CONJUGATE HEAT TRANSFER MEASUREMENTS IN A SINGLE-SIDE HEATED CIRCULAR FLOW CHANNEL UNDER TURBULENT, SUBCOOLED FLOW BOILING CONDITIONS

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ABSTRACT
High heat flux removal (HHR) from phase-changing components and electronic heat sinks involves conjugate heat transfer analysis of the applicable substrate and flowing fluid. The present conjugate measurements include both three-dimensional developing turbulent flow and subcooled water flow boiling. The results form a 3-D conjugate data set which includes all of the above noted complexity and provides a basis for increased understanding of this conjugate heat transfer phenomena. The recommended approach for quasi-steady-state identification included steady local wall temperature selection before subsequent changes in the heat flux.

INTRODUCTION
The optimized design of single-side heated (SSH) phase-facing components (PFC) and electronic heat sinks (EHS) is dependent on using conjugate heat transfer to find the local distribution of inside wall heat flux in the flow channels of the cooling substrate of the component or heat sink. The local inside wall heat flux can be obtained from selectively chosen local PFC wall temperatures close to the mold border of the test channel. To this end, three-dimensional thermal measurements for a single-side heated cylindrical-like test section were made.

TEST SECTION (TS)
The TS was fabricated from Type AISI 304 stainless steel. Cylindrical-like test section with half-90 to 90 degrees of its outside boundary was subjected to uniform heat flux and the remaining half insulated. The outside diameter and length of the test section were 304.8 mm and 200.0 mm, respectively. The actual direct-heated length (L) was 180.0 mm. The inside diameter of the flow channel was 10.0 mm.

TEST CONDITIONS
- Water was the coolant.
- Thermocouples were placed at forty-eight test section locations.
- The mass velocity, heat flux, and inlet water temperature used for the present case were 0.5 kg/m²s, 207 MBtu/hr/ft², and 121°F, respectively.
- The local heat flux is a turbulent flow (Re = 80000) and highly developing flow with a reciprocal Grashof number of 1.5 x 10^11.

RESULTS
Conjugate heat transfer analysis of complex geometries and boundary conditions is highly dependent on having both two- and three-dimensional data which shows the relationship between the local channel wall temperature and the SSH channel heat flux. Examples of such data is presented and provide a unique turbulent, developing flow boiling data base for single-side heated test channels which can be used for comparisons with future computational fluid dynamic and heat transfer predictions.

DEFINITION OF QUASI-STABLE STATES
- Fig. 3 shows typical TS wall temperature history measurements (top and second curve from the top) at 9.0 degrees and an axial coordinate of 145.1 mm and radial coordinates of 9.08 and 8.08 mm, respectively.
- Alternative definition inspection of extrema in a plot of net incident heat flux versus the local TS wall temperature.

OUTSIDE NET HEAT FLUX/WALL TEMPERATURE
- Results are presented which show the relationship, at different radial between the outside net heat flux, (q_e) and the local wall temperature (T_w). Although not identical, this relationship between q_e and T_w would be directly related to the 2-D local boiling curve if the radius at which this relationship was considered was equal to the inside radius of the flow channel. This work will eventually lead to the latter.

FUTURE WORK
The results form the basis for:
- The examination of inside flow channel heat flux and heat transfer coefficient distributions.
- Future computational fluid dynamic and conjugate heat transfer comparisons.
- The assessment and comparison of existing subcooled boiling curve (BC) correlations with two-dimensional boiling curves, after the data has been transformed to BC form.

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