Extremely large CFD simulations with OpenFOAM® benefit from standardized processes in the cloud - Experience report on the integration of automated workflows in highly complex IT environments

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The implementation of standardized processes for virtual product development is not trivial in practice. CFD simulations with OpenFOAM are complex because they use a large number of different simulation data sets. They also require considerable computing power. However, engineers strive for high resolution while reducing computational time. The integration of CFD into computer-aided product development has allowed extremely large simulations to be carried out efficiently for several years. Simplifying complex simulation designs in favour of shorter run times on available resources, however, often remains a manual process. In this context, GNS Systems' CFD experts developed a fully automated workflow for optimal aerodynamics simulation. This workflow benefits from highly scalable resources in the cloud and simultaneously reduces the response time of simulation jobs significantly.

The starting point of the investigation was the question what engineers need in order to quickly and correctly handle extremely large simulations in the cloud with a software development kit such as OpenFOAM. Experience from previous projects shows that a customized development environment in the cloud, with central access to the required services and data, significantly accelerates many simulation projects. The combination of a fully automated workflow with scalability to up to 10,000 cores additionally reduces response times. Analysis engineers benefit from a tool that efficiently supports the coordinated execution of recurring process tasks, even in heterogeneous IT environments.

The presentation of the fully automated workflow in the cloud based on an aircraft model made of coloured plastic terminal bricks also includes practical tips for its integration into the often highly complex IT environments for CFD simulations. Based on realistic results from various experiments with procedures and methods of pre- and post-processing for lift, drag and rotational speed, a continuous workflow for computationally intensive simulations was created. The simulation of the complex model with up to 200 million cells allows very small-time steps and a high spatial resolution. Detailed turbulence calculations using the Large Eddy Simulation method provide a concrete forecast of the quality of the model in practice.

The automated workflow is based on the use of a selected CFD toolset in the cloud, which is already being used successfully in this form elsewhere. For example, a tool for simplified job submission combines existing workflows with standardized containers, virtual machines, job scheduling and cluster management. The improved job management significantly reduces the response time of simulation jobs by determining the resource requirements in the cloud based on the number and size of jobs in the queue. Calculations thus start up to 80 percent faster and results can be evaluated by engineers within a day. Together with the customized development environment in the cloud, it is possible to map the workflow of an optimal aerodynamics simulation in just a few steps. At the same time, productivity in the simulation processes increases due to the reduced effort required for job creation. Even for computationally intensive CFD simulations with OpenFOAM, which use a very high number of cores, the automated workflow provides users with reliable, error-free and high-quality results in the shortest possible time.