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Thermal Analysis of the SSC Beam Scraper*

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THERMAL ANALYSIS OF THE SSC BEAM SCRAPER

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ABSTRACT

When a particle beam impacts a beam scraper, heat is generated resulting in a rise in the temperature of the material. The maximum temperature rise should be kept to a minimum in order to maintain scraper efficiency and performance. In this paper the results of a thermal analysis of a scraper are presented.

INTRODUCTION

Beam scrapers are devices, located in the West Utility region of the collider rings, for removing the unwanted, diffused halo of particles that surrounds the dense central core of the accelerated beam¹. It is important to minimize the peak scraper temperature to avoid excessive thermal deflection in a lateral direction on scraping surface. As indicated in Figure 1, three main scraper designs, using copper material, were evaluated from a thermal viewpoint. The first design involves no effort to cool the scraper. The second involves solid cooling while the third design adds water cooling.

ANALYSIS

A transient, three dimensional finite element model was developed using ANSYS². The temperature dependent thermo-physical properties of copper were accounted for. The scraper initial temperature was assumed to be 305 K for all the analyses. Load boundary conditions included a constant scraping rate of about 1.45×10^9 protons per second³ resulting in about 1284 watts applied for 20 minutes. Figures 2 and 3 show the energy deposition density per proton along the longitudinal and lateral directions of a copper scraper⁴. Radiation effects were omitted and an adiabatic condition was assumed on the scraper outside surfaces. Based on these analyses, an optimum scraper design can be chosen.

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RESULTS

Table 1 shows the thermal analyses results associated with three different scraper design concepts. A temperature rise was significantly reduced almost 400 K from a baseline (case 1) to a solid cooling (case 2) and improved even further with a water cooling design (cases 3, 4 and 5).

CONCLUSION

Based on the present thermal analysis, a water cooled scraper gives the lowest peak temperature after 20 minutes at full scraping rate.

REFERENCES

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3. Discussion with R. Soundranayagam.
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Case No.	Description		$\Delta T_{\max}$ (K)
1	Baseline design with 1" x 2" x 47" copper rod		456
2	Solid cooling with 6" Dia. x 47" copper block, 2" scraping surfaces		54
3	Solid and water cooling with two 1/2" Dia. water channels spacing 1" from scraping surface	2 liters/min. per channel	27
4		5 liters/min. per channel	20
5		10 liters/min. per channel	17

Table 1. Peak scraper temperatures for different design concepts (after 20 minutes).

Figure 1. Schematic of the SSC beam scraper with different design concepts: (a) baseline design, (b) solid cooling, and (c) solid and water cooling.

Figure 2. Longitudinal distribution of maximum energy deposition density in the copper scraper for chosen parameters of the scraper system.

Figure 3. Lateral distribution of energy deposition in the copper scraper at shower maximum and averaged over 120 cm of length.

Figure 4. Variation of temperature on scraping surface along scraper length for the three design concepts.

Figure 5. Variation of scraper peak temperature with time for the three design concepts.

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