

# A NEW FULLY AUTOMATIC PIM TOOL TO REPLICATE TWO COMPONENT TUNGSTEN DEMO DIVERTOR PARTS

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■ **Motivation:** Powder Injection Molding (PIM) is a time and cost effective near-net-shape forming process with advantages concerning shape complexity, material utilization and high final density. This work will investigate the new fully automatic 2Component-PIM (2C-PIM) tool to replicate parts of the KIT divertor design concept of modular He-cooled finger units such as the tungsten tile and tungsten alloy thimble in one step without brazing for the further DEMO power plant. 2C-PIM is a powerful process for mass production as well as for joining of even complex shaped parts.

## ■ The key steps in Powder Injection Molding for tungsten:

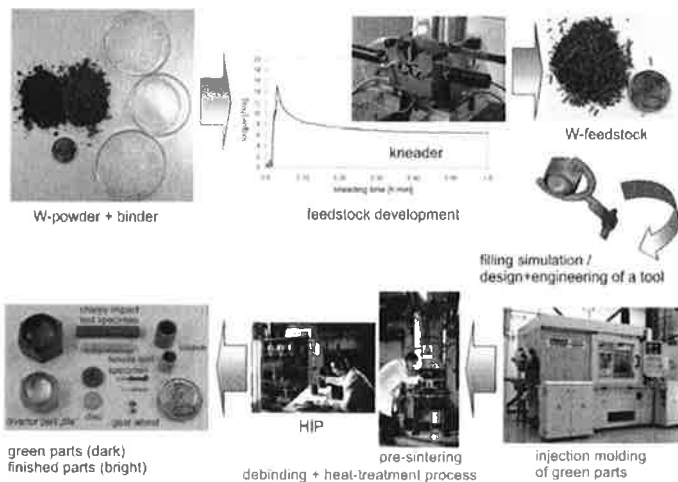


Fig. 1: The PIM process for tungsten - developed at KIT.

■ **The filling simulation of the injection molding process:** allows the definition of the future gating system parameters (position, size, shape) and is very helpful to detect problems (air inclusions, mold filling, premature settings) before the building of the tool is realized.

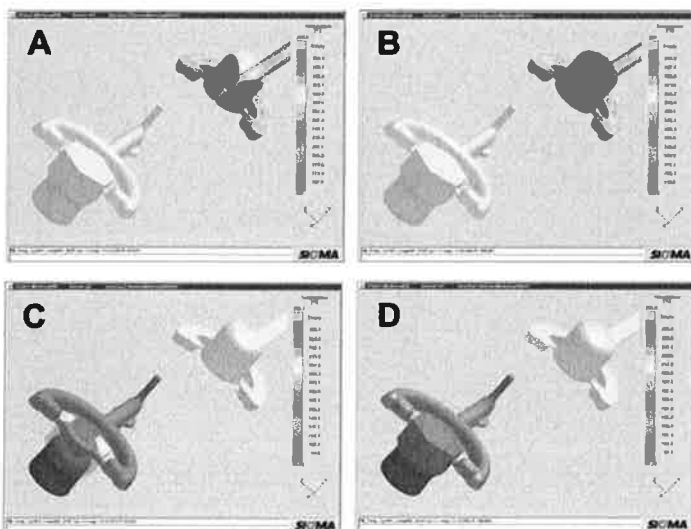


Fig. 2: The filling simulation of the thimble and the tile.

■ **Injection molding with the new fully automatic 2C-PIM tool:**  
Step I: molding of the W-alloy thimble ( $W-2La_2O_3$  respectively  $W-2Y_2O_3$ ) and automatic moving of the tool around  $180^\circ$ .  
Step II: molding of the W tile on top of the thimble.

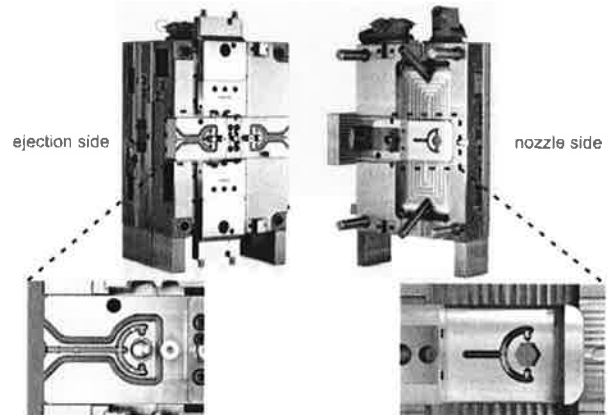


Fig. 3: The new fully automatic 2C-PIM tool.

■ **The heat-treatment process:** follows after debinding of the green parts. First pre-sintering ( $1800^\circ C$ , two hours, dry hydrogen atmosphere) to reach a state with only closed porosity. After that the samples were compacted by HIP-cycle ( $2000^\circ C$ , two hours, 200 MPa, argon atmosphere).



Fig. 4: Finished mockups: green parts (left) and after heat-treatment (right).

■ **The material connection:** of the 2C-PIM combinations  $W + W-2La_2O_3$  (Fig. 5, middle) and  $W + W-2Y_2O_3$  (Fig. 5, right) are successful. No cracks or gaps in the seam of the joining zone between the W tile and the W-alloy thimble are visible. As comparison, the resulting microstructure of the one-component tungsten PIM mockup is shown in Fig. 5, left.

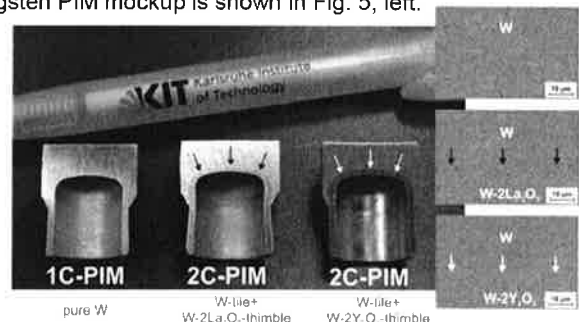


Fig. 5: Analyses of the joining zone quality between tile and thimble.

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