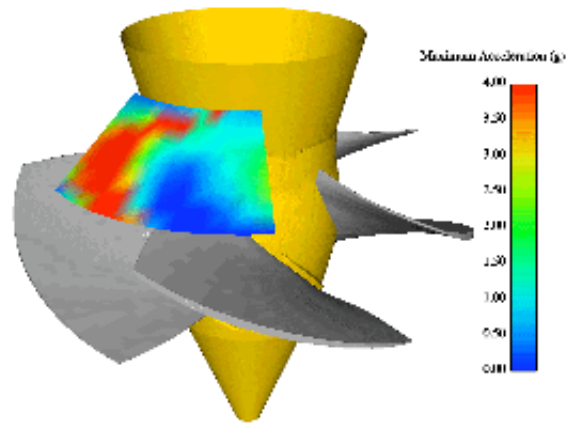


Virtual Fish Help Voith Hydro Make Green Power Source Greener

by Ellen Gooch

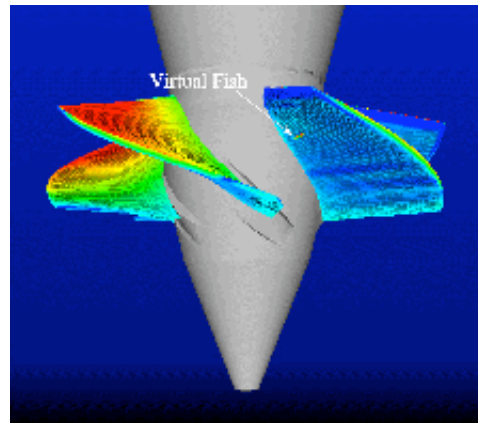
Hydroelectric dams have always been considered environmentally friendly power sources. They don't emit fumes into the air, pollute water or produce radioactive by-products. Only one problem prevents hydroelectric power from gaining the equivalent of an environmental green card: A small percentage of fish are injured or killed when passing through the dams' large water turbines.



While this problem can never be solved completely, Voith Hydro is doing its share to help. Voith, a supplier of hydraulic turbines since 1867, is using computational fluid dynamics (CFD) analysis and visualizations to design turbines that are friendlier to fish.

Better Methods for Survival

For more than 40 years, biological researchers tracked survival rates by catching fish downstream from hydroelectric dams. Though an honest effort, it did not shed much light on the actual turbine mechanisms affecting fish survival. A more precise method for measuring fish passage, called balloon tagging, has been used since the early 1990s to recover fish in carefully controlled test settings. Based on the results of those experiments, survival rates for fish passing directly through large turbines range from 88 to 94 percent. Not bad, but still not good enough for Voith.



Through the use of balloon-tag testing and 3D CFD methods, the U.S. Department of Energy's Advanced Hydro Turbine (AHT) program has already found correlations between fish survival and turbine design and operation. Testing at Wanapum Dam in Washington state using balloon-tagged fish validated how turbine mechanisms contribute to fish mortality. The study also showed that the presumed best-efficiency flow conditions might not necessarily be the best conditions for fish survival.

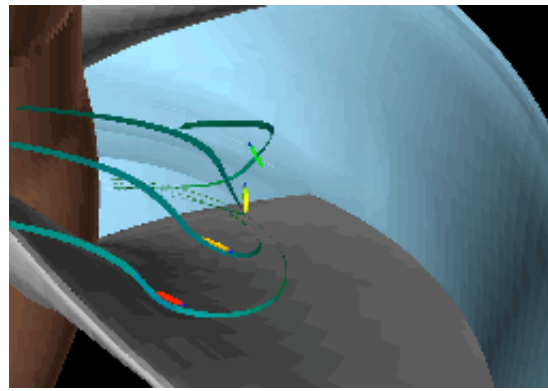
Using this and other knowledge gained through physical tests, Voith Hydro developed an environmentally enhanced water turbine, later dubbed the Efishent Kaplan model. Elements of the design were implemented at the Bonneville power plant in Washington state. Preliminary testing using balloon tags is expected to show an increase in fish survival. As a result of positive feedback, several other hydroelectric plants are being considered for upgrades to Efishent standards.

Virtual Fish to the Rescue

Buoyed by the success of the Efishent Kaplan turbine, Voith Hydro is taking its research far beyond balloon tags to visualizing what happens to fish as they pass through the turbines. In conjunction with the Georgia

Institute of Technology, Voith Hydro has developed virtual fish that swim in a computer-generated animated environment.

The virtual fish method of analysis is based on the assumption that fish swimming through the complex flow field of a hydro turbine can be represented as simple geometrical ellipsoids moving through a digital flow field. Initial velocities and pressures through the water passage are calculated using CFX-TASCflow CFD software. Researchers then input initial fish positions, sizes and other properties into the virtual fish program.

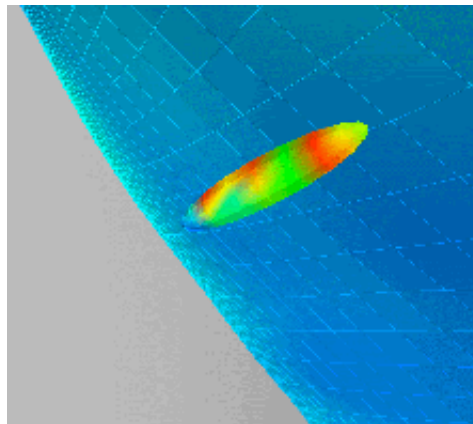


CFX-TASCflow calculations and kinematic formulas are used by the virtual fish program to determine the forces on the fish and resulting movements and rotations. The computational data is then imported into EnSight, a software program for analyzing, visualizing and communicating large CFD problems. EnSight generates animated simulations that enable Voith researchers to visually analyze the interactions among fish, turbines and water.

Flexible Virtual Fish

Along with the animation, EnSight produces a grid of initial release points, plotted and colored with maximum accelerations and velocity of impact, along with other quantities that help identify danger areas for fish. Fish can be colored with scalars, which are watched for changes as they move through the turbines. EnSight is used to graph yielded values, even creating a selected value-vs.-time graph as the fish are moving.

The visualization software enables Voith engineers to search for phenomena that are not only harmful to fish, but also detrimental to the efficiency of the machine. These include vortices, areas of flow separation, and cavitation, or vaporization (boiling) caused by swiftly moving water. One way EnSight users can find these "hot spots" is by interactively moving scalar-colored planes throughout the flow field, checking for high vorticity or low pressure.



Beyond its use as a research tool, EnSight visualizations are a vehicle for communication. Voith Hydro presents its animation on a large screen for viewing in 3D stereo using special glasses from NuVision. The 3D stereo images allow simulations to be viewed with true depth perception, which makes it easier to see flow fields and object interaction.

Use of advanced visualization and simulation tools in concert with well-planned and executed physical tests is already helping environmental engineers better understand the forces that affect fish when they encounter hydraulic turbines. With improved operating practices and designs such as Voith Hydro's Efishent Kaplan turbine, the hydroelectric industry is furthering its reputation as a green power source that continually strives to become greener.

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Read about this application in:

September 18, 2000 issue of *Design News*

Issue Two, 2000 of *The International Journal on Hydropower & Dams*

May 2000 issue of *Civil Engineering*