Concepts NREC

The Experts in Turbomachinery

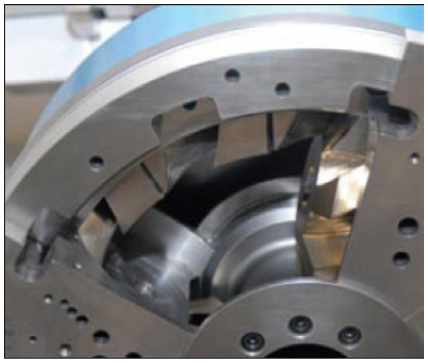
Case Study

Mechanology's Innovative New Compressors are Ready to Deliver Breakthrough Benefits

Manufacturing the complex impellers of the TIVM™ compressor and testing the unique oscillating-vane Dragonfly™ compressor required the services of Concepts NREC.

As an innovator of compressor and expander technologies, Mechanology, Inc., of Attleboro, Massachusetts, is a twenty-year-old company with a breakthrough core technology that is now ready for commercialization. But development of the unique TIVM (Toroidal Intersecting Vane Machine) has not been without design and manufacturing challenges.

According to Steve Chomyszak, company co-founder and chief engineer, "Our positive displacement expander technology offers the flow and power density features of a turbine and has been described as the first major innovation in compressors in over thirty years." The compact and versatile TIVM technology can be configured in many applications as a single or multistage compressor, expander, or an integrated compressor/expander, with important ramifications for energy conservation, reduced carbon emissions, and national energy independence.



This Toroidal Intersecting Vane Machine, or TIVM, uses multiple chambers in a rotary torus configuration to generate high power density at slow speeds.

Inventing the TIVM engine

Steve Chomyszak tells the story best. "As a graduate student in manufacturing technology at Stanford University, my passion was to design a new internal combustion engine, and my laboratory was the school's machine shop. That is where I had my inspiration for the toroidal intersecting vane machine, and that's where I spent the next three years conducting experiments.

"While at Stanford, I met another machine shop zealot and believer in the TIVM concept who encouraged me to continue development beyond graduation – and offered to join me in developing a basic working prototype that would at least prove the concept.

"Over the next ten years of experiments and iterations, I assumed the role of chief designer and engineer, and we both machined and assembled parts working out of an apartment bedroom, with a

Mechanology's Innovative New Compressors are Ready to Deliver Breakthrough Benefits, continued

few basic machine tools in the basement. By 1985, our work had achieved encouraging success – as well as an understanding of what needed further thinking and refinement. We were almost ready to start a business."

Mechanology is founded

"Still inspired by the prospect of inventing a new and better internal combustion engine, in 1989 we formally founded Mechanology as a technology development company with a focus on proving and patenting the TIVM design. But as experiments continued, funded by investor money and government contracts, it was becoming clear that the TIVM would most likely come to readiness for commercialization as a compressor or expander.

"For one such DOD (U.S. Department of Defense) application, we configured the TIVM as a low-cost steam expander that, unlike a small turbine, had no high-speed shaft and required no gearbox. In 1999, the DOE (U.S. Department of Energy) evaluated the TIVM as a potential solution to the air-management system of automotive fuel cells, and they funded Mechanology's specialized adaptation of the TIVM design for an integrated compressor and expander. That contract gave this one-bedroom start-up the credibility to raise money, equip a new facility, and grow."

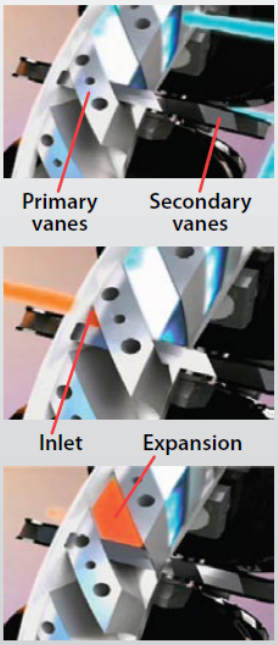
Concepts NREC designed, built, and programmed this rig used to test Mechanology's patent-pending Dragonfly compressor, a 500 hp positive-displacement oscillating vane machine.

Mechanology meets Concepts NREC

"Now having a very well-equipped machine shop, we built the first working TIVMs that successfully pumped air and built pressure. But to meet our engineering targets for manufacturability and performance in the applications we were pursuing, we desperately needed the services of a highly advanced five-axis machine shop running sophisticated CAM toolpaths to accommodate our highly specialized turbomachinery design. And that requirement is what ultimately led us to Concepts NREC – but not until after other shops had attempted and failed to produce the critical tolerances and quality needed for the complex toroidal impellers.

How the *TIVM* works

The *TIVM* has two sets of vanes arranged so that their respective paths of motion share a common intersection. Spaces or chambers are dynamically formed where the vanes intersect to expand and then discharge the working air, steam, or gas. In the expansion sequence, the high-pressure working fluid enters the chamber through an inlet port causing expansion and increased volume that, in turn, cause the primary vanes to rotate. The rotating primary ring delivers mechanical power to an integrated drive shaft. The *TIVM* has no valves. Flow is controlled by the timing of the primary vanes passing inlet and discharge ports.



"Because the TIVM does not require seals, tolerances for sealing friction and leakage are critical. At the recommendation of a well-respected turbomachinery design insider, we asked Concepts NREC to machine the same sample part the two previous suppliers had not been able to successfully manufacture.

"The part we received from Concepts NREC was truly an exceptional solution that met the conditions

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we supplied, and it worked. And when we came to their Woburn facility to inspect the part, a tour of the plant revealed balancing and spin testing services that we also needed right then. And as we discussed various applications of the TIVM technology, Concepts NREC offered to provide other experience-based turbomachinery services we were certainly going to need in the near future.

After other shops had failed, Concepts NREC successfully met all critical tolerances for machining the intersecting impellers used in Mechanology's TIVM compressor.

"It was clear to me then that this was going to become a long-term relationship. We seemed to be the perfect match for this independent turbomachinery specialist with the capability to fuel our innovative process."

Concepts NREC was also a key participant in helping to develop another unique technology at Mechanology – a first-of-its-kind, wind-driven, positive displacement oscillating air compressor that Mechanology calls Dragonfly. The 14,000-pound, 500 hp, double-acting compressor was designed to provide high efficiency, high power density, and variable speed/presure operation, all in a compact, lightweight configuration.

The challenge to Mechanology was to meet a fourteen-month deadline to develop, build, and test a full-scale Dragonfly machine. Concepts NREC met their obligation to design and manufacture the Dragonfly test rig complete with instrumentation and software, as well as assistance in designing a state-of-the-art test lab.

"In retrospect," according to Steve Chomyszak, "we not only saved time using Concepts NREC, they certainly helped us manage risk – and proved the adage about only using proven suppliers when a project is on a fast-track schedule. To be successful, we must have confidence in our partners."

Mechanology in transition

"Our patented TIVM and Dragonfly technologies are ready for commercialization through partnerships and li- censing, and industry is taking notice," says Chomyszak. "We recently built and are now testing a smaller, third-generation Dragonfly compressor, and we are currently developing a TIVM steam expander for DOD to be used in producing power from the exhaust of a diesel genset. This is an exciting time for me and the thirty-five others at Mechanology who have become believers that iteration is indeed the mother of perfection."

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