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HIGH-ORDER ACCURATE SCALE-RESOLVING SIMULATIONS OF LOW PRESSURE TURBINE LINEAR CASCADES USING PYTHON AT PETASCALE

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The turbine stages of a jet engine extract energy from exhaust gasses to drive the compressor, fan, and other auxiliary systems. Approximately half the weight of a turbine stage comes from the turbine blades. In order to reduce this contribution, modern turbines are designed to use as few blades as possible. However, this results in individual blades being under higher-loading, which can lead to fully-separated flow over the aft-portion of each blade; introducing complex, unsteady, three-dimensional phenomena, and thus reduced LPT efficiency, which can have a significant negative effect on overall fuel consumption rate. Accurate simulation of unsteady turbulent flow in the vicinity of complex geometric configurations is critical for improved design of turbine stages, and hence 'greener' aircraft that are more fuel-efficient. In this talk we will demonstrate application of PyFR [1], a high-order accurate Python based computational fluid dynamics solver, to petascale simulation of flow over low-pressure turbine linear cascades. Rationale behind algorithmic choices, which offer increased levels of accuracy and enable sustained computation at up to 58% of peak DP-FLOP/s on unstructured grids, will be discussed in the context of modern hardware. A range of software innovations will also be detailed, including use of runtime code generation, which enables PyFR to efficiently target multiple platforms, including heterogeneous systems, via a single implementation.

REFERENCES

[1] F. D. Witherden, A. M. Farrington, P. E. Vincent. PyFR: An Open Source Framework for Solving Advection-Diffusion Type Problems on Streaming Architectures using the Flux Reconstruction Approach. Computer Physics Communications, Volume 185, Issue 11, Pages 3028-3040, 2014.