A COUPLED CFD AND STRUCTURAL ANALYSIS OF A SOLID TARGET FOR TARGET STATION 2 OF THE ISIS NEUTRON FACILITY

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ABSTRACT

ISIS Neutron Source is located at the Harwell Science and Innovation Campus in Oxfordshire. It is the UK's only neutron facility and has been leading the global innovation and research excellences since its establishment in 1985 [1]. This is attributed to the neutron beams which can penetrate most of the known and unknown materials in a greater depth than those of X-rays etc., which allows researchers from across the global to carry out their cutting edges experimental investigations on their samples in an unimaginable details i.e., at atomic levels. In order to produce such brilliant neutron beams, a target of solid tungsten clad with solid Tantalum has to be employed for both Target Station 1 (TS1 established in 1985) and Target Station 2 (TS2 established in 2009) of the ISIS neutron facility.

This paper is focused on a target that was developed for the newly built TS2 of the ISIS facility. Employing the above solid target, neutron beams were produced when it was bombarded by synchrotron accelerated proton beams travelling at 84% of the speed of light with a pulsed frequency of 10Hz for the TS2 target. Such an operational condition is equivalent to about 20kW of heat load which was spatially deposited onto the solid target. As a result, the target experiences elevated temperature during its operation. Therefore, water cooling channels were designed for the target to remove some of the heat load to reduce the temperature gradient. In addition, due to different thermal expansion properties possessed by both solid tungsten and Tantalum, thermal stresses induced within these two materials should not go beyond their allowable working strength at the corresponding temperature values.

In order to quantitatively understand the thermal and structural performance of the TS2 target under the above operational condition, a coupled CFD and thermal stress analysis was conducted using ANSYS CFX, Thermal and Structural software packages. In the CFD model, the heat load deposited onto the solid target was assumed to obey Gaussian and polynomial distributions in radial and axial directions, respectively. Both thermal energy model and shear stress transport turbulence model were used for all solid parts and cooling fluids, respectively. This analytical model was then validated by physically

measured temperature values during the target operation, i.e., the measured values agreed well with those calculated/predicted ones. Such reliable CFD results were then taken out as input into the thermal and structural analysis models to carry out subsequent thermal stress analysis. As a result, thermal stresses within the issued target were revealed quantitatively, for the first time by utilising this approach. The results of the thermal stresses showed that the current target for the TS2 of the ISIS facility has optimal geometry, since it minimised thermal stresses (that was caused during its operation) compared with the ones that had been used previously for the TS2 of the ISIS facility.

This paper will report all the analysis results and their comparison with those seen in their real operations.

SUGGESTED THEMES

Engineering Analysis, Verification and Validation