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A LES STUDY OF TURBULENT FLOW AROUND TWISTED AND TAPERED CANTILEVER.

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A study was performed on the passive control of Vortex-Induced Vibrations (VIV) for different geometric forms of cantilever subjected to a turbulent flow. The method used is LES with dynamic Smagorinsky model, TVD spatial scheme and backward difference scheme in time. The results show a reduction of the drag coefficient (C_d) on mean by 5% and a reduction of the RMS of lift coefficient (C_l) by 50/80% for taper/twisted configuration, which is consistent with related studies.

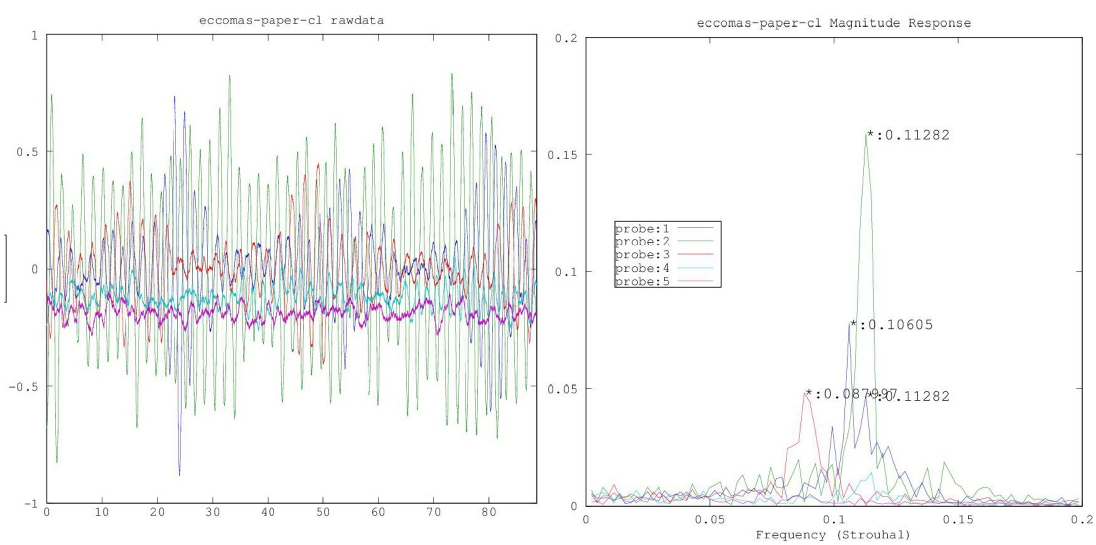
Method and Numerical Details

The incompressible Navier-Stokes governing equations are solved by a segregated solver using the PISO algorithm. The FVM method is applied, with a limited linear (TVD) spatial discretization and a backward difference as temporal discretization using the pisoFoam solver from the OpenFOAM package [1]. LES is used as turbulence model with the homogenous dynamic smagorinsky as SGS model. The fluid is velocity driven with an uniform flow across inlet at 1 m/s, no-slip condition at floor/cantilever and slip condition for the other walls. The pressure is set to zero-gauge pressure at outlet. A cantilever with dimension (5x1x1)D^3 [D=0.2 m] is placed in a rectangular domain (31x16x12.5)D^3 with 10D from inlet, 20D from outlet and 7.5D from the walls. The Reynold number is 5000 with respect to D and inlet velocity. The mesh is unstructured (tetrahedrons) and refined in the wake until convergence with respect to the RMS of the velocity field (threshold 0.01 m/s) yielding a total 5 MCell mesh.

Simulations and Results

Four case with different geometric form of cantilever were studied, where each geometry aims to disrupt the Vortex-Induced Vibrations (VIV) for the free-end cantilever case: slanted free-end (4D/5D), tapered (3D/D), twisted (45^o) and combination of the two latter. A straight cantilever was used as a reference case (regular). The results (Fig 1) implicate that tapering is of secondary importance compared to twisting and combining the taper with twisted form is a superimposed effect. Further, slanted tip reduces the entrainment from tip but the signal strength remains similar as the maximum peak strength (envelope) for the regular case. The mean C_d drops by 5% and RMS of C_l goes from regular case 0.18 to 0.04/0.03 for twisted/twisted-taper and 0.34/0.13 for slanted/taper. For the two twisted cases, the dynamics are different compared the regular case where the C_l varies weakly in time around a non-zero value. The results are consistent with [2, 3], where despite the corner effect (cylinder) the same trend is observed regarding the changes in RMS of C_l and the mean value of C_d. Furthermore, using the DMD technique with a sampling around the amplified region of the envelope signal, a clear correlation between the shapes of the enveloped signal in C_l and the entrainment is found.

Figure 1: C_l data to left and FFT to right: (1) regular, (2) slanted, (3) taper, (4) twisted (5) twisted-taper



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