Evaluation of conservative and innovative manufacturing routes for gas cooled TBM and Breeder Blanket First Walls

H. Neuberger, J. Rey, F. Arbeiter, F. Hernandez, S. Ruck, C. Koehly, L. Stratil, R. Niewöhner, A. Felde

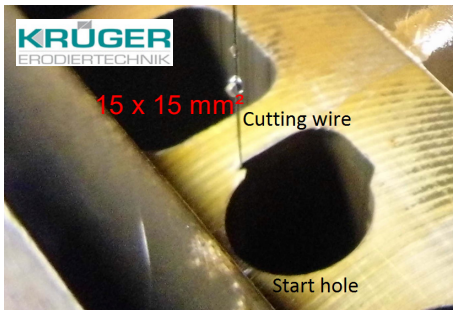
Karlsruhe Institute of Technology, P.O. Box 3640, 76021 Karlsruhe, Germany

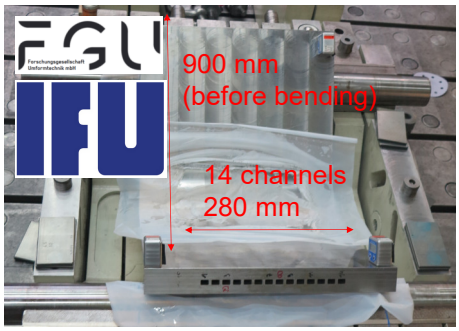
Introduction

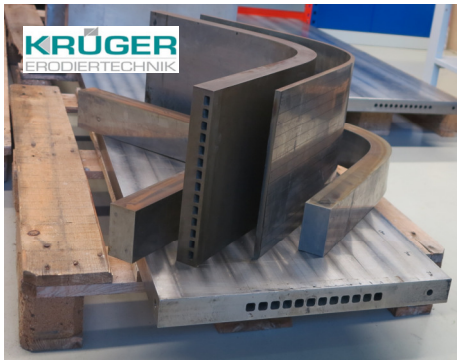
- Different manufacturing routines were investigated at KIT INR for the realization of First Walls for nuclear fusion components, e.g. the ITER Test Blanket Module (TBM) and DEMO Breeder Blankets (BB) for the Helium Cooled Pebble Bed (HCPB) concept.
- One conventional routine was demonstrated successfully basing on Electrical Discharge Machining (EDM), forming and machining.
- Additionally, Additive Manufacturing (AM) processes were investigated: Selective Laser Melting (SLM) and Metal Powder Application (MPA) & machining.
- The paper reports a recently completed First Wall demonstrator basing on conventional manufacturing versus the new innovative concepts basing on AM.
- The Potential of AM concerning cost reduction, precision, effort for licensing and suitability for HT-enhancement structures is evaluated.

Conservative routine

- EDM (wire cutting for channel fabrication)
- Cold Forming
- Machining to final external dimensions





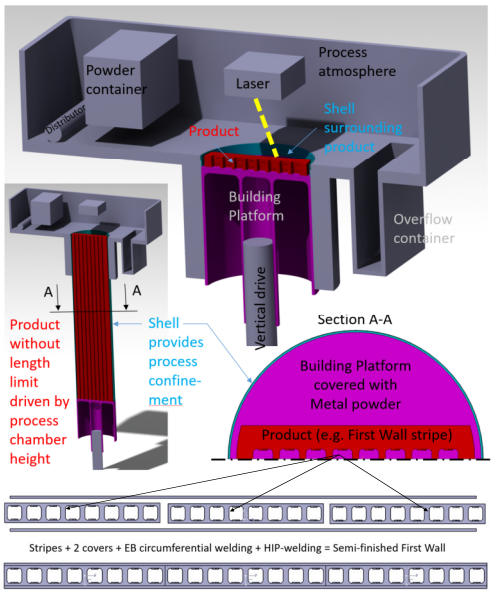


Pros and cons for EDM/Forming & machining:
+ State of the art. Equipment is existing
+ Low effort for licensing, already done
- High manufacturing costs, long process time
- Precision level fair, S_{FW} +/- 0.5 mm
- Heat transfer structures only for L < 1000 mm

Additive Manufacturing

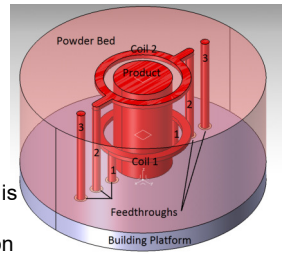
Selective Laser Melting

- Applied as continuous production according to KIT concept, dedicated patent is pending
- FW is manufactured in stripes, the stripes are assembled by EB welding and HIP, then forming and machining is applied



- Deformations of parts due to thermal effect can be reduced by innovative powder bed temperature regulation system:

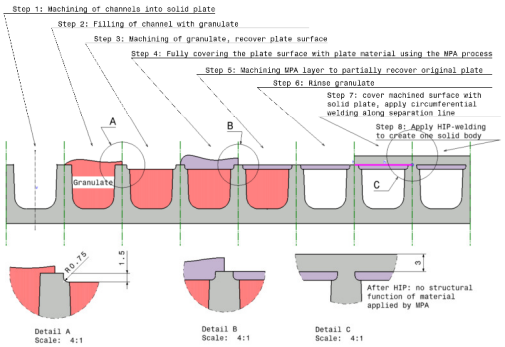
Heater coils are produced by AM on top of feedthroughs penetrating the building platform. Current is applied to heater coils, the electrical resistance is used as command signal for T-regulation



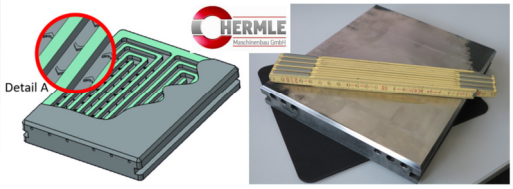
Pros and cons for SLM as continuous process:
+ Perfect for high complex and thin walled parts
+ Reduced production costs (comp. to EDM)
+ HT-enhancement structures feasible
- High effort for licensing, AM is not in C&S
- Precision fair, forming also applied to flat plate

Metal Powder Application & Machining

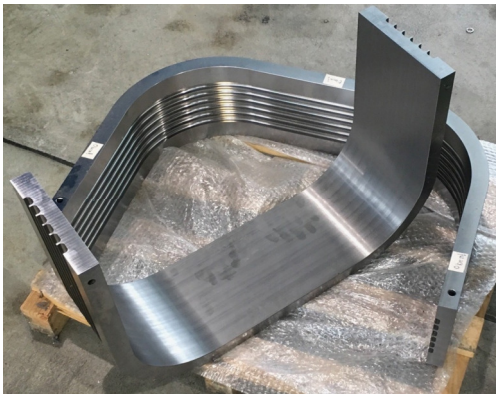
- Process scheme as applied by Hermle AG (1-6)
- EB + HIP for structural welding contact (7+8)



- First MPA demonstration part



- The process is also applicable to non-flat plates



Pros and cons for MPA & machining:
+ Reduced production costs (by 50 %, com. EDM)
+ Licensing reachable (MPA no structural function)
+ Precision excellent (forming before machining)
+ Material combinations are possible (e.g. Cu/St)
+ HT-enhancement structures feasible

Conclusions

- One conservative routine has been demonstrated for manufacturing of nuclear fusion First Wall components by EDM, forming and machining.
- Additive Manufacturing provides interesting and cost saving alternatives with advantages in terms of precision and HT-enhancement structures.
- Selective Laser Melting and Metal Powder Application will be continued in the work program beyond the pre-conceptual development phase.

EUROfusion

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053.
The views and opinions expressed herein do not necessarily reflect those of the European Commission.