ANSYS in the Cloud

Wind Turbine Aerodynamics Study

Summary

- The case study refers to the evaluation of the wind turbine performance using a Computational Fluid Dynamics (CFD) approach.

- Various high-end software applications can be used to perform wind turbine aerodynamics study. ANSYS Workbench environment was the perfect fit in this case with minimal effort in setting up the model and performing the simulation trials.

- The combination of HPC Cloud, UberCloud Containers, and ANSYS Workbench helped speed up the simulation trials and completed the project within the stipulated time frame.

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"The HPC cloud provided a service to solve very fine mesh models and thus reduced the simulation time drastically."

THE TEAM

- **End-User/CFD Expert**: Praveen Bhat, Technology Consultant, India.

- **Software Provider**: ANSYS, Inc.

- **Resource Provider**: ProfitBricks

- **HPC Expert**: Burak Yenier, Co-Founder, CEO, UberCloud.

USE CASE

With an ever increasing energy crisis occurring in the world it will be important to investigate alternative methods of generating power other than fossil fuels. Wind energy is an abundant resource in comparison with other renewable resources. Moreover unlike the solar energy, the utilization cannot be affected by the climate and weather. A wind turbine is the device which extracts the energy from the wind and converts into electric power.

The case study refers to the evaluation of the wind turbine performance using a Computational Fluid Dynamics (CFD) approach. Standard wind turbine designs are considered for this UberCloud experiment. The CFD models were generated in the ANSYS CFX environment. The simulation platform was built on a 62 core HPC cloud server with ANSYS 15.0 modelling environment. The cloud environment was accessed using a VNC

viewer through the web browser. The 62 core server with 240 GB ram installation was at ProfitBricks. The CPU and the RAM were dedicated to the single user and this was the largest instance that was built in ProfitBricks. The ANSYS software was running in UberCloud's new application containers, see the Appendix for a short description.

Process Overview

The following defines the step by step approach in setting up the CFD model in the ANSYS Workbench 15.0 environment.

1   The standard wind turbine designs which are in the 3D CAD geometry format are imported in the ANSYS Design modeller. The model is modified by creating the atmospheric air volume around the wind turbine design.

2   Develop the CFD model with atmospheric air volume surrounding the wind turbine in ANSYS Mesh Modeller.

3   Import the CFD model in the ANSYS CFX Computational Environment.

4   Define the model parameters, fluid properties, and boundary conditions.

5   Define the solver setup & solution algorithm. This portion of setup is mainly related to define the type of solver, convergence criteria and equations to be considered for solving the aerodynamic simulation.

6   Perform the CFD analysis and review the results.

The ANSYS CFX simulation setup is solved in the HPC Cloud environment. The simulation model needs to be precisely defined with good amount of fine mesh elements around the turbine blade geometry. The following snapshot highlights the wind turbine geometry considered and ANSYS CFX mesh models.
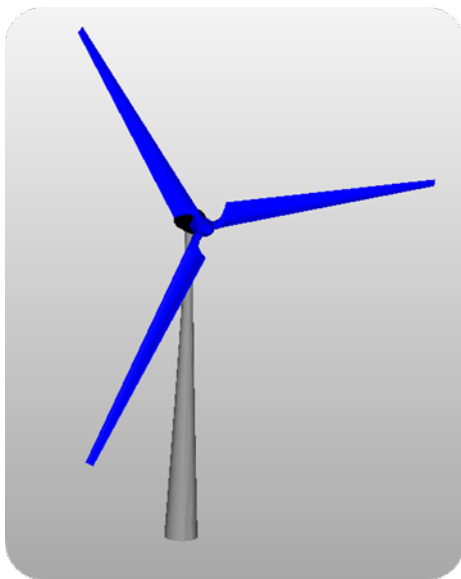

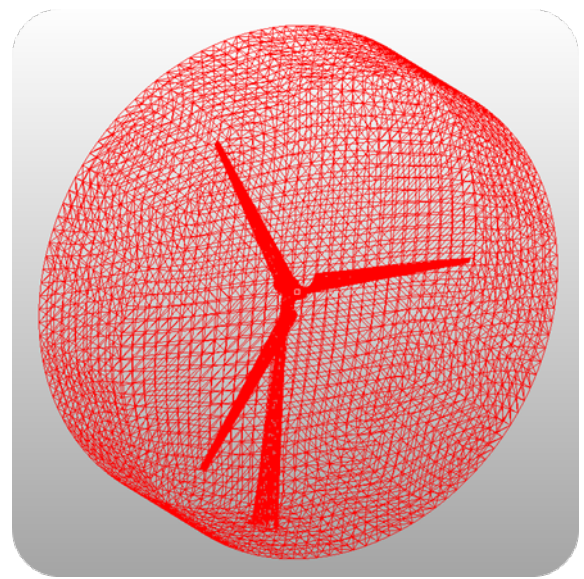**Figure 1: Wind turbine Geometry**

Figure 2: Computation Fluid dynamics model of wind turbine

The CFD simulation is performed to evaluate the pressure distribution and velocity profiles around the wind turbine blades. The wind turbine blades are subjected to average wind speed of 7 to 8 m/min. The following plots highlight the pressure and velocity distribution around the wind turbine blades.
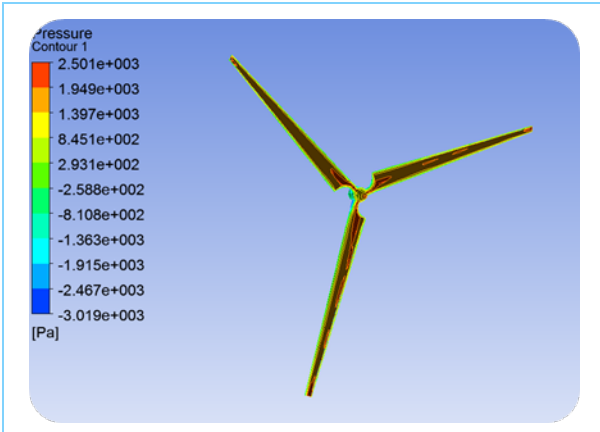
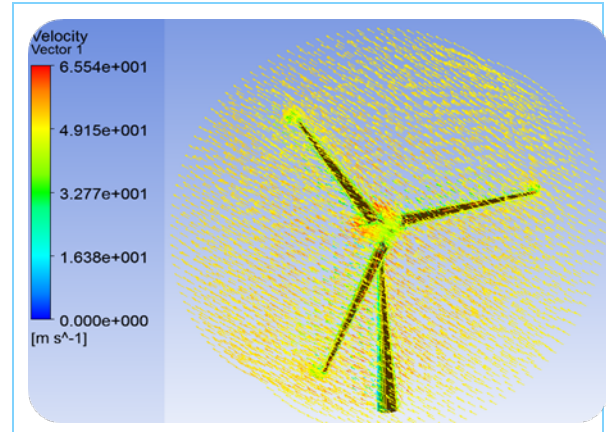**Figure 3: Plot of pressure distribution on the wind turbine blades**

Figure 4: Vector plot of velocity profiles around the wind turbine blades

HPC Performance Benchmarking

The aerodynamic study of wind turbine blades is carried out in the HPC environment which is built on a 62 core server with CentOS Operating System and ANSYS Workbench 15.0 simulation package. The server performance is evaluated by submitting the simulation runs for different parallel computing environments & mesh densities. The simulation runs were performed using ANSYS CFX by varying the mesh densities and submitting the jobs for different numbers of CPU cores. Three different parallel computing environments were evaluated: Platform MPI, Intel MPI and PVM Parallel.

Each of the parallel computing platforms has been evaluated for their performance on the total compute time and successful completion of the submitted jobs. Further the best parallel computing environment is proposed based on the experiments conducted and results achieved.
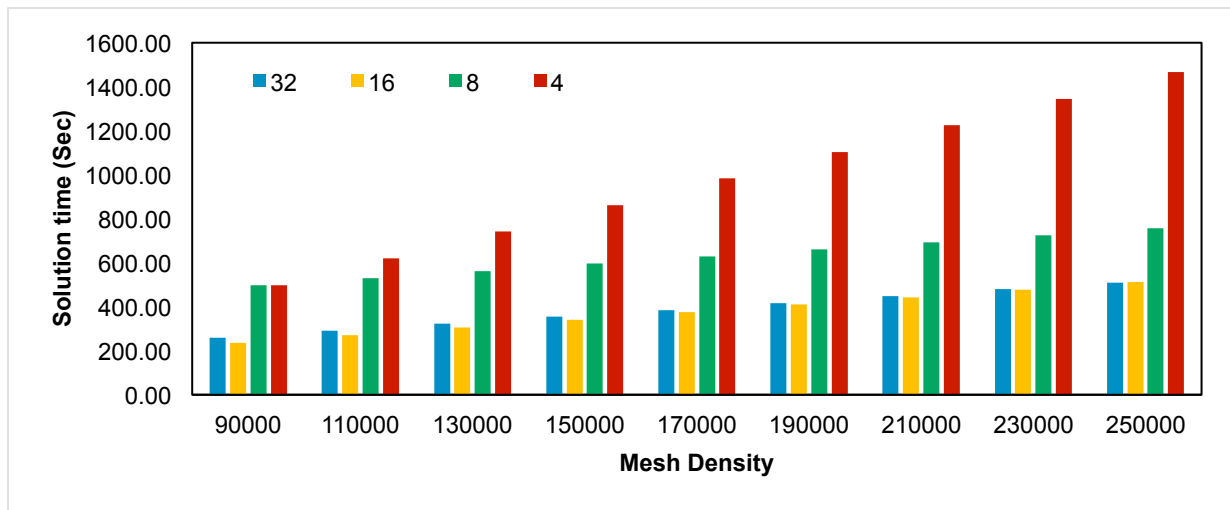

Figure 5: Solution time for different element density using Intel MPI parallel computing platform
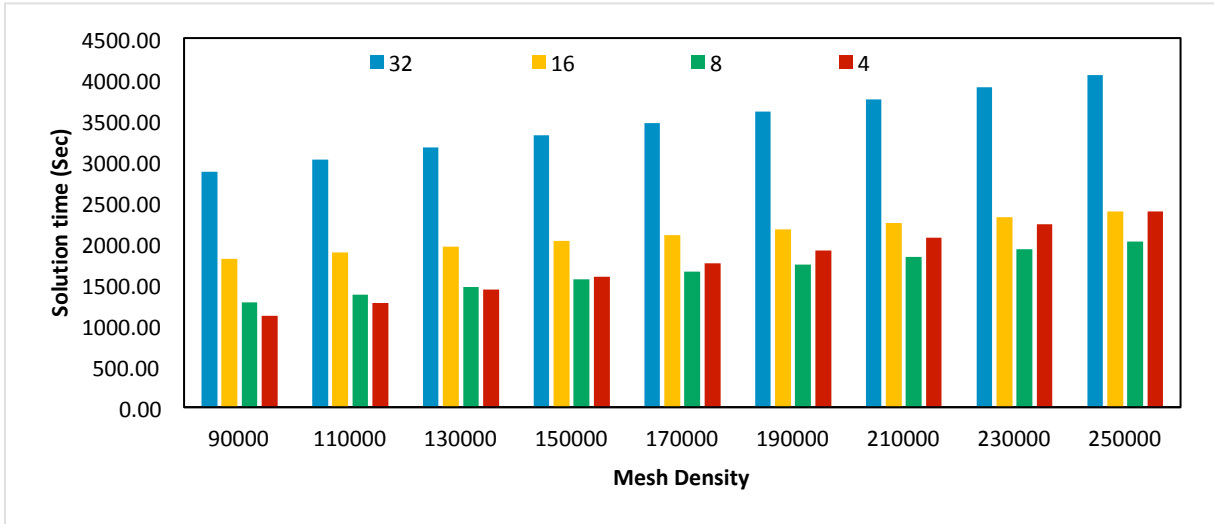
Figure 6: Solution time for different element density using PVM MPI parallel computing platform

Figures 5 & 6 show the plots of solution time required for different mesh density where the simulation models are solved using Intel MPI and PVM parallel computing platform. The Intel MPI parallel computing platform shows a stable performance with the solution time reducing with increases in the number of CPU cores (Ref. Figure 5). The PVM parallel computing platform is highly unstable with higher solution time required for higher CPU cores. The simulation time required for a 32 core configuration is higher than the time required for a 4 core configuration for the same simulation model (Ref. Figure 6).
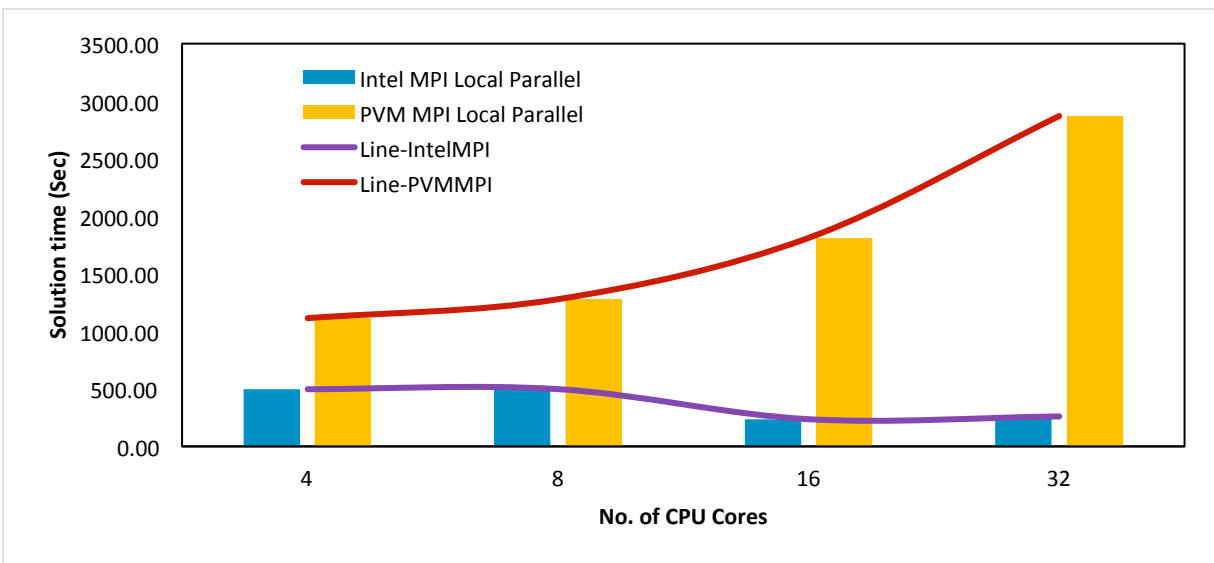
Figure 7: Performance comparison of different parallel computing platforms for a moderate mesh density (90K)
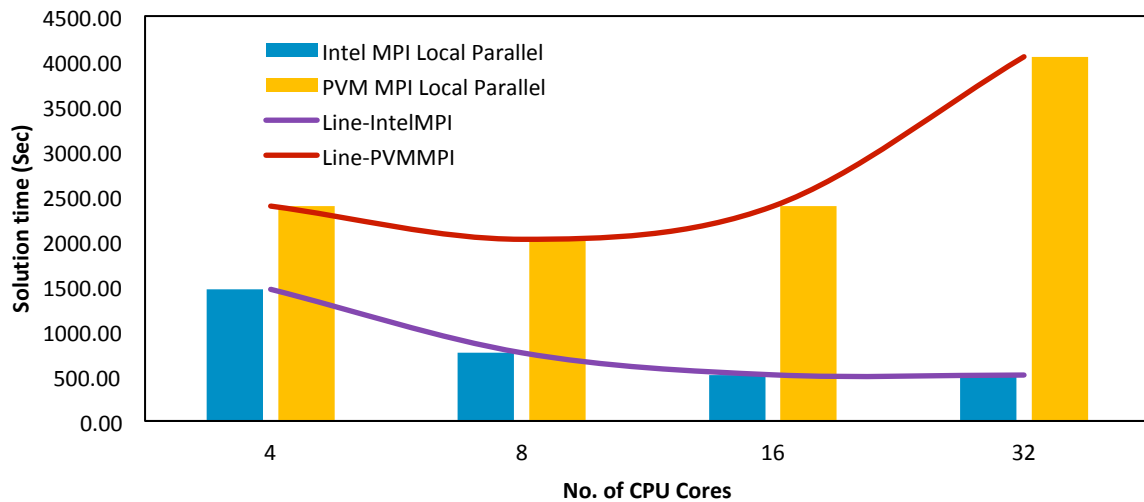
Figure 8: Performance comparison of different parallel computing platforms for a mesh density of 250K

Figures 7 & 8 highlight the HPC performance comparison done with different parallel computing environments. The simulation model was built with mesh densities of 90K and 250K and separate experiments were conducted with the simulation models by submitting the simulation jobs for different CPU cores. The solution time required to solve the simulation model is captured for different parallel computing platforms. The Intel MPI platform shows a better performance as the simulation time reduces with increasing number of CPU cores and is stable when compared to the PVM parallel computing environment.

Effort Invested

End user/Team expert: 75 hours for simulation setup, technical support, reporting and overall management of the project.

UberCloud support: 16 hours for monitoring & administration of host servers and guest containers, managing container images (building and installing container images during any modifications/bug fixes) and improvements (such as tuning memory parameters, configuring Linux libraries, usability enhancements). Most of the mentioned effort is one time effort and will benefit the future users.

Resources: ~600 core hours were used for performing various iterations in the simulation experiments.

CHALLENGES

The project started with setting up the ANSYS 15.0 workbench environment with ANSYS CFX modelling software on the 62 core server. Initial working of the application was evaluated and the challenges faced during the execution were highlighted. Once the server performance was enhanced, the next set of challenges faced was related to technical complexity. This involved accurate prediction of wind turbine blade behavior under aerodynamic loads which is achieved through defining appropriate element size for the mesh model. The finer the mesh the higher is the simulation time required and hence the challenge was to perform the simulation within the stipulated timeline.

BENEFITS

1   The HPC cloud environment with ANSYS 15.0 Workbench made the process of model generation easier with process time reduced drastically because of the use of the HPC resource.

2   The mesh models were generated for different cell numbers where the experiments were performed using coarse-to-fine to highly fine mesh models. The HPC computing resource helped in achieving smoother completion of the simulation runs without re-trails or resubmission of the same simulation runs.

3   The computation requirement for a very fine mesh (2.5 million cells) is high, which is near to impossible to achieve on a normal workstation. The HPC cloud provided this feasibility to solve very fine mesh models and the simulation time drastically reduced thereby providing an advantage of getting the simulation results done within acceptable run time (~1.5 hours).

4   The use of ANSYS Workbench helped in performing different iterations in the experiments by varying the simulation models within the workbench environment. This further helped in increasing the productivity in the simulation setup effort and thereby providing a single platform to perform the end-to-end simulation setup.

5   The experiments performed in the HPC Cloud environment showed the possibility and gave extra confidence to setup and run the simulations remotely in the cloud. The different simulation setup tools required were installed in the HPC environment and this enabled the user to access the tool without any prior installations.

6   With the use of VNC Controls in the Web browser, the HPC Cloud access was very easy with minimal or no installation of any pre-requisite software. The whole user experience was similar to accessing a website through the browser.

7   The UberCloud containers helped with smoother execution of the project with easy access to the server resources, and the regular UberCloud auto-update module through email provided huge advantage to the user that enabled continuous monitoring of the job in progress without any requirement to log-in to the server and check the status.

CONCLUSION & RECOMMENDATIONS

1.   The selected HPC Cloud environment with UberCloud containerized ANSYS on ProfitBricks cloud resources was a very good fit for performing advanced computational experiments that involve high technical challenges and require higher hardware resources to perform the simulation experiments.

2.   There are different high-end software applications which can be used to perform wind turbine aerodynamics study. ANSYS 15.0 Workbench environment helped us to solve this problem with minimal effort in setting up the model and performing the simulation trials.

3.   The combination of HPC Cloud, UberCloud Containers, and ANSYS 15.0 Workbench helped in speeding up the simulation trials and also completed the project within the stipulated time frame.

ABOUT UBERCLOUD

UberCloud makes it easy to run your simulations on powerful cloud infrastructure.

No more compromises on mesh quality or model fidelity because of hardware limitations. With UberCloud's flexible software platform and network of cloud partners, you get on-demand access to major providers such as Microsoft Azure, HPE and others. Choose from a variety of secure data centers, and hardware options such as InfiniBand, GPUs etc.

Unleash the full power of your analysis software and boost confidence in your results.

With over 200 technical-computing-as-a-service case studies, UberCloud has the experience, software platform and partnerships required for your success.

Engineers and scientists rely on UberCloud to manage the complexity of cloud and software operations, so they can focus on their analysis.

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