High heat-flux accelerator targets: Cooling with liquid metal jet impingement

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In order to evaluate the performance of jet impingement for high heat-flux cooling, experimental cooling loops based on water and liquid metal jet impingement were designed and constructed. The current liquid metal system, based on an eutectic alloy of gallium and indium (GaIn) with a melting point of 15.7 °C, employs an annular inductive electromagnetic pump. The experiments showed that it is capable of accommodating a heat flux of about 20 MW/m^2 over an area of $10^{?4}$ m^2. The jet velocity is less than 4 m/s and the required differential pressure from the pump is less than 10^5 Pa.

In the present work the experimental section is supplemented by a theoretical one in which the cooling capability of impinging jets of liquid metal is modeled. In particular, turbulent flow in a dead end associated with the rear surface of a high-temperature target, and the corresponding heat-transfer process, are considered. The developed novel analytical model embodies the main peculiarities of the heat-transfer process and agrees fairly well with the experimental data. In addition, a detailed direct numerical simulation was done with the STAR-CD code. The gross underprediction of the turbulent heat transfer rate by the STAR-CD code is attributed to overprediction of the eddy viscosity in liquid metal flows.

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