Malm, Johan; **Schlatter, Philipp**; **Henningson, Dan S.**

Coherent structures and dominant frequencies in a turbulent three-dimensional diffuser. (English) Zbl 1248.76102

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From the summary: Dominant frequencies and coherent structures are investigated in a turbulent, three-dimensional and separated diffuser flow at $Re = 10\,000$ (based on bulk velocity and inflow-duct height), where mean flow characteristics were first studied experimentally and later numerically. Coherent structures are deduced by proper orthogonal decomposition (POD) of the flow, which together with time probes located in the flow domain are used to extract frequency information. The present study shows that the flow contains multiple phenomena, well separated in frequency space. Dominant large-scale frequencies in a narrow band $St \equiv fh/u_b \in [0.0092, 0.014]$ (where h is the inflow-duct height and u_b is the bulk velocity), yielding time periods $T^* = Tu_b/h \in [70, 110]$, are deduced from the time signal probes in the upper separated part of the diffuser. The associated structures identified by the POD are large streaks arising from a sinusoidal oscillating motion in the diffuser. Their individual contributions to the total kinetic energy, dominated by the mean flow, are, however, small. The reason for the oscillating movement in this low-frequency range is concluded to be the confinement of the flow in this particular geometric set-up in combination with the high Reynolds number and the large separated zone on the top diffuser wall. Based on this analysis, it is shown that the bulk of the streamwise root mean square (r.m.s.) value arises due to large-scale motion, which in turn can explain the appearance of two or more peaks in the streamwise r.m.s. value. The weak secondary flow present in the inflow duct is shown to survive into the diffuser, where it experiences an imbalance with respect to the upper expanding corners, thereby giving rise to the asymmetry of the mean separated region in the diffuser.

MSC:

76F99 Turbulence
76M22 Spectral methods applied to problems in fluid mechanics

Keywords:

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Software:

Nek5000

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