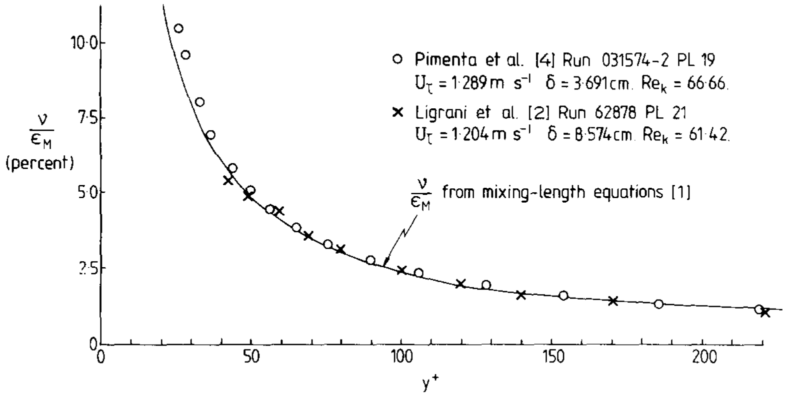

FIG. 1. Variation of ν/ε_M in near-wall regions of fully rough turbulent boundary layers.

and we would expect our physically realistic model to perform much better than if all viscous effects are unscientifically omitted. Viscosity independence of bluff body flows does not normally occur at roughness Reynolds numbers as low as 55, so it is clear that the flow over an impermeable wall having uniform spheres roughness requires more care in turbulence modelling than Mills and Hang seem to think.

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COMMENTS ON 'SOME PROPERTIES OF THE COEFFICIENT MATRIX OF THE DIFFERENTIAL EQUATIONS FOR PARALLEL-FLOW MULTICHANNEL HEAT EXCHANGERS'

I SHOULD like to make some comments on the information given in the short communication by L. Malinowski, *Int. J. Heat Mass Transfer* **26,** 316 (1983).

Malinowski states that the general solution of the matrix differential equation for parallel-flow heat exchangers

$$\frac{dt}{dx} = At, \tag{1}$$

as given by Wolf [1], is not a general solution at all, even with the complement given in ref. [2], since multiple non-zero latent roots of A may occur.

This is not entirely true, but the main point is that the general solution is already known.

In the mid 1970s it was proved that for $\Sigma W_i \neq 0$, matrix A has one, and for $\Sigma W_i = 0$ two, and only two, zero latent roots [2, 3]. More recently Zaleski proved that all the blocks of the Jordan canonical matrix J, corresponding to the non-zero latent roots of A, are of the first order, irrespective of a possible multiplicity of the latent roots [4].

The general solution to equation (1) is

$$t = K\,e^{Jx}\,C, \tag{2}$$

where K is the matrix transforming A to the Jordan canonical form $A = KJK^{-1}$, and C is a vector of constants. Hence it is clear that for $\Sigma W_i \neq 0$, J is a diagonal matrix while for $\Sigma W_i = 0$ it has one second-order block, corresponding to zero latent roots, and all the others are of the first order.

The general solution (2) provides the basis for computations of the thermal performance of parallel-flow heat exchangers. However, such computations are practically possible only if the number of channels is notably restricted, as otherwise they can be prohibitively time-consuming and difficult to carry out, particularly if matrix A happens to be ill conditioned. This last situation occurs when channels must be counted in tens or more, as is frequently found with plate heat exchangers. In such cases the approximate method developed by Settari and Venart [5] for solving equation (1) proves more effective [6].

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