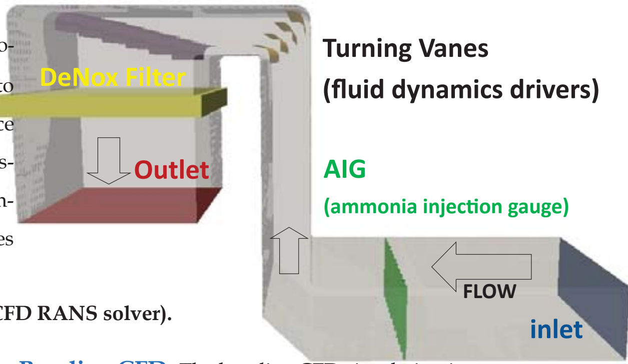
SCR-DeNO$_X$ Power Plant Design Optimization using HPC platforms: a Possible Automatic Workflow

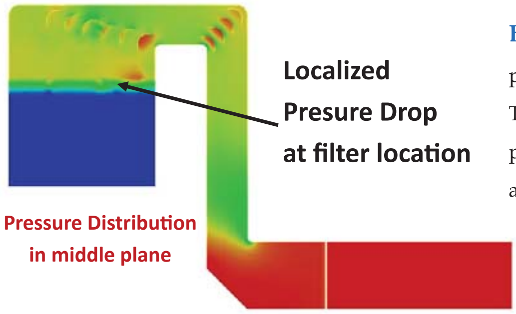
Feo D., Ponzini R., Pieri R., Auteri F.

Introduction. Selective **catalytic reduction (SCR)** with ammonia or urea is one of the most important industrial applications involved in NOx emissions reduction within power plants. **The design optimization of such systems is complex and can take huge advantage in the usage of automatic open-source tools and HPC platforms.**

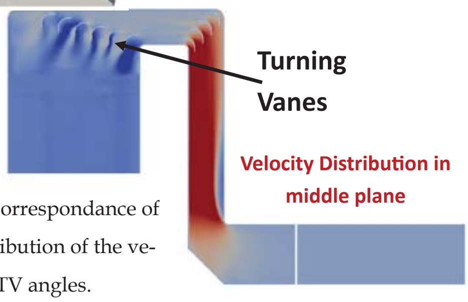
Main Targets of the Project. A complete and automatic optimization workflow has been developed to face this kind of applications using only open-source tools. The workflow is meant to be able to autonomously evolve from a baseline plant CAD design to an improved one modifying the angle of the turning vanes (TV). The selected computational tools are:
DAKOTA (optimization engine) and OpenFOAM (CFD RANS solver).

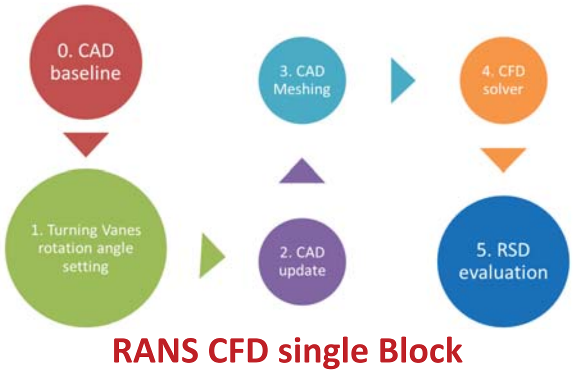


CAD Definition and Problem selection. As a first application we selected a reference problem previously studied by other autors (XU et al.; Computers&Chemical Engineering 2013) using CFD to rank and improve the fluid dynamics performances of a 300 MW coal-fired power plant.

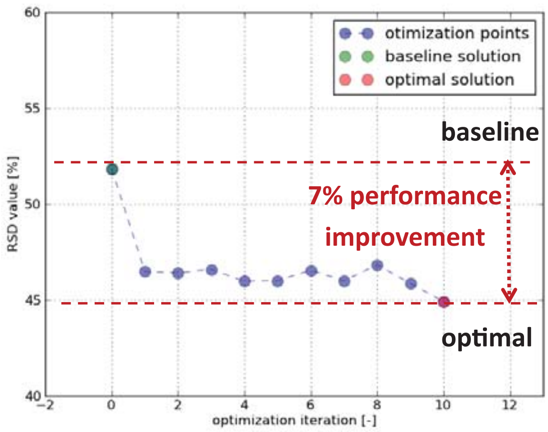


Baseline CFD. The baseline CFD simulation is performed using the CAD defined in the cited work. The velocity of air at the inlet is set to 4 m/s and the pressure at the outlet is set as reference. The solver is a steady-state RANS with a k-omegaSST turbulence model. A localized pressure drop is present in correspondance of the active filter modeled as a porous media. The distribution of the velocity at the inlet surface of the filter is driven by the TV angles.



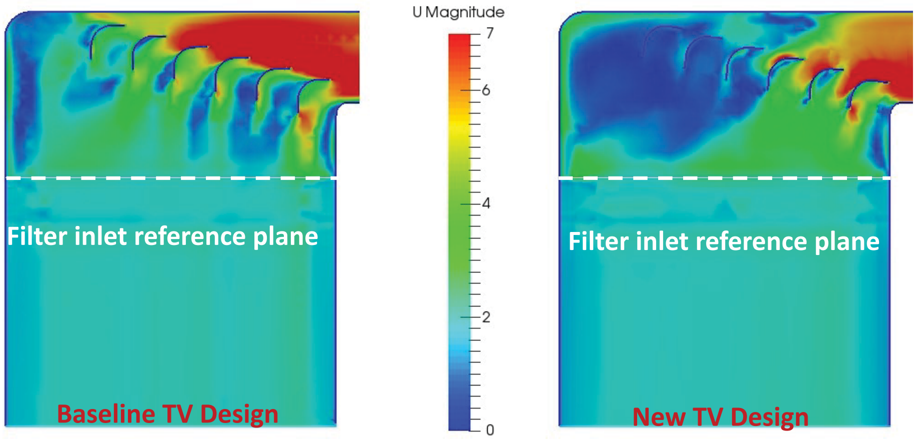


Single RANS CFD Block. The outcomes of the baseline CFD solution is used as input to define the reference status of the design and compute the inputs and outputs of the optimization process. According to work by Xu the synthetic parameter is a RSD value computed at the inlet surface of the filter, while the input are the angles of the TV.



Automatic Optimization Loop. The optimization loop is therefore an iterative process (unconstrained, bounded with a single objective function) where the CFD single block is executed for each new design until an optimal solution is found. The TV are free to change their angle along the principal axis on the range –5/+15 degrees. The New Design is obtained iterating the process on a maximum of 30 steps.

New Design CFD. The New Design CFD obtained as final output shows an improved value of the target RSD index of more than 7%. The flow patterns are coherently better distributed showing a more smoother velocity distribution on the selected reference plane.



Discussion&Conclusion. The application presented herein shows how a more than **7% global improvement of fluid dynamics performance can be obtained using fully automatic CFD-driven shape optimization loop**. This is considered a very promising results that could be eventually exploited introducing other CAD design parameters in the optimization process. Finally it is worthwhile notice that the workflow is built on top of an existing HPC platform using only open-source code and is therefore suitable to be exploited on more demanding CFD problems.