AS EQUIPMENT ROTATES, SO GOES THE WORLD

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Turbomachinery applications play a significant role in most industries: power generation, oil and gas, aeronautics, HVAC, chemical processing, healthcare and automotive. Efficiency gains can result in global improvements, particularly in the carbon footprint. While stringent emissions standards drive industrial equipment design, other factors play important roles. Fuel prices are volatile. Emerging OEMs create pockets of increased competition with resulting shortened time frames. Offshore, deep-water and shale gas reservoirs call for dramatic technology advances. Equipment is pushed to new operational boundaries, yet durability demands remain constant. Turbomachinery design has become a series of trade-offs.

Not surprisingly, rotating equipment companies increasingly leverage engineering simulation to build in efficiency as they reduce emissions, fuel burn and time to market. To achieve targets, developers look at improving all aspects of machine performance. Industry leaders develop and use high-temperature tolerant and lightweight materials to enable higher firing temperatures and reduce weight, while maintaining or improving machine reliability. Virtual design is especially valuable in incorporating smart capabilities that control fuel burn, automate load switching, monitor remote equipment and gather data. Advanced thermal simulation is particularly important as temperatures increase and parts are subjected to increased cycling as a result of more varied operational requirements. High-performance computing now enables simulation with greater fidelity and realism, and provides engineers with rapid turnaround and increased throughput required for digital optimization. Engineers can refine designs significantly before physical tests are performed, accelerating the process and reducing risk.

This "best of turbomachinery" issue of *ANSYS Advantage* includes many examples that validate the value of engineering simulation in building better products.

COMPRESSION AND GAS MOVING

Large centrifugal compressors used in the oil and gas industry must meet several stringent requirements, including high efficiency, high pressure, high reliability and small footprint. Recent emphasis on wide operating ranges increases the challenge. Dresser-Rand leveraged simulation in designing compressor stages to operate at higher flow coefficients and inlet-relative Mach numbers. The result was nearly a 10 percent improvement in the surge margin.

Efficient equipment reduces power consumption as well as operating costs. Rotating machinery company Continental Industrie designed a centrifugal compressor with a potential for up to 5 percent energy savings during wastewater treatment operations — an annual savings of $6,000 to $20,000 per compressor. Using simulation, the company completed the design with a three-person team in a reduced time frame, and still the first prototype met performance requirements. The aggregate savings would be substantial if even one compressor was adopted by each of the 20,000 U.S. municipal wastewater treatment plants.

In the automotive sector, turbochargers are used to get more power out of smaller engines with the additional objective of not affecting a driver's perception of handling and performance. The ideal compressor (the heart of a turbocharger) is efficient over a broad operating range and has low inertia while complying with package size limitations, robustness and cost constraints. PCA Engineers easily meets these complex requirements by using a highly automated simulation process that provides high-fidelity aerodynamic, structural and thermal information, reducing engineering effort and time to market.

HYDRAULIC TURBINES

Today's hydraulic equipment must cover an increased operating range and cycle more frequently. In the hydropower industry, plants experience enormous demand swings. Engineers at ANDRITZ HYDRO analyze turbine performance over time, under conditions that are constantly changing. To quickly retrofit aging plants and troubleshoot performance, they successfully apply virtual analysis to replicate the incredible level of product detail.

Strong vibration and pressure pulsation in hydraulic turbomachinery may be harmful to machine performance, longevity and safety. Voith Hydro observed strong vibrations that can cause fatigue cracking in the guide vanes of a large Francis water turbine. It leveraged multiphysics simulation to solve a very difficult field problem.

Grundfos, which develops circulator pumps for HVAC, uses simulation optimization to investigate hundreds of designs without manual intervention. The process reduced overall design time for a new pump by 30 percent and saved approximately $400,000 in physical prototyping.

THERMAL TURBO

Turbines must run at very high temperatures to reduce fuel burn, but they require internal cooling to maintain structural integrity and meet service-life requirements. Engineers used simulation to evaluate state-of-the-art turbine-blade cooling-channel geometries and developed an innovative geometry that outperforms existing designs.

Simulation delivers robust design with a high degree of confidence that a product will operate as expected. Pratt & Whitney leverages simulation from the earliest stages of aircraft engine design to improve both development speed and product fidelity.

Turbomeca used embedded software simulation on its helicopter engine control system, decreasing development time by 30 percent. The process also reduced coding errors.

Turbomachinery design presents many challenges for R&D teams. Analyzing flow requires high-fidelity simulation tools, and virtual analysis is dependent on compute power. As technology advances into the future, expect to realize more high-fidelity solutions, and more detailed design of experiments (with thousands of fast runs) to optimize components. Nano- and mega-scaled grids will together provide accurate resolution for even the most challenging problems. Multiple physics analysis — including aero, mechanical, thermal and vibration — will be part of every design handbook, used in parallel, interactively and simultaneously. Engineers then will be able to develop turbomachinery that incorporates the right blend of trade-offs.