A.8: Design and simulation analysis of SWLS vacuum chamber for Indus-2

In long straight section (LS-4) of Indus-2, superconducting wavelength shifter (SWLS) with on axis peak field of 5 T is planned to be installed for providing hard x-rays to users. The device is being developed indigenously at RRCAT. Length of SWLS vacuum chamber is kept 1400 mm and its cross-section is shown in Figure A.8.1. Material of construction of this chamber is AA6063-T6. Very low molecular flow conductance of chamber and space limitation along chamber length prohibits attainment of required ultra-high vacuum (UHV) level in the chamber using lumped pumps at ends. Ti-Zr-V ternary alloy non-evaporable getter (NEG) coating (~ 1 µm thickness) with hydrogen pumping speed of 0.2 l/cm^2/s on internal surface of chamber and lumped combination (SIP+TSP) UHV pump having pumping speed of 270 l/s and 1000 l/s, respectively at both ends is proposed to handle thermal and photon-induced desorption (PID) gas load. Analysis is carried out by considering H_2 (95%) and CO (5%) as the dominant gases in the UHV system. PID yield for respective gases have been taken from literature [1].

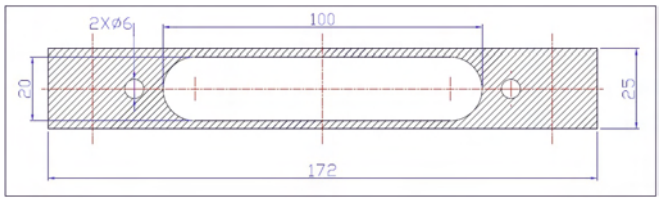

Fig. A.8.1: SWLS vacuum chamber cross-section.

Pressure variation along SWLS vacuum chamber obtained with the help of Monte-Carlo simulation software developed by CERN is shown in Figure A.8.2 for two cases (without and with NEG pumping). It can be observed that pressure less than 2x10^{-9} mbar can be achieved in the SWLS vacuum chamber after 60 Ahr of integrated beam dose with proposed pumping scheme.

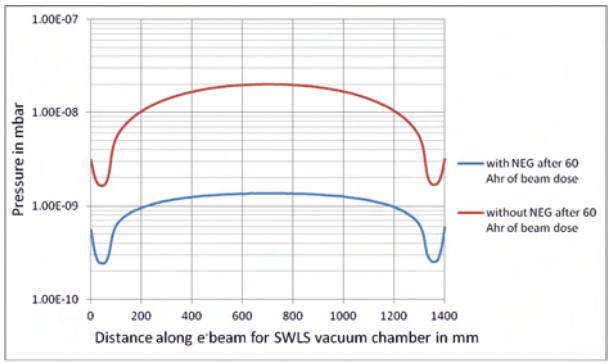

Fig. A.8.2: Pressure profile for SWLS vacuum chamber with and without NEG coating.

Structural analysis has been carried out for SWLS vacuum chamber in order to ensure structural stability against atmospheric loading when evacuated to UHV range. The maximum Von-Mises stress and deformation achieved in the chamber are 42.8 MPa and 164 µm, respectively, which are well within design limits.

Synchrotron radiation (SR) associated with SWLS will be tapped through 0^0 port of downstream dipole vacuum chamber for beam line experiments. Only fraction of SR fan is extracted via beamline, rest will be falling on vacuum chambers and photon absorbers. In new design of dipole chamber, one horizontal absorber, with oxygen free high conductivity (OFHC) copper as material of construction, is proposed to have +/-1 mrad window for SWLS SR passage. With help of Synrad, it is analyzed that ~ 750 W of SR power is falling on this absorber with peak heat flux of 8.5 W/mm^2. SR fan associated with SWLS and downstream dipole chamber and 3D SolidWorks model of absorber assembly is shown in Figure A.8.3.

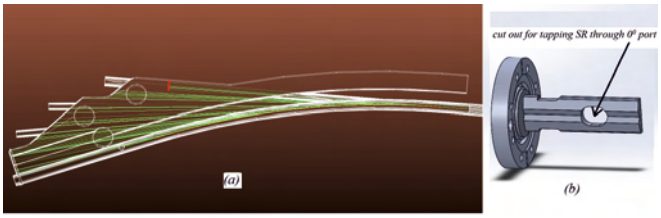

Fig. A.8.3: (a) 3D view of downstream dipole vacuum chamber with SR fan associated with SWLS and downstream dipole chamber and (b) 3D model of horizontal photon absorber.

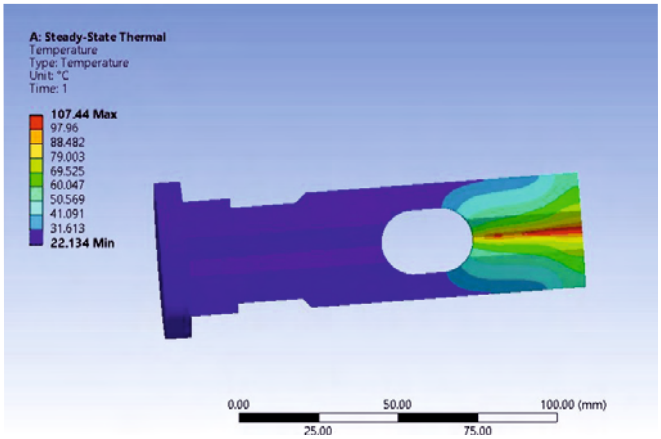

Fig. A.8.4: Temperature distribution in horizontal photon absorber as a result of SR falling on it.

Cooling of absorber is done with low conductivity water (LCW). Cross-section of the coolant channel is kept at 5 mm x 6 mm and flow rate has been optimized to 6 lpm. Under these conditions, peak temperature in absorber is 107.44 °C as shown in Figure A.8.4, which is well under design limit.

References:
1. J. Gomez, "Photon stimulated desorption from Cu and Al chambers", Journal of Vacuum Science & Technology A25, 1251 (2007).

Reported by:
Sushil Kumar Sharma (sushilks@rrcat.gov.in)