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The Dean equations extended to a helical pipe flow. (English) Zbl 0675.76040

J. Fluid Mech. 203, 289-305 (1989).

Summary: The Dean equations are extended to the case of a helical pipe flow, and it is shown that they depend not only on the Dean number K but also on a new parameter $\lambda\ /\mathcal{R}$, where λ is the ratio of the torsion τ to the curvature κ of the pipe axis and $\mathcal{R}$ the Reynolds number referred in the usual way to the pipe radius a and to the equivalent maximum speed in a straight pipe under the same axial pressure gradient. The fact that the torsion has no first-order effect on the flow is confirmed, but it is shown that this is peculiar to a circular cross-section. In the case of an elliptical cross-section there is a first-order effect of the torsion on the secondary flow, and in the limit $\lambda\ /\mathcal{R} \to \infty$ (twisted pipes, provided only with torsion), the first-order 'displacement' effect of the walls on the secondary flow is recovered.

Different systems of coordinates and different orders of approximations have recently been adopted in the study of the flow in a helical pipe. Thus comparisons between the equations and the results presented in different reports are in some cases difficult and uneasy. In this paper the extended Dean equations for a helical pipe flow recently derived by *H. C. Kao* [ibid. 184, 335-356 (1987; Zbl 0645.76045)] are converted to a simpler form by introducing an appropriate modified stream function, and their equivalence with the present set of equations is recovered. Finally, the first-order equivalence of this set of equations with the equations obtained by *S. Murata*, *Y. Miyake*, *T. Inaba* and *H. Ogawa* [Bull. JSME 24, 355 ff. (1981)] is discussed.

MSC:

76D10	Boundary-layer theory, separation and reattachment, higher-order effects	Cited in **21** Documents
35Q99	Partial differential equations of mathematical physics and other areas of application	

Keywords:

Dean equations; secondary flow; flow in a helical pipe; extended Dean equations

Full Text: DOI

References:

[1] Dean, Phil. Mag. 4 pp 208– (1927) · doi:10.1080/14786440708564324
[2] Cuming, Aeronaut. Res. Counc. R. M. 15 pp 461– (1952)
[3] Choi, J. Fluid Mech. 15 pp 461– (1988)
[4] DOI: 10.1146/annurev.fl.15.010183.002333 · doi:10.1146/annurev.fl.15.010183.002333
[5] DOI: 10.1017/S0022112081002073 · Zbl 0483.76040 · doi:10.1017/S0022112081002073
[6] DOI: 10.1017/S0022112078001032 · Zbl 0374.76028 · doi:10.1017/S0022112078001032
[7] DOI: 10.1016/0169-5983(87)90008-6 · doi:10.1016/0169-5983(87)90008-6
[8] DOI: 10.1007/BF01535586 · Zbl 0377.76026 · doi:10.1007/BF01535586
[9] Murata, Bull JSME 24 pp 355– (1981) · doi:10.1299/jsme1958.24.355
[10] Mercier, Fusion Nucleaire 3 pp 89– (1963) · doi:10.1088/0029-5515/3/2/006
[11] DOI: 10.1016/0045-7930(86)90017-4 · Zbl 0608.76032 · doi:10.1016/0045-7930(86)90017-4
[12] DOI: 10.1017/S0022112080001310 · doi:10.1017/S0022112080001310
[13] DOI: 10.1017/S002211208700291X · Zbl 0645.76045 · doi:10.1017/S002211208700291X
[14] Germano, Atti VIII Cong. Naz. AIDAA, Torino September 125 pp 1– (1985)
[15] DOI: 10.1017/S0022112082003206 · Zbl 0533.76029 · doi:10.1017/S0022112082003206
[16] Dean, Phil. Mag. 5 pp 673– (1928) · doi:10.1080/14786440408564513