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REJOINDER

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ROSE'S communication raised an important point concerning the effect of surface thermal conductivity (constriction effect) on dropwise condensation heat transfer. Specifically, he emphasized the fact that the available experimental evidence is not in agreement in regard to the significance of the constriction effect. And indeed, as he stated, there are at least three experimental studies [5–7]*, which appear not to be supporting the constriction model. Of the three references [7], involved non-PTFE surface (a steel surface was thinly copper plated). The measurements in the last reference were done carefully. Even allowing for an error of one standard deviation due to the uncertainty in the thermocouple positions, the experimental result still would not agree with the prediction proposed in [1], cf. Dr. Rose's Fig. 1. We are in complete agreement with Rose's conclusions on this point. It may be noted, refering to Fig. 1, that for the fluxes larger than $0.27\ MW/m^2$, the ratio of the adjusted streamside coefficient for steel to that for copper was about 0.77, while the work of [1] predicts a value of 0.63. Further calculation shows that the probability that the discrepancy between the experimental results in [7] and the prediction of [1] could be attributed to this form of error is less than 16%. This probability is small but finite, and in our opinion, based on this evidence alone a conclusion that the constriction phenomena in dropwise condensation could not produce a significant effect on the condensation heat-transfer coefficient is not warranted.

The other two sets of results obtained from the PTFE plated surface [5, 6] cannot be reliably used to indicate relative importance of the constriction resistance for the following reasons. The constriction effects are caused by the non-uniform heat fluxes at the condensing surface. The surface heat flux nonuniformity is controlled by the total local thermal resistance which consists of two resistances in series: the one produced by non-uniform drop-size distribution, and the other caused by the resistance of the PTFE layer. The first one is highly non-uniform. The second resistance however is relatively large and uniform, and the distribution of the resulting combined local resistance therefore, would appear much less non-uniform than the first resistance alone. Additional difficulties with PTFE layers are related to the fact that the overall results are very sensitive to uncertainties in the values of the thermal conductivity and the thickness of the layer.

It is of some interest to mention here that all the experimental results which appear not to be supporting the constriction model are obtained by using an extrapolation method to evaluate the temperature of the condensing surface. Some of the investigations which are showing presence of the constriction effect were also obtained by the extrapolation method. We are in agreement with Rose that in some of them probability for a large experimental error was higher than in [7]. On the other hand, all the experimental results which measured the surface temperature directly showed either presence of the constriction [2], or presence of the phenomena directly related to the constriction effects (surface temperature fluctuations), e.g. [a, b].

Rose, refering to the observed differences in condensation heat-transfer coefficient for different surface materials, proposed that those differences could have been caused by promotion effects (which would be absent when both surfaces were plated with the same material). This is an interesting concept which, in our opinion, is worth pursuing further. Still, in dropwise condensation we are clearly dealing with non-uniform surface fluxes and some kind of the constriction effects must be present. A suggestion advanced in the communication that "owing to the extremely high coalescene rate, the surface temperature would be essentially uniform"—which is equivalent of stating that the constriction resistance would be negligible—was neither supported by experimental evidence, e.g. [a, b] nor, in our opinion, was it based on an acceptable rationale; large drops—which are responsible for constriction effects—do not change significantly their positions by coalescence.

In conclusion, with the present understanding of the overall model it appears to us that any complete and coherent description of dropwise condensation cannot exclude the constriction effects.

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* Numbered references are from Rose's communication.

REFERENCES

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