SLS/DLS Vacuum Workshop 7th July 2020

Notes accompanying the slides "CAE Mapping Process"

Thermal & Structural presentation by Stephen Hodbod, Senior FEA Analyst, Diamond Light Source

Background

The presenter has been working at Diamond since last September and has applied techniques for combining CAE processes and simplifying geometry learnt from many years in the automotive industry.

Introduction

The slides attempt to describe the vessel the geometry with respect to its heat dissipation function. A combination of Dipole and Insertion Device loading are shown and the contributions from each. At this stage in the process, the geometry for 'Option 3' is relatively new and therefore a finer representation of the heat loading is not yet available.

Slide 2 – Geometry of Vacuum Vessel

An exploded view showing the overall layout of the 'Long straight to Mid straight' (LM) Girder vacuum section of approx. 7.5 m in length.

The beam is travelling from L to R and the cross section is viewed from above. The inline, tapered and discrete finger absorber locations are identified together with bulk wall cooled vessels.

Slide 3 – Geometry of Light Fans

Here CAD representations of the Dipole fans and Insertion Device (ID) fans (provided by Alan Day) are shown for the example of straight 13. Straight 13 includes both ID light and Dipole light from an upstream source. Note that the fans of light are approximate, especially in the case of the ID light sources.

Identifiable are the trimming of dipole light by the finger absorbers and the shadowing of ID light.

Slide 4 – Photon Flux of Dipoles (Synrad)

Coarse mesh results of Dipole light (primarily used for vacuum emittance calculations by Matthew Cox) are shown as Flux Density. The colour plot is for guidance and does not provide the Surface Heat Flux (required for FEA). A value of 10% re-emittance was applied.

Photon flux is shown along the straight and curved sections of the vessel. It is possible to witness the shadowing caused by tapered inline absorber at the very start of the vessel. In addition, each Dipole fan has a discrete start and finish illuminated section.

The geometry was prepared in SpaceClaim (preprocessor for ANSYS) and more information on the simplification is available at the end of the presentation (Slides 10-11).

Slide 5 – ID Projection (COMSOL) & Shadowing (CAD)

A parameterised COMSOL model created by Matthew Cox was used to map a two-dimensional power grid onto the target. The power grid is beyond the absorber and has a size of 50x50mm with a discretisation of 0.1 mm. Peak power for the grid is shown but as the absorbers are nearer to the source, their power input is greater and governed by the Inverse Power Law and the Sine of the Grazing Angle (see slide 9).

Older and present designs of geometry are shown and the shadowing process of splitting surfaces in SpaceClaim by using the ID fan.

Slide 6 – ANSYS Mapping both ID & Dipole

This slide shows the contribution of both Dipole and ID light by using ANSYS to combine the load cases. Care must be taken with the flat facet size in Synrad and the (parabolic) mesh density in both COMSOL and ANSYS to accurately capture the peak and total power loading.

A general rule is that max. temperatures for Oxygen Free High Conductivity Copper (OFHC) should not exceed 400°C. In this case the rather high temperature was obtained due to the length of the finger absorber and distance from the cooling passages.

Slide 7 – Targets Stress and Strain

Here tested data for Hot Rolled OFHC is shown against DLS targets for absorbers for this material. This is used in general for copper-based materials at DLS including CuCrZr and CuAg0.10(OF) for which limited data on stress limits are available.

It was recommended to run an elastic analysis first, although in practice the non-linear material model will predominantly be used.