# Chopping Away at **Solids**

Geometry of a typical casing, impeller and cutter bar assembly

## CFD simulation provides a pump company with a virtual test facility.

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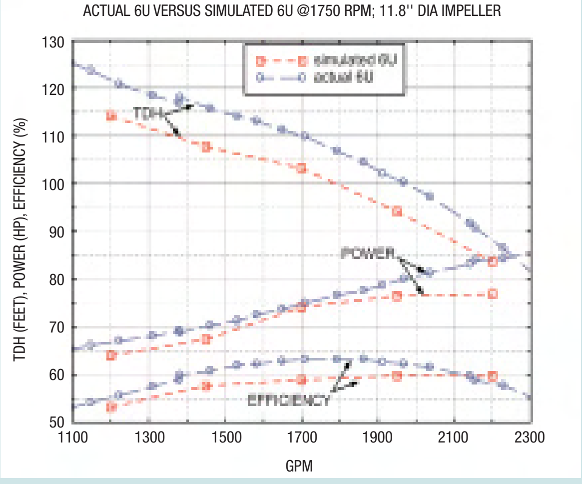
In a Vaughan chopper pump, the main impeller vanes extend all the way to the center hub of the impeller, and the suction plate includes two stationary fingers that protrude to the center of the suction opening. As the main vanes pass by the stationary fingers, a chopping action results, which macerates any solids entering the pump.

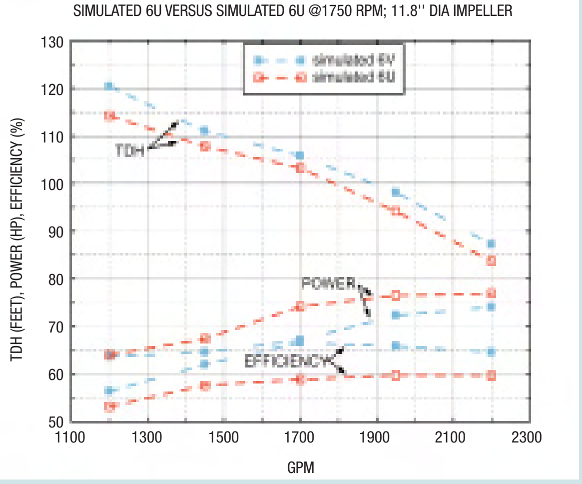
Chopper pumps utilize a chopping action between the impeller and the suction plate to break down solids that pass through the pump into smaller pieces. Vaughan Company, an established pump manufacturer in Washington, U.S.A., designs and manufactures a line of centrifugal chopper pumps. These pumps originally were designed in the 1960s for use in the local dairy industry to transport manure to and from storage tanks. Since then, Vaughan chopper pumps have been refined continually and awarded a number of patents; the company has earned wide acceptance for many applications that require solids handling. Today, Vaughan chopper pumps are used in various phases of municipal and industrial sewage treatment, food processing, and pulp and paper industries, in which the pumped liquid contains solids that need to pass through the pump without clogging or plugging.

The benefit of a Vaughan chopper pump over a typical non-clog or slurry pump is that it reduces the solids size of material passing through the pump. The unique chopping requirements and suction arrangement of these pumps make it difficult to apply standard impeller design practices in order to evaluate hydraulic performance. As energy costs continue to rise, developing more efficient pumps becomes increasingly critical for all pump manufacturers. Vaughan Company found that simulation was an effective and efficient way to approach the optimization of pump design.

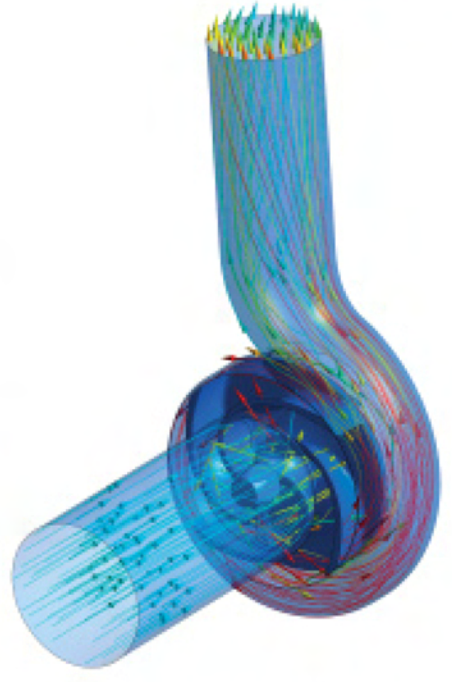
Vaughan Company's simulation process begins by importing computer-aided design (CAD) models from Pro/ENGINEER® into ANSYS DesignModeler software. The impeller domain and casing domain are meshed separately and assembled within the CFX pre-processor in which boundary conditions are applied. The ANSYS CFX solver performs the required calculations; then, results are viewed and pump performance is calculated in the computational fluid dynamics (CFD) post-processor. The ANSYS Workbench platform facilitates the entire simulation process, from geometry import through visualization.




Performance curve for a recently redesigned 6-inch pump. The simulation slightly underpredicts TDH because the geometry for the impeller and casing had to be reverse-engineered, and there were likely some differences between the model and the actual parts.




Comparison between the simulated existing impeller and the simulated redesigned impeller ensured that the redesigned impeller had TDH characteristics that were as good as the original impeller. The new design achieved an approximately 8-point increase in efficiency over most of the flow range.



Results of the simulation were visualized using ANSYS CFX-Post software.

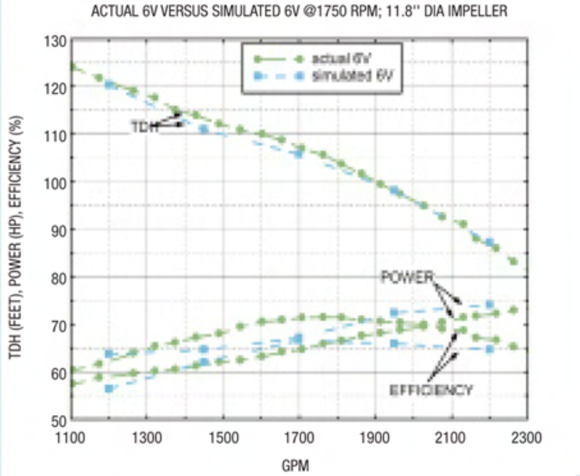
In order to optimize designs for increases in impeller performance, new impeller designs are modeled, and then their performance is simulated and compared to the simulation for the existing impeller. Originally, the impeller blade shapes were generated in Pro/ENGINEER. But the process was cumbersome, and ANSYS BladeModeler blade design software is now used. This software allows for easy generation of blade shapes to meet specifications and for the export of control curves to Pro/ENGINEER, in which the solid model is constructed.

Vaughan Company's primary interest has been in improving the efficiency of existing designs, as opposed to generating new models. A simulation is run for a given pump, and these results are compared to real performance data. In testing the real pump, a valve on the discharge side of the pump is progressively opened or closed. At each different performance point (that is, valve position), pressure and flow data are collected. These data points then can be connected to show total dynamic head (TDH, measured in feet), power (measured in horsepower) and efficiency (percent) with respect to flow (gallons per minute, or GPM). The simulation is run in a similar manner. Several simulations at various flow rates are performed on a given model. The performance data then can be extracted via the CFD post-processor, and a virtual performance curve can be constructed for that model.

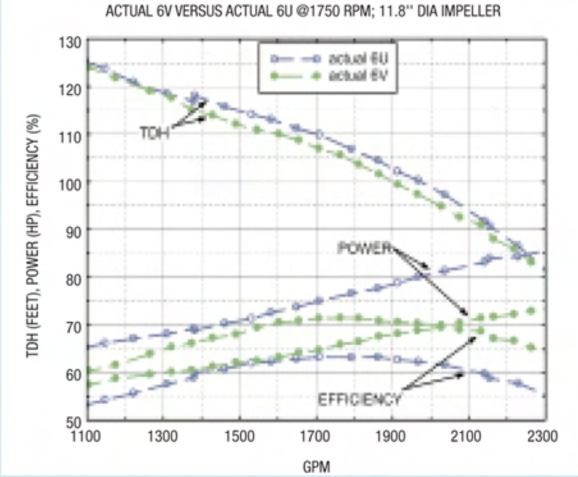
The simulated pump performance accurately predicted the actual pump performance in all seven models completed to date. Similar results are expected for the two models currently being redesigned.

The results of simulation have been very rewarding for Vaughan Company, especially when compared with fabricating and testing prototypes, which are very expensive and time-consuming. Such good performance testing correlation has been achieved between the simulation and cast impellers created from the same design that physical prototypes are no longer pursued by the company. Instead, all research and development (R&D) prototypes are modeled, simulated and optimized, then go straight to production castings.

Vaughan Company has been able to utilize ANSYS CFX simulation software, in combination with Pro/ENGINEER® Wildfire™, to effectively build and test prototype pump models at an engineer's desk. The relatively low cost of this type of R&D program allows testing of a large number of impeller blade shape variations, an approach that enables better optimization of any given design. In addition, it is a simple matter to extract a wide variety of information, including not only pressures and flows but also component forces, to better optimize the complete pump design. This optimization affects hydraulic design as well as mechanical design, such as the bearing selection via accurate impeller loads. ■




Comparison of the simulated redesigned impeller with the actual redesigned impeller test results show the TDH curves matched very well. Efficiency exceeded expectations, probably because very conservative simulations were run that slightly overpredicted the power required.




When comparing performance of the original pump and the new design, the TDH is a very close match and an 8- to 9-point improvement in efficiency was achieved across the entire flow range.