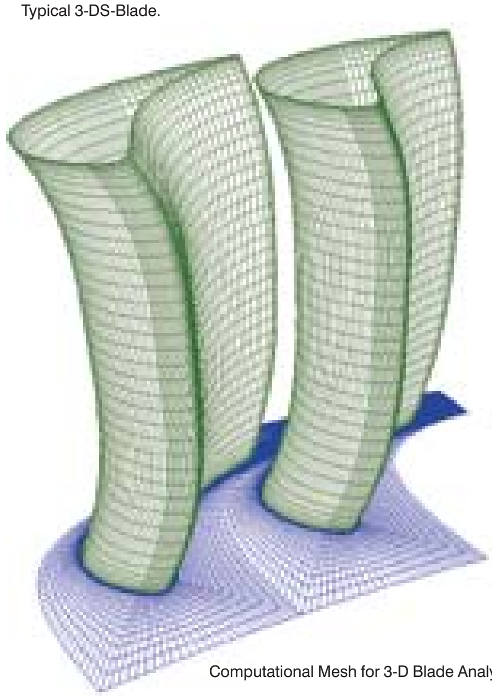
CFX AIDS DESIGN OF WORLD'S MOST EFFICIENT STEAM TURBINE

Typical 3-DS-Blade.



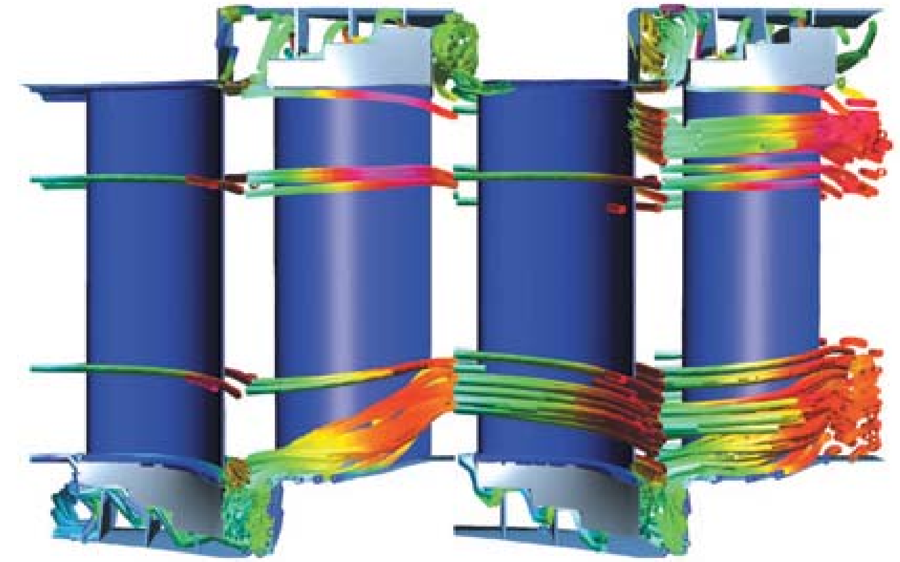
Computational Mesh for 3-D Blade Analysis.

by Mathias Deckers, Steam Turbine Blading Technology for Siemens, Germany

The VEAG power plant in Boxberg, Germany, has recently recorded a world-record of 48.5% gross efficiency for its Siemens' steam turbine, with specific efficiencies of 94.2% for the high-pressure turbine and 96.1% for the intermediate-pressure turbine.

By allowing Siemens engineers to visualize the flow inside the turbine with a minimum amount of model tests, CFX played an important role in the development of that turbine. We selected CFX-TASCflow primarily because it can analyze a much broader range of turbine features than the other packages that we investigated, and over the years it has proven its ability to model most of our designs. We have also found that CFX staff provide very competent technical support.

We started by comparing CFX results with experiments on a linear-cascade physical model. We imported the geometry into CFX-TurboGrid and generated meshes for each stage. We used CFX-TASCflow's multiple frame of references feature to model the interface between the different stages. After some adjustments to the grid and turbulence model, we got very close correlation between the physical and virtual prototype.



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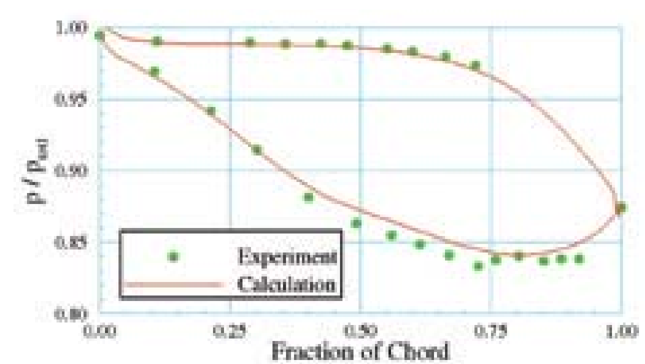
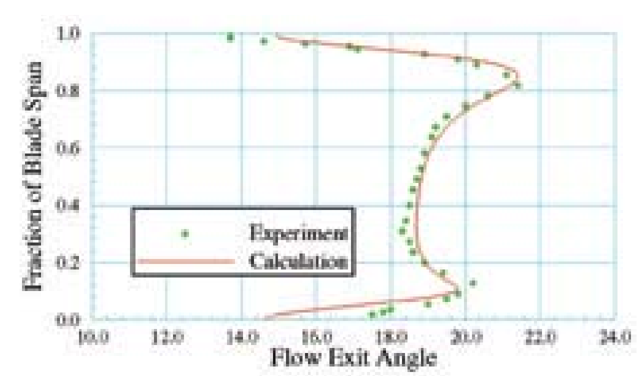
Blade-to-Blade View of Computational Mesh.

> 'CFX has been used to design nearly all of Siemens' recent high-performance steam turbines'



Comparison of calculated and Measured Surface Pressure Distribution (Mid-Span).



Comparison of Calculated and Measured Variation of Flow Angle.

We then applied CFX to designing the new turbine, systematically varying design parameters to fully understand their effects on the flow field. Because of this we became aware of the importance of secondary flows generated at the root and shroud. This insight spurred the development of our 3-DSTM blade in which the airfoil section changes along the length of the blade to match the complex flow field. This by itself can increase the stage efficiency by as much as 2%, generating millions of dollars in incremental revenues for a single large turbine.

The automated tools in CFX helped to simplify what has become a far more complicated design process, with many different airfoil sections to consider rather than just one for each blade. CFX-TurboPost helps by providing exit angle, total pressure and velocity components as functions of radius, entropy losses in each stage and an estimate of the turbine efficiency. These numbers help us to determine whether one design is better or worse than another.

CFX has also been used to improve other aspects of the turbine. For example, the intermediate-pressure turbine exhaust flow diffuser has been changed to improve flow guidance and to reduce vortex formation in the exhaust steam section. The high-pressure turbine inlet section has been optimized to provide a more homogenous flow distribution in the entire inlet area to the stationary blade rings. CFD analysis of the exhaust section of the low-pressure turbine was used to develop baffle plates that further minimized the flow losses.

CFX has been used to design nearly all of Siemens' recent high-performance steam turbines, leading to substantial increases in efficiency. Siemens Power Generation supplied VEAG with a five-cylinder turbine and the 907 Megawatts it generates represents a milestone in the production of energy-efficient electrical power. We are now in the process of commissioning an even larger turbine at Niederaussem in near Cologne that we expect will set another efficiency record. We are working to achieve even greater improvements by facilitating the use of CFX in the day-to-day design process at Siemens.