Process for pilot hole fabrication in wire cutting (Electrical Discharge Machining, EDM) to improve length/diameter-ratio and precision

Developed at KIT (Karlsruhe Institute of Technology) for Test-Blanket-Module components, this technology offers increases limits in length/diameter ratio and precision (drift) of pilot holes used for Electrical Discharge Machining (wire cutting). Instead of fabricating a start hole e.g. by deep-hole drilling, grooves are machined into the surface of bodies by standard machining. The bodies are then joined together using diffusion welding. Thus, limits in terms of length/diameter ration as well as drift along the drill axis can be eliminated. This fusion based technology and know-how could now find promising applications in the field of hard metal processing companies and EDM equipment manufacturers.

Description of the technology

The technology has been developed to overcome limits in pilot hole fabrication using EDM (wire cutting). Nuclear fusion components, e.g. the First Wall are penetrated by cooling channels, one option for fabrication is EDM. Typical length/diameter ratios in this application are in the order of 200 and thus close to (or even beyond) technological limits with regard to precision requirements (drifting) in terms of deep-hole drilling.

The technology described here was developed in order to increase limits in length/diameter ratio and precision (drift) of pilot holes used for Electrical Discharge Machining (wire cutting). Instead of fabricating a start hole e.g. by deep-hole drilling, grooves are machined into the surface of bodies by standard machining. The bodies are then joined together using diffusion welding. Thus, limits in terms of length/diameter ration as well as drift along the drill axis can be eliminated. Length/diameter-rations > 250 are reachable (e.g. channel diameter 2 mm, length = 1000 mm is possible). KIT has also a strong expertise behind the technology offer: innovative and flexible combination and application of multiple manufacturing processes (EDM, forming, Additive Manufacturing) and welding technologies.

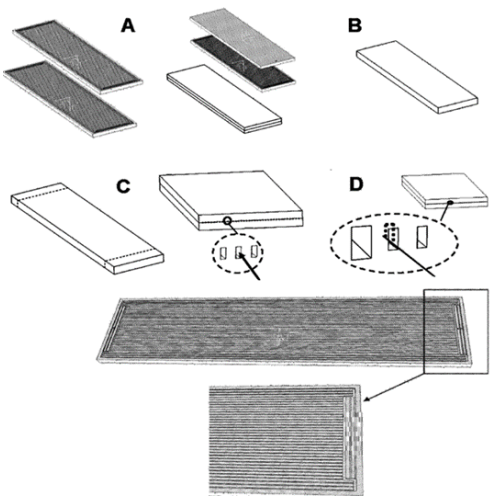

Fig.1 Process sequence: A) machining of grooves into surface, b) positioning of plates onto each other and joining, c) removing of face sides to access pilot holes, d) wire cutting.

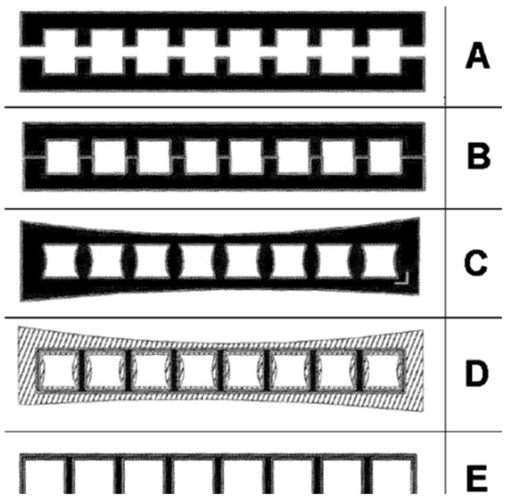

Fig.2: Detailed view of grooves with transversal connection to evacuate gas during Electon Beam welding before HIP

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Innovation and advantages of the offer

The main innovation is to machine grooves into accessible surfaces of segments instead of drilling through a solid body. The surfaces are joined subsequently using Diffusion welding (Hot Isostatic Pressing). The precision limit in using this process routine is driven by standard machining tolerances since the surface is directly accessible while performing the tolerance-sensitive machining operation. Drifting of a drilling device during penetration of a solid is not applicable. To apply the joining operation, the machined grooves are aligned along each other that continuous cavities along the bonding surfaces are formed. Joining is performed in two steps: first by circumferential Electron Beam Welding inside of a vacuum chamber, subsequently inside a HIP -welding chamber at high pressure and temperature to create one solid body with internal penetrations.

Non-fusion Applications

This fusion based technology and know-how could now find promising applications in the field of hard metal processing companies and EDM equipment manufacturers. Two examples of technologies from aircraft turbine combustion chamber manufacturing to circumvent length limits of cooling channels triggered by pilot hole manufacturing : Shorter segments (~ 300 mm channel length) assembled by EB-welding. Disadvantage: fusion welding seam crossing channels, Fabricate channels directly into a plate without pilot hole by cutting an entry slot directly into the outer surface with the cutting wire. Then manufacture channel and exit via the entry slot. The slot at the external side of the plate is closed subsequently, e.g. by soldering of welding.

EUROfusion Heritage

The technology has been developed at KIT (Karlsruhe Institute of Technology is a technical university of the state of Baden-Württemberg and a national research centre in the Helmholtz-Gemeinschaft) during the nationally funded project BMBF-Förderkennzeichen 03FUS0011: Test-Blanket-Module for ITER: Development and qualification of industrial manufacturing technologies.

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