Design of a Small Compact Transportable Neutron Source in TIARA / EU-FP7

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Neutron sources are increasingly used in physics laboratories and also have potential applications to the ADS. Improving yields is the key; this entails improving the density of the neutron flux and compactness of the neutron source. Under the auspices of the EU-FP7 project TIARA, “Test Infrastructure and Accelerator Research Area”, efforts are currently underway at CERN to design a small compact transportable neutron source with a dense neutron field which could be installed in many facilities and laboratories around the world.

Projet Summary

Context (TIARA)

Objectives (Material irradiation at high doses in accelerator facility)

Organisation (work packages: design / CFD / Thermal hydraulics / Neutronics)

The overall aim of TIARA is to structure and optimise the R&D effort in the field of Accelerator Science and technology in Europe. In particular the task entitled TIHPAC serves to encourage the application of target technology to as wide applications as possible. After a review of the existing application, a need was identified for a flexible compact neutron source allowing testing of materials samples in a compact flexible configuration allowing its shipment to different laboratories around the world.

Overall Design

The goal is to provide a flexible facility for material testing under p+n irradiation, LM corrosion and constant/cyclical stress.

Thermal Heat Exchanger

The thermal exchanger is an assembly of 2 distinct parts. The primary fluid (yellow) flows in a central pin located inside a receiving secondary circuit (black). The 2 parts may be disconnected for great flexibility, safety and easy maintenance.

The spiral shape of the secondary part extends the flow path length and makes the exchanger more compact and efficient.

A gas gap is inserted between primary and secondary walls for leak detection and physical separation of primary and secondary circuits.

Target fluid flow

Meshing method: Patch conforming + inflation in fluid/solid walls

Assumptions: Transient analysis in total time 10 s. Thermal energy for heat transfer and SST turbulence model in fluid domain. Initial temperature of 200 °C. Maximum flow rate of 38 kg/s at the inlet and 100 kW enthalpy difference between inlet and outlet.

Target and sample loading mechanism

The target is swept by liquid metal at high speed which cools the entrance point of the beam and serves as spallation material.

The beam is flattened in order to impact a greater part of the samples. The LM flows inside the chassis (blue), around the collector (red) and along the conical window, back into the sample holder (grey).

A mechanism applies a load to the sample by demultiplying a smaller force in the push rods (magenta).

Pressuriser

Target

Frame

Sump

Trolley

Electromagnetic pump

Drain tank

Conical beam Window

LM Outflow

LM Inflow

Sample

Front view of the target

Samples behind the window

Max. Temp. in Fluid: 504 K
Max. Temp. in Window: 525 K
Max. Temp. in Samples: 497 K
Max. Pressure in Fluid: 51830 Pa
Max. Velocity in Fluid: 2.975 m/s

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