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An Evaluation of Enhanced Cooling Techniques for High-Heat-Load Absorbers

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Abstract

Many components of the storage ring and front ends in the third generation of light sources are subjected to high heat loads from intense x-rays. Temperature rises and thermal stresses in these components must be kept within acceptable limits of critical heat flux and low-cycle fatigue failure. One of the design solutions is to improve heat transfer to the cooling water either by increasing water velocity in the cooling channels or by using inserts, such as porous media, twisted tapes and wire springs. In this paper we present experimental and analytical results to compare various enhanced cooling techniques for conditions specific to heating from an x-ray fan.

Keywords: heat transfer, high heat load, enhanced cooling, absorbers

1. Introduction

The Advanced Photon Source (APS) 7-GeV storage ring (SR) is presently operating at its Phase I current limit of 100 mA. Future goals for the APS include increasing the beam current to 200 mA over the next several years—eventually to the Phase II specification of 300 mA. Detailed analyses are underway to ensure the thermal safety of SR absorbers and new front-end and beamline components [1,2] at higher beam currents.

For existing components, the straightforward solution to handle higher heat loads would be to increase water velocities in their cooling channels. Previous analyses for the SR absorbers and scrapers showed that velocities of up to 15 ft/sec would be required at 300 mA. Water circuits for these components contain flow restrictors (orifices or small-diameter coiled tubes) that can be replaced to provide increased flow. We anticipate that in some circuits the required velocities would not be achieved even if the flow restrictors were completely removed. Erosion-corrosion of the cooling channels at higher velocities is also a serious concern.

A higher cooling efficiency can also be obtained by using turbulence-enhancing inserts in the cooling channels, such as wire meshes, twisted tapes and wire springs. Their effectiveness has been studied extensively under uniform heating conditions [3,4,5]. In this paper we present experimental and analytical results for such inserts, simulating concentrated heating from intense dipole x-rays. Practical matters that should be considered when implementing one of these enhanced cooling schemes are discussed.