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Letter to the Editor

Letter to the editor: Comment on the paper "Extensive study on laminar free film condensation from vapor-gas mixtures"

The recent paper [1] by Shang et al developed a new method to account for the variable property effect on laminar film condensation with a noncondensable gas for the gravity flow. The variable property effect is important and was also analyzed by Minkowycz et al [2], who found that the difference between the variable property solution and the constant property solution by Sparrow et al [3] was appreciable. However, the other contribution indicated in the paper's abstract [1] about the 'correct determination of the interfacial vapor condensate saturated temperature' is invalid, which causes the paper's results [1] differ substantially from Minkowycz's [2].

The paper's [1] Fig. 8 was used to compare between the paper's results and Minkowycz's [2] the condensation heat transfer reduction (q/q_{Nu}) caused by the noncondensable gas as a function of the temperature difference (T_∞-T_w). The comparison was based on the analysis of the same physical condensation process with the same bulk temperature (T_∞ = 373 K). The comparison showed that for the temperature difference below about 50degF, there was almost no condensation predicted by the paper [1], while significant condensation predicted by Minkowycz et al [2]. The paper [1] claimed that the results of the classic work [2] 'is incorrect,' due to 'the incorrect determination of the interfacial vapor condensation saturation temperature.' On the other hand, the classic theoretical work [2] has been validated by the experiment investigations [4,5] for condensation with the temperature difference of interest. Therefore, the current note tries to re-examine the discrepancy between the recent paper [1] and the classic work [2] by investigating the different methods used to determine the interfacial temperature from a given interfacial vapor mass fraction, which plays a pivotal role in studying the noncondensable gas effect on the reduced condensation temperature.

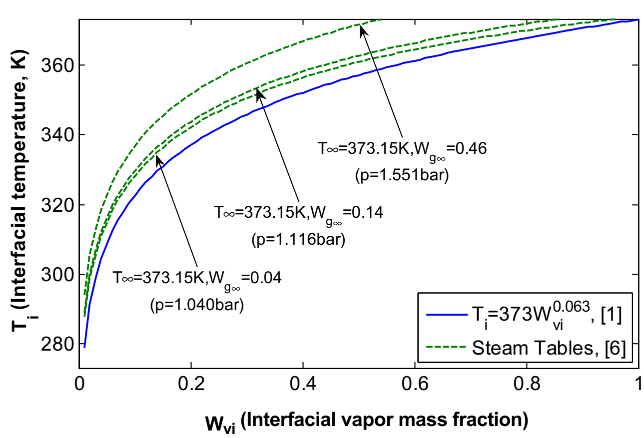

Fig. 1. Comparison of the empirical correlation [1] with results from Steam Tables [6].

The paper [1] developed an empirical correlation for the interfacial temperature which only depends on the interfacial vapor mass fraction: $T_i = 373W_{iv}^{0.063}$, Eq. (61) in the paper [1]. Apparently, the correlation is insufficient to predict the interfacial temperature when the steam-gas mixture total pressure (p) varies while the vapor mass fraction remains unchanged. Therefore it is expected that the paper's empirical correlation would cause a large error due to the neglect of the change in the total pressure. With various total pressures and a fixed steam bulk temperature, Fig. 1 of this note compares the interfacial steam saturation temperatures for a given interfacial steam mass fraction predicted by the paper's [1] empirical correlation to those inferred from Steam Tables [6], which can be regarded as the same source used in the classic work [2]. The solid curve represents the paper's [1] empirical correlation, which is independent of the total pressure. The three dashed curves represent the results inferred from Steam Tables [6], for the total pressure of 1.040, 1.116 and 1.551bar, respectively, corresponding to the bulk air mass fraction used in the paper's Fig. 8 [1] of 0.04, 0.14 and 0.46, respectively. Fig. 1 shows that when the total pressure is above about 1.013bar, the paper's [1] empirical correlation underpredicts the interfacial temperature for a given interfacial vapor mass fraction. When the temperature difference (T_∞-T_w) is sufficiently low, the paper's empirical correlation may have the interfacial temperature predicted lower than the wall temperature, resulting in the undue prediction of 'the noncondensable region' as shown in the paper's Fig. 6 [1]. This fact contributes to explain why the analysis by Minkowycz et al [2] predicted the condensation heat transfer reduction above 0.1 for a temperature difference below 45degF to even as low as 2degF, but the paper [1] predicted much less condensation in the same range of the temperature difference (Fig. 8 [1]) and even no condensation for the temperature difference below about 18degF (Fig. 6 [1]).

In general, the paper's [1] empirical correlation used to determine the interfacial temperature does not account for the probable variation of pressure and may lead to some of the presented results having a large error. Furthermore, the paper's argument that the results obtained by Minkowycz et al [2] 'is incorrect' due to 'the incorrect determination of the interfacial vapor condensation saturation temperature' is invalid.

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