Reply to V.A.F. Costa's comment

Your comments are logically right when dealing with the diffusion coefficient of heat function at the solid–fluid interface. Thanks to your advice.

The energy balance condition at the interface includes two aspects, i.e. both the temperature and the heat flux are continuous. The former means the temperatures for both fluid and solid sides are kept invariant along the tangent direction of the S–F interface,

$$\phi_1 = \phi_2 \quad \text{or} \quad \left(\frac{\partial \phi}{\partial s}\right)_1 = \left(\frac{\partial \phi}{\partial s}\right)_2, \tag{1}$$

while the latter implies that the heat flux along the normal direction of the interface is consistent, or

$$-\Gamma_{\phi,1}\left(\frac{\partial \phi}{\partial n}\right)_1 = -\Gamma_{\phi,2}\left(\frac{\partial \phi}{\partial n}\right)_2. \tag{2}$$

At the near interface the heat function reduces to

$$-\frac{\partial \Phi}{\partial n} = -\Gamma_\phi \frac{\partial \phi}{\partial s} \quad \text{and} \quad \frac{\partial \Phi}{\partial s} = -\Gamma_\phi \frac{\partial \phi}{\partial n}. \tag{3}$$

Substituting Eqs. (1) and (2) into the correlation formula, Eq. (3), we can see that

$$\left(\frac{\partial \Phi}{\partial s}\right)_1 = \left(\frac{\partial \Phi}{\partial s}\right)_2 \quad \text{and} \quad \frac{1}{\Gamma_{\phi,1}}\left(\frac{\partial \Phi}{\partial n}\right)_1 = \frac{1}{\Gamma_{\phi,2}}\left(\frac{\partial \Phi}{\partial n}\right)_2 \tag{4}$$

which confirms the viewpoint of Costa.

But it should be pointed out that the variable diffusion coefficient at the interface has no much influence on the result except for the continuity of the first derivative of the heat function at the interface, as indicated by Eq. (4). This can be seen from the dimensionless transport equation for the heat function

$$0 = \frac{\partial}{\partial x}\left(\frac{1}{\Gamma_\phi}\frac{\partial \Phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(\frac{1}{\Gamma_\phi}\frac{\partial \Phi}{\partial y}\right) + \frac{\partial}{\partial x}\left(\frac{1}{\Gamma_\phi}V\phi\right) - \frac{\partial}{\partial y}\left(\frac{1}{\Gamma_\phi}U\phi\right). \tag{5}$$

The diffusion coefficient could be dropped for both the solid and fluid regions and thus has no influence on the result.

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