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CORRIGENDUM

Flow-induced morphological instability of a mushy layer

Journal of Fluid Mechanics, vol. 391 (1999), pp. 337–357

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Recent investigations by J. A. Neufeld and J. S. Wettlaufer have brought to light certain errors in the paper by Feltham & Worster (1999), which are corrected below. While these corrections do not alter the fundamental instability mechanisms introduced in that paper, they make significant quantitative changes to the stability criteria. Equation and figure numbers preceded by the letter C denote corrected versions of the original items.

Equation (5.8*a*) on page 349 can be conveniently written as

$$[(\mathrm{D}^2-\alpha^2)^2-(\mathrm{D}^2-\alpha^2)\mathrm{D}-\mathrm{i}\alpha\mathscr{U}_\infty(1-s)(\mathrm{D}^2-\alpha^2)-\mathrm{i}\alpha\mathscr{U}_\infty s]w_1=0,$$

where $\mathrm{D}\equiv s(\mathrm{d}/\mathrm{d}s)$ and $\alpha=kPr$, from which the general recurrence relation

$$[(j+r)^2-\alpha^2][(j+r)^2-(j+r)-\alpha^2-\mathrm{i}\alpha\mathscr{U}_\infty]a_j = \mathrm{i}\alpha\mathscr{U}_\infty[\alpha^2+1-(j+r-1)^2]a_{j-1} \quad \text{(C5.15)}$$

can be readily obtained for solutions of the form

$$w_1=s^r\sum_{j=0}^{\infty}a_js^j. \quad \text{(C5.9)}$$

The corrected recurrence relation can be used to determine that the pressure perturbation at the mush–liquid interface is as represented in figure C5. At large j the coefficients behave as $a_{j+1}/a_j\sim-\mathrm{i}\alpha\mathscr{U}_\infty/j^2$ and hence the series is strongly convergent. In detail we find rather different characteristics from those shown in the original paper, having the properties that $\mathrm{Re}\,[\hat{p}_1]\sim-k\mathscr{U}_\infty^2$ as $k\to0$, which corresponds to the inviscid result, and $\mathrm{Re}\,[\hat{p}_1]\to0$ as $k\to\infty$. These results have been confirmed independently by direct numerical evaluation of equation (5.3).

Overall, although the physical mechanism that underlies the instability is identical to that described in the original paper, the pressure perturbation is much smaller than previously calculated, which means that the mushy layer is much less prone to instability, as shown in figure C6.

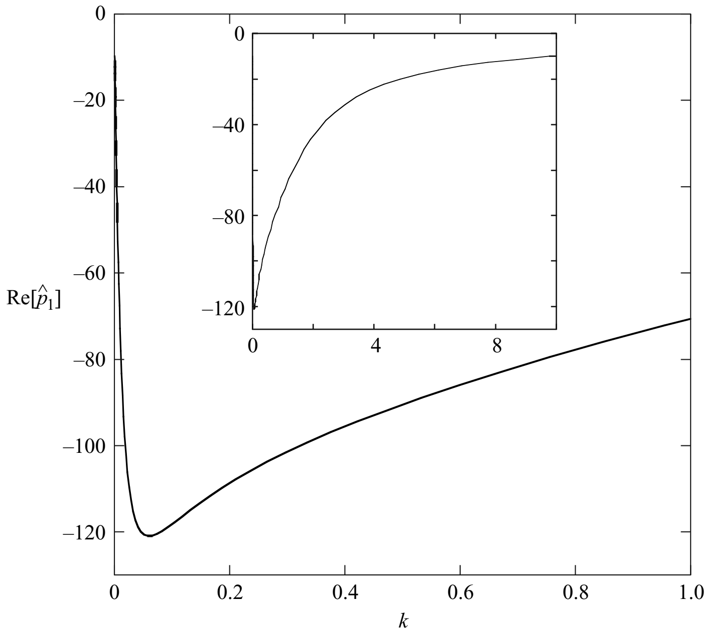

FIGURE C5. The real part of the pressure at the mush–liquid interface Re [$\hat{p}_1(\mathscr{U}_\infty, Pr, k)$] versus wavenumber k for $\mathscr{U}_\infty = 100$ and $Pr = 10$. The inset shows the decay at large wavenumber.

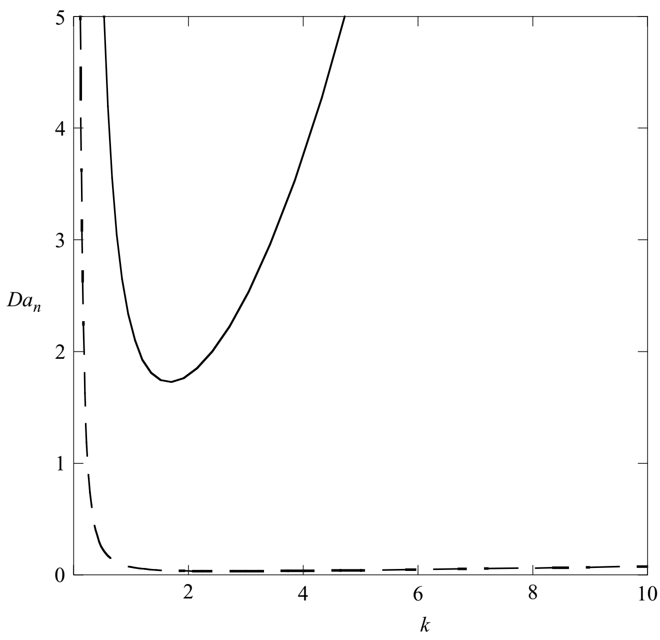

FIGURE C6. Neutral curve for a viscous melt, for $\mathscr{U}_\infty = 100$, $Pr = 10$ and $\tilde{\theta}_\infty = 1$. The solid curve results from the corrected theory and the dashed curve is the result presented in the original paper.