ 80 % and more, compared to standard rolled EUROFER material could be demonstrated in case of tensile- and Yield- strength as well as energy consumption in Charpy tests.

Also the joining of generatively fabricated sub-components together with conventionally fabricated EUROFER parts has been investigated in order to test the option of the fabrication of hybrid components. These hybrid components are intended to combine e.g. parts with straight channels fabricated by EDM together with generative fabricated parts with turns of cooling channels which cannot be realized using standard machining technologies.

This paper reports the first promising qualification results of generatively fabricated EUROFER parts. Also the weldability of generative fabricated parts and EUROFER-97 has been demonstrated. Preliminary qualification results of the welding are shown, and possibilities for experimental qualifications are discussed.