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Caution: Precision Error in Blade Alignment Results in Faulty Unsteady CFD Simulation[1] BRYAN LEWIS, JOHN CIMBALA, ALEX WOUDEN, The Pennsilvania State University — Turbomachinery components experience unsteady loads at several frequencies. The rotor frequency corresponds to the time for one rotor blade to rotate between two stator vanes, and is normally dominant for rotor torque oscillations. The guide vane frequency corresponds to the time for two rotor blades to pass by one guide vane. The machine frequency corresponds to the machine RPM. Oscillations at the machine frequency are always present due to minor blade misalignments and imperfections resulting from manufacturing defects. However, machine frequency oscillations should not be present in CFD simulations if the mesh is free of both blade misalignment and surface imperfections. The flow through a Francis hydroturbine was modeled with unsteady Reynolds-Averaged Navier-Stokes (URANS) CFD simulations and a dynamic rotating grid. Spectral analysis of the unsteady torque on the rotor blades revealed a large component at the machine frequency. Close examination showed that one blade was displaced by 0.0001° due to round-off errors during mesh generation. A second mesh without blade misalignment was then created. Subsequently, large machine frequency oscillations were not observed for this mesh. These results highlight the effect of minor geometry imperfections on CFD solutions.

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Bryan Lewis
The Pennsilvania State University

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