Instability Analysis of a Turbulent Vortex Flow

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ABSTRACT

The work deals with instability modes emerging in vortex flows under the high turbulence/swirl intensity operation regimes. At these conditions the flow often exhibits unsteady features such as presence of rotating vortex structures which essentially affect mean and instantaneous flowfield characteristics. The problem is of significant practical interest since this kind of the flow unsteadiness has been found to occur in a variety of industrial installations like gas turbine combustors, cyclone separators and cyclone furnaces [1, 2] where it drastically influences the working processes and in addition raises critical concerns on the operation safety. The study also is of importance in a fundamental sense as it is relevant to the problems of vortex stability and vortex breakdown [3].

Previously, our experimental studies were applied to unsteady swirling flows generated by axial blade vortex generators which normally allow varying the standard swirl parameter S ([2]) in the range between 0 and 1.5. It was revealed that at S>0.5 the flow undergoes severe changes due to the vortex breakdown effect. As a result nonstationary large scale vortex structures emerge and induce time dependant and spatially complex flowfield. Detailed measurements performed disclosed a number of peculiar, nontrivial features of this flow [1, 4]. In that context the current study extends the analysis to high swirling conditions at swirl numbers S up to 3-6 and Reynolds numbers of order 10^4-10^5. To generate flow with high swirl level a vortex generator with tangential inlets as in cyclonic devices [2] has been used. Different experimental techniques including acoustic probes, LDA and PIV systems have been employed to acquire data on the unsteady flow characteristics. Finally, the studies should provide a dataset over a wide range of the flow regime parameters. In particular, obtained data will be used as a benchmark for further development of theoretical models of the unsteady vortex structures [3].

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