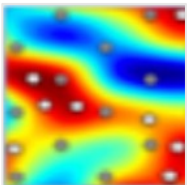


NEWSLETTER #4

JUNE 2023

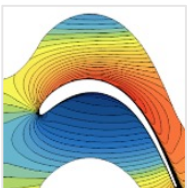


INSIDE THIS ISSUE



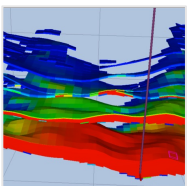
PAGE 2

Aeronautics Pilot
Combustor task
achievements



PAGE 3

Aeronautics Pilot
Turbine task
achievements



PAGE 4

**Energy and Carbon
Sequestration Pilot**
Achievements

Welcome to the ACROSS Newsletter #4!

The fourth edition of the ACROSS Newsletter reflects some of the positive outcomes achieved so far for the Aeronautics (WP5) Pilot and the Energy and Carbon Sequestration (WP7) Pilot.

As such, this newsletter intends to depict some of the achievements obtained for the combustor and turbine concerning the WP5 Pilot; similarly, it depicts some of the achievements obtained in the context of WP7 Pilot which relate to the capability of improving the (in-situ) visualization of simulation runs.

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Questions? Contact info@acrossproject.eu

Aeronautics Pilot – Combustor

In the last months, good progress has been attained by partners involved in WP5, working on both combustor and turbine workflows. Some of the achievements are summarized hereafter.

Combustor task

The ‘FIRST’ combustor investigation has been fully accomplished. The three domains (i.e., fluid, solid and radiative) have been engaged generating a set of calculations progressively more complex.

Latest post-processing analysis is ongoing and is to be finalized after having performed the runs on the IT4Innovations’ Karolina supercomputer. The ‘FIRST’ combustor model is here shown (see Fig. 1), and the major achievements are as follows:

- The solid-time-step approach is confirmed as a positive technical solution to couple fluid and solid analysis.
- Results from tests recently carried out with the goal of optimizing the radiative heat transfer management have been applied, and positive outcomes have been achieved, from preliminary analysis’ results, since overall simulation computing time is reduced with respect to the reference case.

- The LES numerical approach confirms that it produces more detailed wall temperature profiles than the previous SBES approach, without impacting run-time.
- Quality of the simulations has been ameliorated when comparing experimental and numerical values (see Fig. 2).

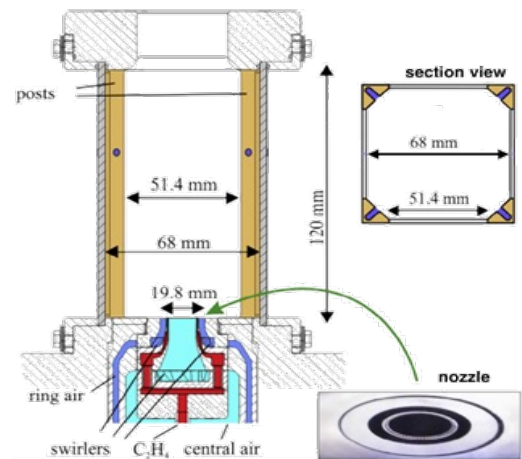


Fig. 1 – ‘FIRST’ combustor model.

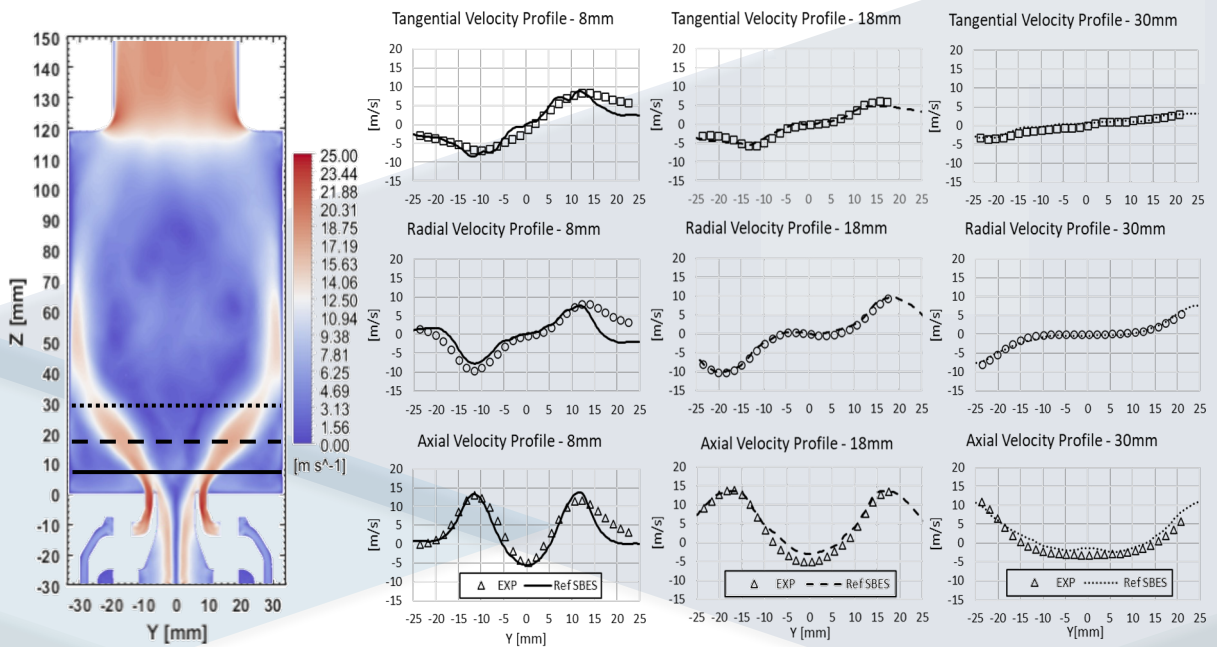


Fig. 2 – ‘FIRST’ combustor velocity profile at different spans (num vs exp).

Aeronautics – Turbine

In the context of WP5, the partners involved in the turbine task have worked on several streams. Key advances achieved so far can be highlighted as follows:

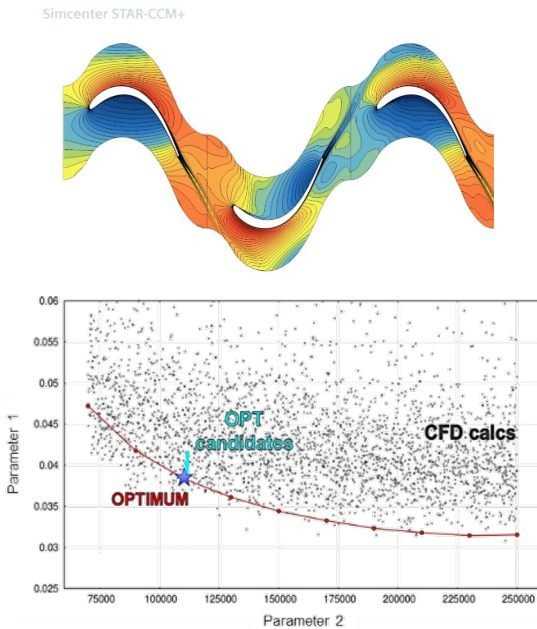


Fig. 3 – STARCCM+ allows to perform URANS calculations.

Fluid Dynamics (CFD) calculations.

After the (first) phase of tools development, the first brick of this huge database has been derived by means of a first optimization campaign. Several optimizations are then scheduled within the project to cover the whole design space, typical of modern aeronautical LPT.

In the first optimization campaign, 2000 URANS calculations were carried out using STAR-CCM+ tool (see Fig. 3) and adopting a proper multi-row environment, which is representative of the actual rotor-stator interaction in a real LPT engine. Calculations were performed using the computing resources provided by CINECA through the Galileo100 cluster.

This first database, before contributing to the final Design System (DS), is leveraged as a reference for testing and developing new AI-based tools, focusing on both accuracy and speed-up. As such, some of these tools have been ported to TensorFlow/Keras frameworks for testing potential performance improvements and easily exploiting heterogeneous HPC resources.

AI database and tool

The new turbine design system will be built over a very large database of multi-fidelity Computational

LES calculation

The LES setup has been validated during the initial phase considering different blade profiles and operating conditions. These tests showed the high accuracy of the adopted environment coupled with an impressive scaling for STAR-CCM+ which effectively exploits up to 30 nodes of the Galileo100 cluster, thus resulting in a time-to-solution restricted to few days.

Such an environment has been lately adopted for evaluating the performance of the first optimum point, focusing not only on the overall performance but also on the underlying loss generation mechanisms, thanks to the advanced HPDA technique developed by the University of Genoa.

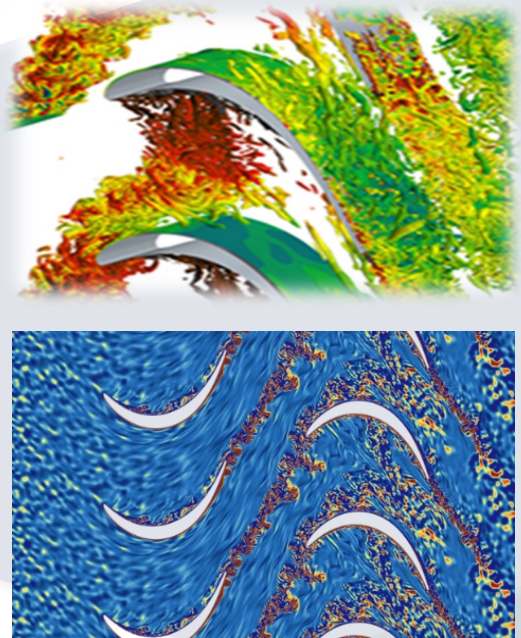


Fig. 4 – Examples of LES calculations.

Energy and Carbon Sequestration

In the last months, good progress has been made within WP7 working on improving many aspects related to the execution of the pilot application. The main achievements are summarized hereafter.

Seamless in-situ visualization

In the ACROSS project, WP7 partners added support for the Damaris middleware to the OPM Flow reservoir simulator. The Damaris middleware allows for easy in-situ processing of simulation data on-the-fly and has recently been extended to integrate asynchronous processing using Python and Dask (see also the newsletter #3). This means that the end-user can provide a Python script that will process the simulation data. This feature has been demonstrated in a workflow. Here, the Dask Python library is leveraged to send the data to a separate visualization process, which in turn runs a Bokeh server to visualize the data. Figure 5 shows the components involved in this workflow.

A key benefit of this approach is that each Python script is relatively small (around 200 lines of code), and should be readable for the domain experts, meaning they can easily change the data plotted without dealing with the OPM Flow code base, or having to recompile the simulator.

Another benefit of this approach is the low overhead involved. Since both Damaris and the Bokeh server runs on separate processes, there is little to no overhead in the simulation run-time, and this can trivially be distributed across a cluster or an heterogenous cloud architecture.

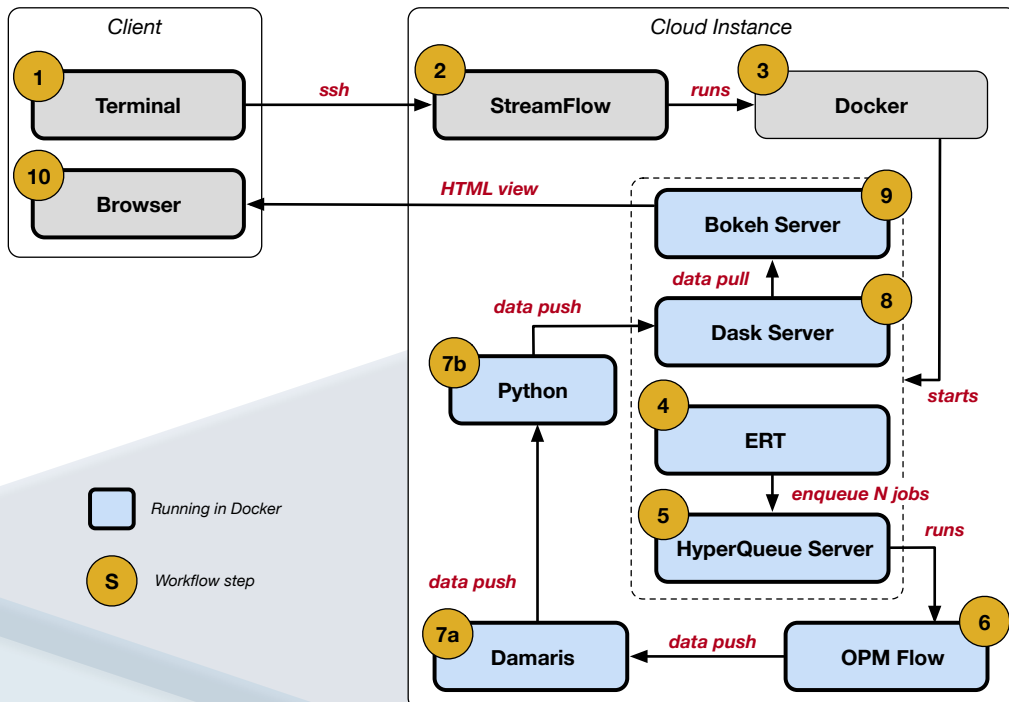


Fig. 5 – Workflow used to demonstrate the in-situ visualization capability (numbers reflect the sequence of steps).

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