Remote in-bore laser cutting & welding tools for pipeworks

The maintenance, replacement and decommissioning of future nuclear fusion reactors will require quick and reliable cutting and joining of in-vessel pipework. It is estimated that cutting and welding could account for up to 60% of the maintenance duration using conventional in-situ processing techniques. Additionally, the expected radioactivity and limited access at the cutting and welding sites mean these processes cannot be done manually and robotic tools are required. To this end, remote in-bore laser cutting and welding tools have been developed for use in 90 mm internal diameter steel pipes. The technology is readily transferable to many remote applications in challenging environments such as fission reactor maintenance, nuclear decommissioning and other in-accessible pipework.

Description of the technology

Concept designs have been produced for an in-bore remote laser cutting tool and an in-bore remote laser welding tool. The two tools have a similar overall design due to the common functionality of alignment, clamping and laser processing. The two tools differ by have different laser processing heads and focusing gas systems to create their respective laser welding and laser cutting conditions. In order for the tools to fit into the pipe, bespoke miniaturized laser processing heads have been designed

The concept operation for both tools are:

I. Insertion of the tool into the pipe via the access point
II. Tool travel along the pipe to the cut/weld site
III. The tool clamps into the pipe and aligns with the cut/weld site
IV. The tool laser cuts/welds the pipe
V. The tool unclamps and is extracted through the access point

The overall design of the remote in-bore laser tools is shown in Figure 3. The tools include a central motorised rotating laser processing head, a pneumatic radial clamping mechanism, articulation joint and pipe alignment mechanism. The design utilises commercially available components (pneumatics, high power fibre connectors, optics lens and high torque motors) and resulted in the tool design being capable of fitting inside a standard DN 90 Sch 40 pipe (90 mm ID, 5 mm wall thickness).

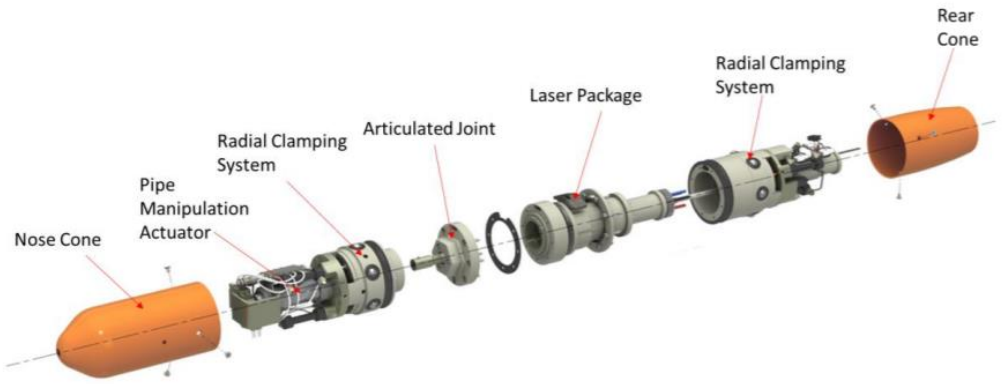

Figure 1: Exploded view of the in-bore laser tool design showing the constitutive functional components (UKAEA, Culham Science Centre)

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Innovation and advantages of the offer

Laser processing was selected for it's high processing speed and was calculated to have a significant benefit by reduce the overall maintenance cycle for fusion reactor from 8 months to 5 months compared with using conventional techniques. The tools are capable of clamping into the pipe, aligning with the cut/weld site and applying the laser process around the inside of the pipe

Pipe cutting rig (top), cut coupons (middle) and integrated in-bore cutting tool (bottom)

Non-fusion Applications

The tools described herein have been developed specifically for use within the fusion reactor environment, however the tool designs and technology demonstrated here is readily transferable to other applications such as fission reactor maintenance, nuclear decommissioning and size reduction in waste management. This concept could be tested outside of the nuclear ecosystem in areas where improved welding & cutting techniques would offer potential enhanced quality, time saving, cost reduction. This could include businesses operating in the following industries: Automotive & associated supply chains, Offshore & Energy, Space or High Energy Physics

EUROfusion Heritage

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