Direct Numerical Simulation of an Oscillating Turbulent Couette Flow

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ABSTRACT : A DNS has been carried out on an oscillating Couette flow with uniform horizontal forcing and an upper plate exhibiting an oscillating plus a constant velocity. The mean turbulent velocity profiles through the cycle reveal that a turbulent boundary layer is formed at the upper plate. It is also observed that the magnitude of the near-bed (lower plate) velocity is larger for waves following the constant velocity at the upper plate than for waves opposing the current. The current resulting from the constant component of the upper plate velocity, is qualitatively different from the turbulent current in a Couette flow; the oscillating part of the near bed (lower plate) velocity acts as a resistance to the near-bed current. The mean turbulent bottom shear stress (at the lower plate) has been compared with that obtained by Spalart and Baldwin (1987) for waves alone and an almost similar wave Reynolds number. It appears that the qualitative behaviour is similar, but the bottom shear stress obtained from the present simulation has a steady component due to the current. The maximum and minimum shear stress values from the present simulation are 'lifted' vertically compared to those by Spalart and Baldwin (1987). This is an effect of the current; the magnitude of the peak of the bottom shear stress becomes smaller and larger as the waves are opposing and following the current, respectively. It appears that the bottom shear stress is largest during the part of the cycle where the turbulence intensities are largest. This takes place where the near-bed velocity is largest, i.e., just before the velocity changes sign. Overall, the results confirm that the wave-current boundary layer flow regime is determined by the wave alone case, as pointed out by Lodahl et al. (1998), at least when the current is weak compared with the amplitude of the wave velocity. Further detailed results will be given in the presentation.

Keywords : Turbulence, Wave, Current, Oscillating boundary layer

References

Lodahl, C. R., Sumer, B. M. & Fredsøe, J. (1998). Turbulent combined oscillatory flow and current in a pipe., *J. Fluid Mech.* **373**(25): 313–349.

Sleath, J. F. A. (1987). Turbulent oscillatory flow over rough beds., *J. Fluid Mech.* **182**: 369–409.