BY SHEILA GAILLORETO

New turbomachinery is optimized with the best performance models. Breakthroughs in efficiency, stability, durability and cost all require conceptual models.

Innovative Turbomachinery Solutions

Wide range of capabilities help bridge gap in global shortage of design engineers

Concepts NREC, an independent turbomachinery design and development organization, has been described as one of the best-kept secrets in the industry. For more than half a century, this worldwide organization has provided the "behind the scenes" technology tools, services and products that have aided in the development and production of some of the world's most advanced products. The organization offers complete resources for the design, analysis and manufacture of specialized equipment incorporating centrifugal, mixed-flow and axial compressors, pumps, turbines and fans. Concepts NREC employs a staff of over 100 professionals with facilities in both the states of Vermont and Massachusetts in the U.S.A. and representatives in Africa, Asia, Europe, Middle East and South America.

Dr. David Japikse, founder, chairman and senior technical director of Concepts NREC, was the recipient of the 2008 SAE Cliff Garrett Turbomachinery Award. As a requirement of acceptance, Japikse wrote and delivered a paper titled, "Turbomachinery Performance Modeling," as it applies to efficient power generation.

The world of turbomachinery is vast, far reaching and plays an essential role in everyday life. From providing clean drinking water and processing waste, to sustaining the travel, freight transportation and petrochemical industries, turbomachinery impacts our everyday lives, yet little, if any, emphasis has been given to the efficiency aspect of turbomachinery and all its ancillary components. Most of the world's electricity is generated by turbines — steam, gas, hydraulic. Internal combustion engines, used in power generation applications, likely utilize a turbocharger in order to meet performance requirements — again involving or touching the turbomachinery realm.

Apart from the pure power production side of the energy equation, it has been estimated by Electric Power Research Institute (EPRI) that approximately 3% of all power in the U.S. is used to drive turbo pumps. Add to this the fans, blowers, process compressors and refrigeration compressors and the numbers start adding up quickly. The end result is that a lot of power tends to be generated without any electricity being appreciably involved.

Japikse's paper poses the question: what impact would the improvement of just 1% efficiency have on the economy? He offered the following specific technological improvements that could have an immediate and tangible efficiency impact. The first area of focus from Japikse's perspective is in the pursuit of alternative aero engine cycles. Although this is not an area that *D&GTW* typically covers, Pratt & Whitney's PurePower PW1000G — with its patented Geared Turbofan technology — provides a genuine example of what is possible and is worth at least a brief mention as it relates to improving efficiency. The PW1000G targets double-digit reductions in fuel burn, environmental emissions, engine noise and operating costs. Engine certification is scheduled for late 2011 to support entry into services on the Bombardier CSeries and Mitsubishi Regional Jet in 2013.

A second area to look for efficiency improvements as suggested by Japikse is in the area of fans, blowers and pumps. There has been no major pioneering development work in this industry in the last 30 or more years. He suggests that the pump industry should be actively looking for areas of improvement. Advanced manufacturing methods exist today that could be easily applied to the pump industry and could yield efficiency improvements perhaps

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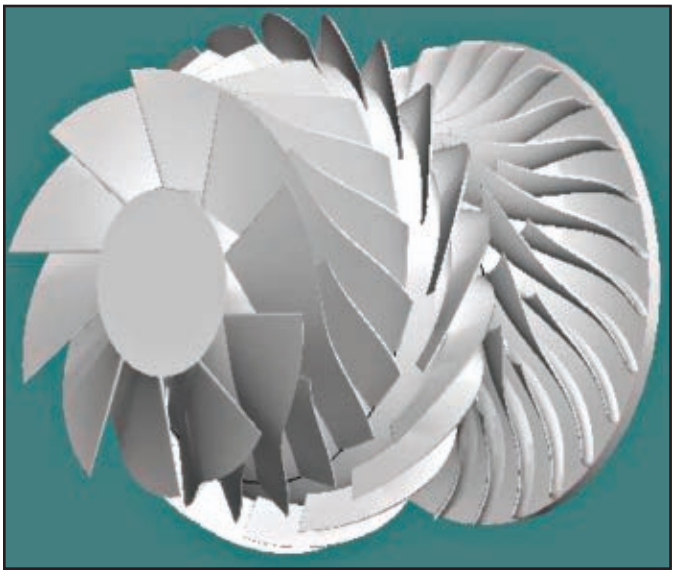


A 700 SHP gas turbine compressor design. Every step in the design process is open to scrutiny until optimum choices are made.

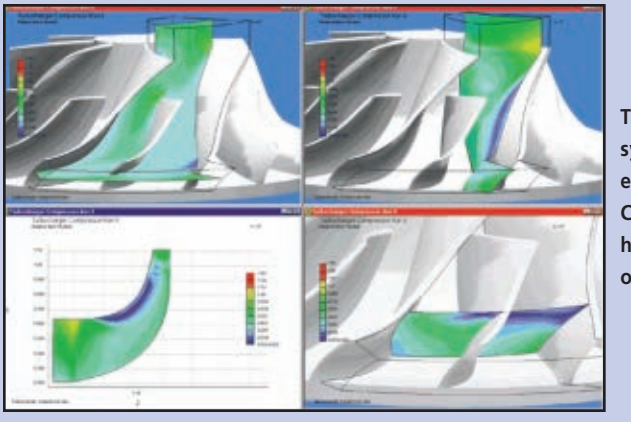
in the 2 to 4% range. Along the same lines, Japikse suggests that industrial compressors could adopt or apply technologies currently being used for turbo or irrigation pumps to improve efficiencies. The current method used to get from one stage to the next, in industrial compressors, is quite inefficient — the technology exists to improve this process, but it is not being applied or used in industrial compressors. For both the pump and compressor markets, he recommends a level of incentive may be required to push for this change.

The last area Japikse pointed out as a target for efficiency improvements lies in the application engineering process. Equipment is typically ordered so far in advance that the full specifications are not always known. In an effort to safeguard and/or guarantee equipment performance data or criteria, manufacturers typically specify equipment that exceeds the criteria, which potentially leads to more power specified than actually needed. Japikse suggests modifying this process by purchasing equipment with the ability to adjust or shift the specifications within a window of approximately 10%.

Japikse's paper further details how performance modeling takes on a critical role as it applies to efficient power generation. In order to design better machines, one must start with solid math and science based on solid principles of turbomachinery performance. Japikse's study explores and focuses on types of modeling procedures by researching underlying mathematics and comparing the work of multiple authorities. Japikse's paper is available by request at: info@conceptsnrec.com.

Concepts NREC is also active in the area of green turbomachinery design. The company is working on several projects including several in conjunction with the U.S. Department of Energy (DOE). Other projects include wave energy turbines to generate electricity from wave motion, hydrokinetic turbines to recover energy from river or tidal flows, hydrogen pipeline transmission compressors for the safe and efficient delivery of hydrogen gas to fuel cars, and fish-friendly hydroelectric turbines for efficient and effective power generation. Japikse offered the following comment in regard to the "green" concept, "This is not a faucet that can be turned on or off. Long-term commitment is needed, and experience is still a critical asset to which capital and development cash need to be added to carefully planned projects." The DOE has shown a great deal of leadership in this area, which is very encouraging to Japikse, though he also believes the industry can and should do more. "This is an important area due to the high cost of energy and the need to be green. These issues are highly complex technological issues and require great skill

Specialized Software Solutions



The Pushbutton CFD system quickly generates design-level CFD calculations and has rapid setup with one keystroke.

Concepts NREC's Agile Engineering Design System's turbomachinery design approach encompasses the complete engineering process. The system offers specialized five-axis machining software and a smoother transfer of data to CAD packages. This system's advanced technology tools, methodologies and application experience easily integrate with the user's enterprise framework and help leverage the strength of product life-cycle (PLM) solutions. Several new enhancements and updates to Concepts NREC's core software product portfolio were announced at the ASME Turbo Expo 2009, recently held in Orlando, Florida, U.S.A.

COMPAL — performs mean-line analysis and design optimization for centrifugal or mixed-flow compressors. Unique design wizards lead the user

to handle," he added. Concepts NREC can also supplement a client's in-house capabilities with advanced engineering and proven expertise in any or all phases of project development. They also offer educational programs for professional engineers, managers, marketers, sales professionals and others in the turbomachinery industry that need to know about the latest design tools and capabilities, who want to improve or expand their product range, or who specify, install, use or troubleshoot turbomachinery equipment.

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through the design, analysis and data reduction processes for open or closed 2-D or 3-D impellers including radial or axial inlet guide vanes, seals, diffusers and exit elements.

RITAL — performs one-dimensional analysis of the performance of radial and mixed-inflow turbine stages. The same consistent built-in model for design, analysis and data reduction modes supports inlet volutes, rotor and nozzle diffusion/losses, disc friction and other fundamental phenomena of sub-sonic turbine performance.

AXIAL — performs design-point and off-design meanline performance modeling for subsonic and supersonic designs. The system supports single and multistage axial impellers including compressors, gas turbines, steam turbines, hydraulic turbines, pumps and fans.

AXCent — designs and analyzes three-dimensional stage geometries for axial, mixed-flow and centrifugal compressors, pumps, fans and turbines. AxCent combines the capabilities of the most widely used turbomachinery codes to design any single or multistage turbomachines.

Pushbutton CFD — an efficient and full Navier-Stokes CFD system, streamlined for the agile turbomachinery analysis and design. The system quickly generates design-level CFD calculations and has rapid setup with literally one keystroke. Fast run times take less than 10 minutes.

STRESSPREP — performs flexible parametric stress-analysis modeling of radial and mixed-flow compressor and pump impellers, plus radial turbine wheels. Five computationally efficient models include front and rear counterbores, balance rings and variable fillet radii.

AXISTRESS — produces full 3-D parametric modeling of axial-flow blades for compressors, turbines, pumps and fans. Detailed solid model structured meshing, boundary conditions, aerodynamic loading and material models allow for a wide range of centrifugal and mixed-flow designs.

Concepts NREC's Agile Engineering Design solutions integrate CAE/CAM tools with process management and manufacturing. Its systems can simulate virtual performance, reliability, durability and lowest-cost production. The software allows users to build, test and refine actual products based on standards and best practices. Development phases can be accelerated to capture best opportunities for market success. A growing knowledge base is driving rapid innovation and best-in-class products with the ability to predict product behavior for PLM, quality assurance and process certification.