Film Boiling Heat Transfer from Downward-facing Hemisphere DELTA

Chan Soo Kim, Kune Y. Suh
Seoul National University
San 56-1 Sillim-Dong, Kwanak-Gu, Seoul, 151-742, Korea

Abstract

The strategy of in-vessel retention through external vessel cooling (IVR-EVC) was suggested to protect the lower head from being overheated due to relocated material from the core during a severe accident. The cavity flooding was selected because of relatively simpler installation than flooding within the thermal insulator. However, the cavity flooding tends to take much more time than flooding within the thermal insulator. The differential time between the two flooding strategies was estimated to be as large as forty minutes in a typical pressurized water reactor (PWR). It is thus questionable whether the reactor vessel could indeed be soaked prior to relocation of the molten core unless the core damage state is recognized early enough to allow for timely flooding of the lower head. Once the core material has been accumulated prior to flooding, the initial heat removal mechanism may most likely be transient, turbulent film boiling of water. The current understanding is mostly limited to steady-state, laminar film boiling on the sphere, however. Further the correlations were developed from the test sections much smaller than the reactor vessel. The laminar film boiling heat transfer coefficients will tend to underestimate the actual heat transfer from the lower head. In this study the film boiling heat transfer coefficients for a downward-facing hemispherical surface are measured from quenching tests. The test section is made of copper to maintain the Biot (Bi) number below 0.1. The results of this experiment are compared with predictions by the laminar film boiling correlations. It is observed that the higher thermal conductivity of copper results in the lower wall superheat and heat flux at the minimum heat flux condition in the tests. Re_δ is not large enough for the film boiling region to be turbulent in this experiment. Thus, the experimental values are greater than the numerical results because of the Helmholtz instability. The boiling mechanism on the downward-facing hemisphere is visualized through a digital camera.