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# LETTER TO THE EDITORS

## COMMENTS ON "PARALLEL FLOW AND COUNTER FLOW CONDENSATION ON AN INTERNALLY COOLED VERTICAL TUBE"

IN THE above paper Sparrow and Faghri [*Int. J. Heat Mass Transfer* **23**, 559–562 (1980)], it was mentioned that the following equation has to be solved numerically for parallel flow:

$$\frac{d\theta}{dX} = \frac{1-\theta}{1+\beta\theta^{1/3}}. \tag{1}$$

This equation however can be solved by integration by parts to yield an exact solution as given below:

$$\frac{(1+\beta\theta^{1/3})}{(1-\theta)}\,d\theta = dX \tag{2}$$

Integration of equation (2) with the condition $\theta = 0$ at $X = 0$ gives

$$X = -\ln(1-\theta) - 3\beta\left\{\theta^{1/3} + \frac{1}{6}\ln\left[\frac{(1-\theta^{1/3})^2}{1+\theta^{1/3}+\theta^{2/3}}\right] - \frac{1}{\sqrt{3}}\tan^{-1}\left(\frac{2\theta^{1/3}+1}{\sqrt{3}}\right) + \frac{\pi}{6\sqrt{3}}\right\}. \tag{3}$$

Similarly the equation for counterflow case will also yield an exact solution for $X$ in terms of $\beta$, $\theta$ and $\theta_e$ as given below:

$$X = \ln\left[\frac{(1-\theta)}{(1-\theta_e)}\right] + 3\beta\left[y - \frac{a}{6}\ln\left\{\frac{(a+y)^2}{a^2-ay+y^2}\right\} - \frac{a}{\sqrt{3}}\tan^{-1}\left(\frac{2y-a}{a\sqrt{3}}\right) - \frac{\pi a}{6\sqrt{3}}\right]$$

where

$$y = (\theta_e - \theta)^{1/3} \quad \text{and} \quad a = (1-\theta_e)^{1/3}. \tag{4}$$

Thus the above two cases of condensation on vertical tubes can be solved exactly, thus avoiding the possible errors obtained with the numerical solution. The plots of $\theta$ vs $X$ in terms of $\beta$ as given in Fig. 2 of the paper under discussion can be drawn using equation (3) given above.

*EDC (Heat Exchangers)*
*Bharatt Heavy Electricals Ltd.*
*Ramachandrapuram*
*Hyderabad 500032*
*India*

U. N. MURTHY