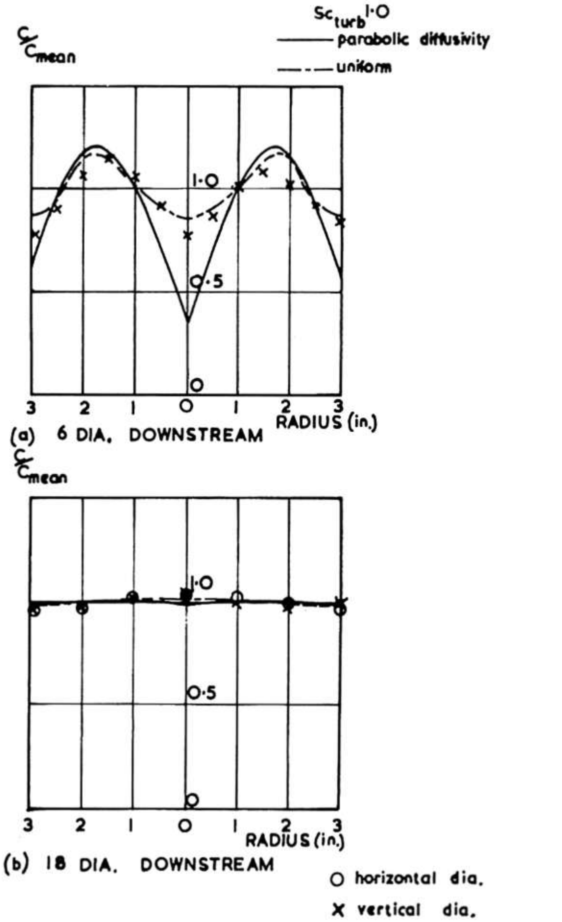

Fig. 14 Comparison of measured concentration distributions with theory for Re 100,000 using ring injection at $a_{inj} = 0.62$

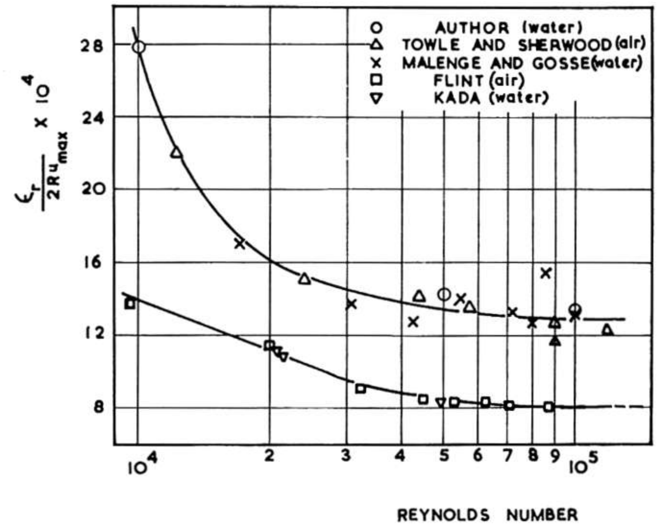

Fig. 15 Correlation of eddy diffusion coefficients

lated concentration distributions, it has been seen that the assumption of zero diffusivity at the pipe center is erroneous. This explains the large discrepancies between the measured and calculated values near the jet at the pipe center. However after the plume of dye has progressed outward, the comparison between the measured profiles and those calculated by assuming a parabolic diffusivity is very good. This would seem to suggest that a parabolic diffusivity is present in the outer half of the pipe diameter but that the inner half instead of decreasing to zero would fall to some positive value.

Acknowledgments

This investigation which was carried out at the Mechanical Engineering Department, University College, Cardiff, was financed by a D.S.I.R. research grant and supervised by Dr. B. J. Brinkworth, to whom the author acknowledges his thanks. He would also like to thank Miss S. Shuttleworth for permission to reproduce her experimental data.

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DISCUSSION

S. J. Leach[2] and J. S. Seager[2]

The choice of the assumption to make about the variation of radial diffusivity with distance across a turbulent pipe flow presents the main difficulty in solving the diffusion equation. The assumption that the ratio of velocity to diffusivity is a constant across a circular cross-section pipe has been made by several authors [16, 17, and 18][3] and seems to give results which are satisfactory for many practical applications. Recently [19] we have made measurements of the ratio of the radial diffusivity to the longitudinal velocity at Reynolds numbers of 0.5 and 3.0 × 10^5 and found that it varies from near the axis to 0.8 radii by less than ±10 percent, but that it rises rapidly toward the wall. We compared solutions of the diffusion equation which assumed this ratio to be constant [1] with experiment and found good agreement up to large distances downstream from an axial source of tracer gas, except in the region close to the walls. This supports

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[2] Ministry of Power, Safety in Mines Research Establishment, Sheffield, England.

[3] Numbers in brackets designate Additional References at end of discussion.

Dr. Evans' conclusion that the diffusivity does not fall to zero on the pipe axis.

We found it convenient to present results as a set of concentration contours with radial distance and (foreshortened) downstream distance as axes, rather than as sets of concentration profiles at different distances downstream, such as in Figs. 7, 9, 11, and 13 of Dr. Evans' paper. The contours could not be confused at crossing points and it was easier to collate the results from various sampling points when using the contour presentation.

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Author's Closure

I thank Dr. Leach and Dr. Seager for their discussion on the content of this paper. Accurate measurement of the radial diffusivity in pipe flow is difficult since either concentration profiles must be measured at two pipe sections some short distance downstream of each other, or local radial mass transfer must be measured. It is difficult to devise a probe to measure only the radial movement of mass in a fluid and, if radial concentration distributions are measured close to each other, then the difference in measurements at some radius will be small.

The ratio of velocity to diffusivity has been assumed to be constant across the pipe section for a Bessel solution of the diffusion equation and it is encouraging to see from Dr. Leach's measurements that this is sensibly so for approximately 60 percent of the flow area. However, the assumptions of Jordan are not only that this ratio is constant across the pipe but that the velocity and diffusivity are not functions of radius. Over the distance from the pipe axis to 0.8 radii, the velocity in established flow decreases by about 20 percent at Reynolds numbers of 10^5.

I agree with Dr. Leach and Dr. Seager that representation of the results in the form suggested by them is very convenient and is to be recommended.