Case Study

Tokamak Layered Armour Limiters Developed for UKAEA

CHALLENGE

One of the challenges facing all fusion developers using a Tokamak approach is that it is inherently difficult to maintain plasma stability for any length of time. A successful tokamak will be one that achieves long term plasma stability whilst being able to manage the consequences of instability. Specifically, when a plasma de-stabilises, it touches the tokamak wall and instantaneously discharges the energy contained. Thus, the tokamak wall must be designed to withstand the discharge energies and thermal load. Many solutions to this challenge are being explored, but the principle behind layered armour limiters is to incorporate a high temperature refractory metal into a component designed to restrict heat transmission; by using a metallic foam sandwich construction with a cooling capability. Our client's challenge was determining whether this structure can be manufactured.

Business need

Manufacturing Demonstration

Why Frazer-Nash

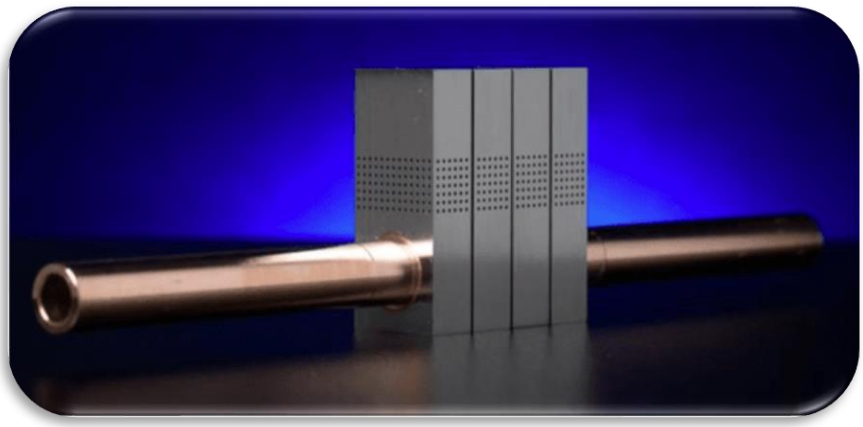
Systems engineering approach to manufacturing challenges with access to industry via AMTecH.

Date project completed

April 2023

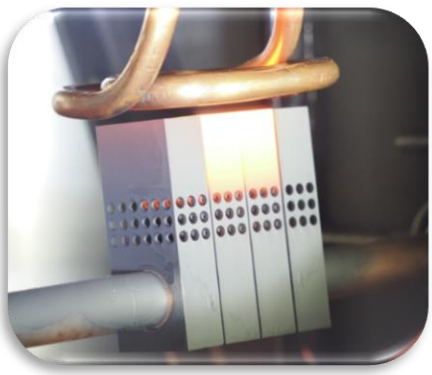
OUR SOLUTION

Frazer-Nash were awarded the contract through the UK Atomic Energy Authority (UKAEA) Spherical Tokamak for Energy Production (STEP) Manufacturing Support Services Framework (Link). Through the Advanced Manufacturing Technology Hub (AMTecH) model, we identified a best athlete subcontractor, TWI Ltd, to carry out design optimisation and manufacturing trials. We worked with them to define an optimum manufacturing method to construct the limiters. UKAEA's preferred method, using metallic foams, was deselected based on material unavailability and the cost of establishing an appropriate supply chain. An alternative method based on conventional machining was developed and ultimately selected for manufacturing trials. TWI developed a diffusion bonding technique to create an analogue of the layered armour limiters to assemble onto a cooling tube. The analogue comprised a block of refractory metal, with a defined volume having cross-drilled holes, to create a lattice like structure. Three different hole sizes were trialled to identify the optimum approach for minimising heat transmission.



The outcome of this work was presented by UKAEA at ISFNT15 in Las Palmas, Gran Canaria in September 23.

BENEFIT



Frazer-Nash Consultancy was able to identify a best athlete from its AMTecH model to offer our client a method of carrying out manufacturing trials, despite the clients preferred method being unaffordable. Through this project, the client has gained knowledge of how to construct layered armour limiters with a combination of conventional machining with diffusion bonding. The client has subsequently tested the most 'porous' design and demonstrated that after 500 cycles at a front face temperature of 1100°C, the sample showed no signs of thermal performance degradation or ligament cracking. In addition, a drop in effective conductivity of about 60% was achieved, with no signs of debonding at the cooling pipe interface.

Find out more

To find out more about our work and how we can add value to your business visit our website.

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