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Rotating Machinery Services Inc. provides full range of turbomachinery repair and upgrade services

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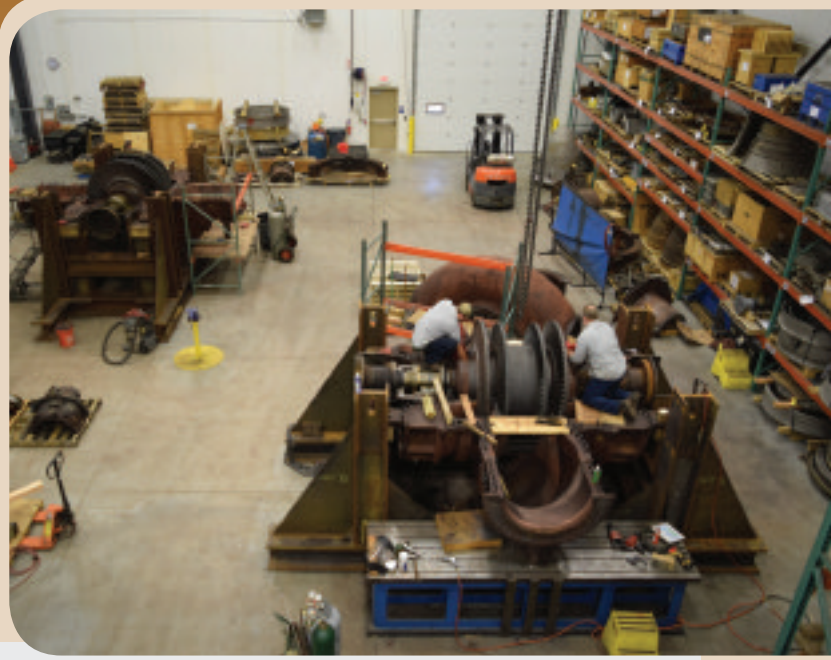

■ The RMS service facility consists of three 10,000 sq.ft. (929 m^2) bays that include a rotor assembly shop (left), large-capacity machine shop with quality control room, and an assembly shop (right) with a full range of lifting, moving and storage equipment.

In 1998, a group of experienced turbomachinery engineers with a strong aftermarket engineering background founded Rotating Machinery Services Inc. (RMS) in Bethlehem, Pennsylvania. Now in its 18th year, the company has steadily grown its business, becoming a major force in providing turbomachinery aftermarket engineering and repair services to the refining, chemical, gas transmission, power generation and steel industries. Earlier this year, RMS opened a satellite engineering office in Appleton, Wisconsin, specializing in the support of the former A-C Compressor line of centrifugal compressors.

RMS performs a wide range of services on turbomachinery, including reliability improvements, performance optimization, repair, component replacement and the supply of upgraded/overhauled surplus equipment. The company has experience with repowering turbomachinery packages and has also supplied new custom-designed equipment skids and lube oil systems. Its experience includes axial and centrifugal compressors, fluid catalytic converter (FCC) and nitric acid expanders, gas turbines, aeroderivative power turbines and steam turbines.

"RMS provides a full range of turbomachinery services, giving users a complete alternative to the OEM (original equipment manufacturer)," said Jerry Hallman, company president and co-founder. "We have a total focus on existing compressor equipment, as opposed to OEMs, which have their resources focused on new equipment. We can provide superior engineered solutions to long-standing problems that the OEM is unwilling or unable to solve. We also focus on 'orphaned' equipment that is no longer fully supported by an OEM. And we provide customers with open access to RMS' experts."

Types of projects include rerates for improved performance; engineered overhauls of rotors and complete machines; mechanical redesigns and upgrades; reapplication of surplus equipment trains; component repairs; new parts supply including rotor blading, disks, shafts, stators, casings, bearings and seals; and field service that ranges from inspection and turnaround support to providing supervisors to full turnkey responsibility.

"We take pride in our ability to refurbish turbomachinery to a condition that ensures long-term trouble-free operation for our customers," Hallman said. "Our assemblers, inspectors, machinists and field service supervisors have an average of 25 years of experience in their respective fields and

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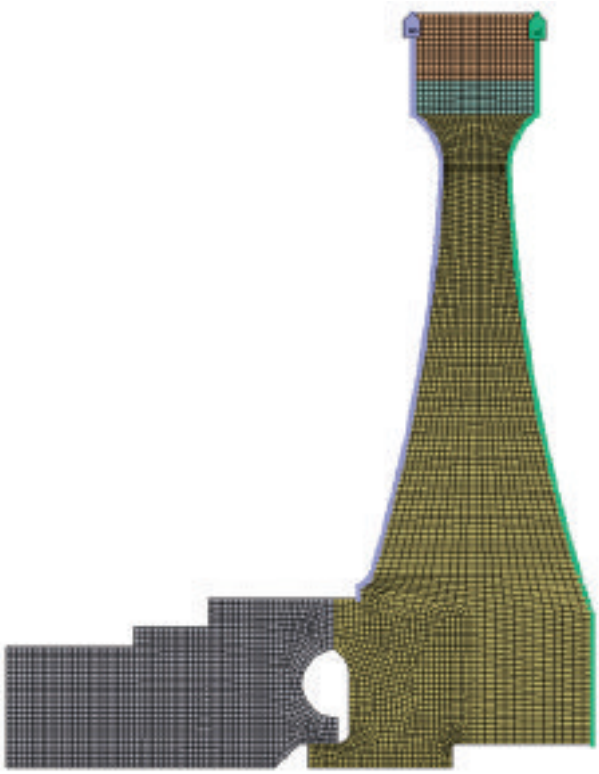
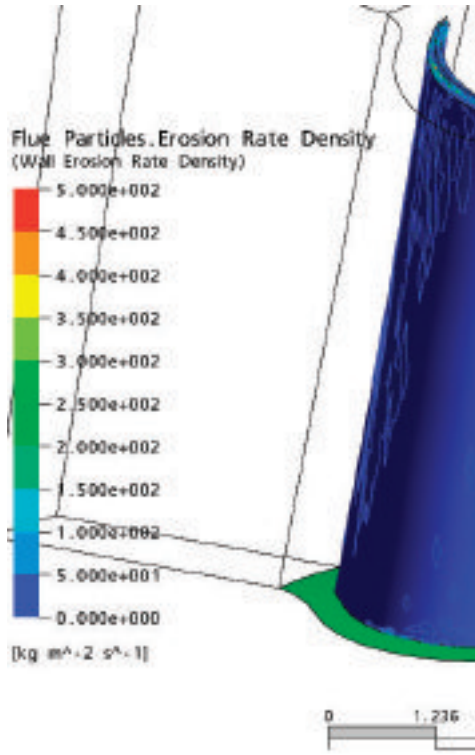




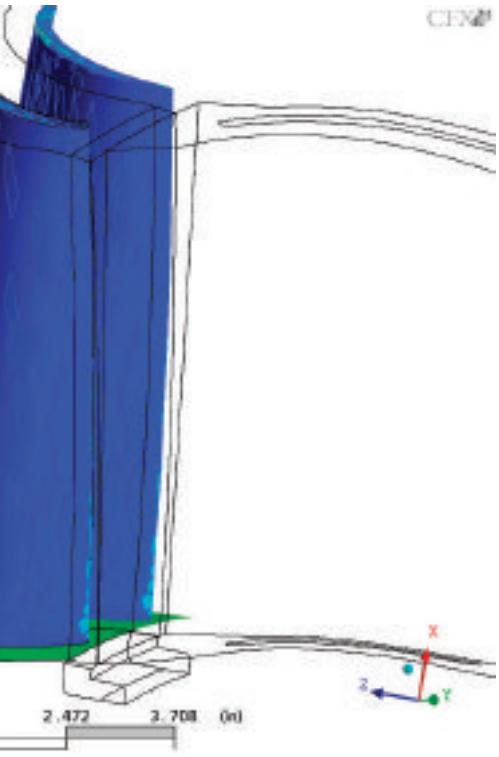
take great pride in our facility and our ability to handle our customer's property with the greatest efficiency and attention to detail."

Hallman said that RMS is affiliated with respected millwright service organizations throughout the country, and RMS supplies field supervision for each crew to ensure proper execution of every project.

"Our organization is made up of uniquely experienced engineers and technicians," said Robert J. Klova, PE, vice president, chief engineer and co-founder. "We leverage our experience with the latest engineering technology. Experience in all types of custom-engineered turbomachinery separates the optimum solution from the run-of-the mill. Strong design and analytical engineering form the backbone of everything we do. Engineering makes the difference, and we focus on continuous development of the next generation of turbomachinery engineers to serve customers' future needs."

RMS has analytical capabilities in structural analysis, aerodynamics, rotor dynamics and metallurgy using the latest analytical tools.

The RMS service facility consists



The capabilities of RMS' experienced engineering staff include expertise in all major types of custom-engineered turbomachinery and a full range of analytical expertise with the latest analytical tools in rotordynamics, structural analysis (e.g., turbine disk, left), aerodynamics (e.g., centrifugal stage flow path, center) and performance (e.g., steam turbine blade erosion, right).

of three 10,000 sq.ft. (929 m^2) bays that include a rotor assembly shop, machine shop with quality control room, and an assembly shop. The rotor shop, which is serviced by a 25 ton (22.5 tonnes) overhead crane, houses multiple indicating stands and stacking pits, two Schenck balancing machines with respective capacities of 40,000 and 17,000 lb. (18,140 and 7710 kg), an electrical runout (glitch) system, a variety of hydraulic coupling and tie-bolt stretching equipment, and a Bracker hydraulic rotor tenon peening system.

The machine shop houses multiple large machine tools including a 5 in. (127 mm) bar CNC horizontal boring mill, a 60 in. (1524 mm) swing CNC vertical boring mill, a Mazak 300M CNC turning-milling center, a 52 in. (1321 mm) swing by 236 in. (5994 mm) between centers engine lathe, and a 90 in. (2286 mm) swing vertical boring mill, as well as a variety of small manual lathes, knee mills and grinders. The temperature-controlled, quality control room houses a number of granite tables, coordinate measuring equipment with scanning capabilities, positive material identification equipment and two precision air bearing rotary table inspection stations. The machine shop is equipped with 25 and 15 ton (22.5 and 13.5 tonnes) overhead cranes.

The assembly shop has six large assembly cells, a weld shop, nondestructive test (NDT) area with magnetic particle and wet magnetic particle booths, an abrasive blast room and multiple abrasive blast cleaning cabinets. This shop is supported by a 35/15 ton (31.5/13.5 tonnes) crane with 27 ft. (8.2 m) hook height and multiple jib cranes. Also in this area, RMS' field service operations maintain a 20 ft. (6.1 m) fully equipped sea container/shop and gang boxes, ready for immediate dispatch to customer sites.

RMS' capabilities are evidenced by its list of successful turbomachinery projects. A recent major project was an ammonia/water turbine generator set, developed from a surplus steam turbine for a process customer in Pakistan. RMS provided the complete train of equipment, with new controls and auxiliaries, including the application of dry gas seals for ammonia containment. To support the project, RMS had to develop

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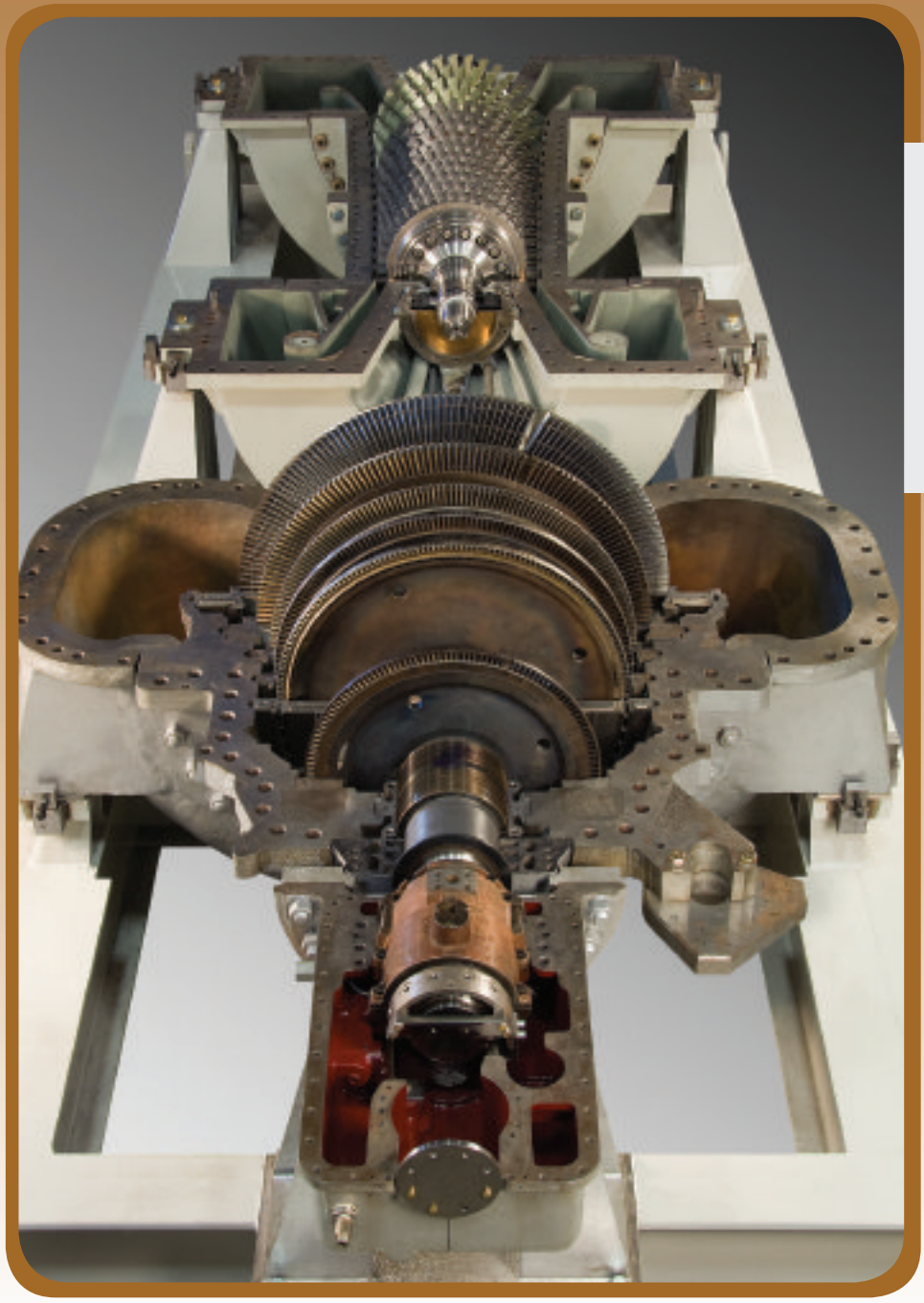
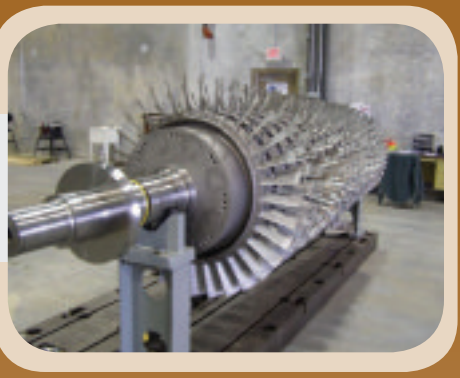
■ RMS provided this complete ammonia/water turbine gen-set for a process customer in Pakistan. Developed from a surplus steam turbine, it provided the complete train of equipment, including controls and auxiliaries and the application of dry gas seals for ammonia containment. To support the project, RMS had to develop performance analysis capability for ammonia and steam mixtures.



■ RMS provided this complete machinery train for a nitric acid plant in 2008. Starting with a surplus train, RMS completely designed the axial compressor and rerated the turbine, providing a new lube oil console as well. It also rerated the customer's existing expander during a turnaround.

performance analysis capability for ammonia and steam mixtures.

The company has special expertise in fluid catalytic cracker (FCC) and nitric acid expanders. Nitric acid is the basic material for the production of fertilizers, explosives and chemicals. In 2014, an I-R E520 nitric acid tail gas expander experienced a high-pressure seal failure. RMS engineering supervised the change-out of the damaged expander with a spare unit that had been sitting idle following a multiyear run. The spare expander had experienced high of 2 to 3 mils (51 to 76 µm) and unstable shaft vibrations during its prior run. Improved cold alignment, bearing changes, and careful setup resulted in low and stable vibration of less than 1.06 mils (27 µm), the lowest historical level for this expander.



An axial compressor rotor is ready for return to a customer after an engineered overhaul in RMS' shop.

In 2008, RMS provided a complete machinery train for a nitric acid plant. Starting with a surplus train, RMS completely designed the axial compressor and rerated the turbine, providing a new lube oil console as well. It also rerated the customer's existing expander during a turnaround.

In 2012, RMS was contracted to support the emergency breakdown of a European refinery's FCC power recovery train. A failed Elliott hot gas expander was at the heart of the breakdown. RMS was able to restore the main axial compressor to service on motor only within a 10-day period. The company then received another contract for a root cause analysis of the failure and for rebuilding the damaged expander using an existing spare rotor. During the inspection process, RMS determined that the entire intake casing assembly was no longer suitable for service. It was able to deliver a new intake casing assembly, including first- and second-stage stator housings in an expedited 16 weeks from date of order. RMS' field service team travelled to Europe to support the installation of the intake casing and expander assemblies, enabling an early startup.

Last year, RMS was offered a unique challenge to urgently replace a Cooper-Bessemer RC20 compressor rotor that suffered a heavy rub failure caused by impellers contacting the diaphragms. The impellers were reverse engineered through mechanical and FaroArm inspection methods in four weeks. RMS engineers analyzed the inspection information, and new CAD models were created. Utilizing forged material from in-house stock, RMS was able to complete five-axis machining of the impellers and a finished product, including overspeed testing, in less than eight weeks. The engineering and manufacture of a new shaft, balance piston and shaft sleeves were completed in 12 weeks, so that the entire replacement rotor assembly was assembled, balanced and shipped in 13 weeks, one week ahead of the agreed-upon 14 weeks. RMS also performed a rotordynamics analysis and developed performance curves for the design.

In addition to service and repair,

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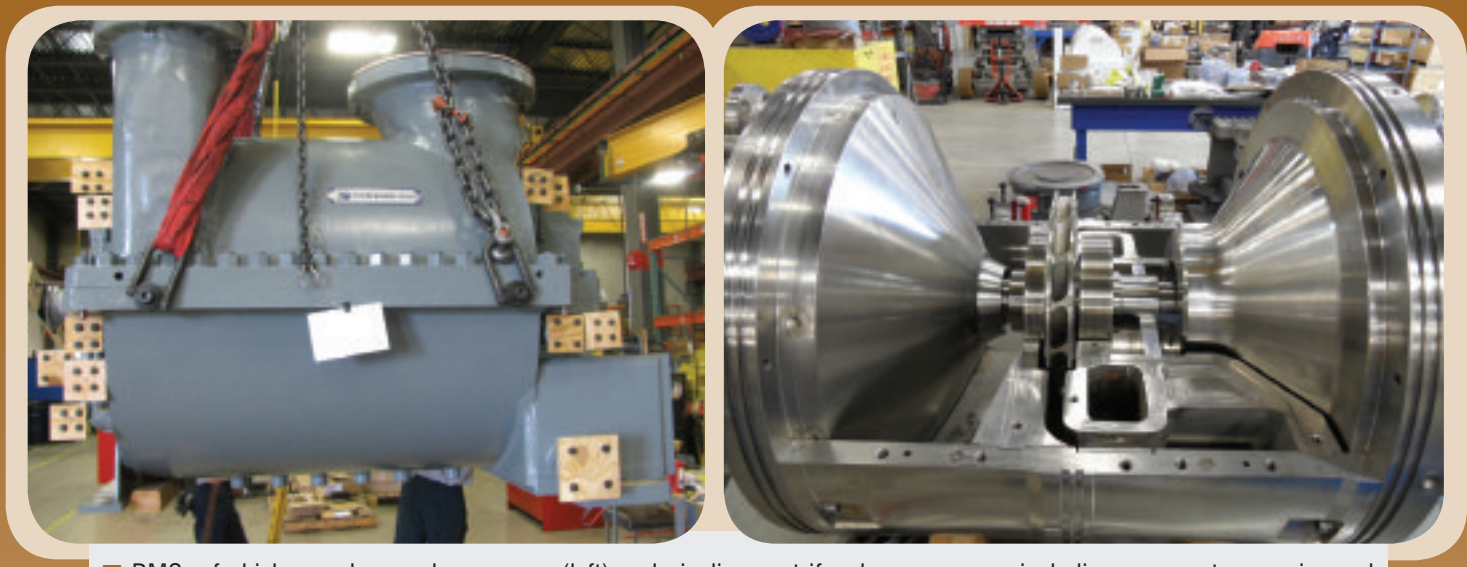
RMS provides engineering and support to users with older power turbines, such as Cooper RT65, I-R GT51 and GT61, Dresser-Rand DR61 and Dresser-Clark DJ125. Projects have included remaining life predictions for rotors and stationary components, casing redesigns, replacement of major stationary and rotating parts including outer casings and rotor disks, field service, and rotor and complete power turbine overhauls.



■ RMS refurbishes and upgrades process (left) and pipeline centrifugal compressors including new custom-engineered aerodynamic assemblies (right).

solving turbomachinery problems with engineering analyses and improved designs has always been an RMS focus. For example, a 1968 vintage GHH horizontally split centrifugal compressor in a toxic gas service had experienced chronic joint leakage over many years. The end user tried various fixes including purchasing a spare compressor with a thicker casing; yet the sealing problem could not be consistently eliminated. Finally, the end user was faced with the need to replace the machines entirely. However new compressors would not match the existing layout and pipe locations, and lead time was over 30 months. RMS custom designed and manufactured two new 300 series stainless-steel "drop-in" replacement compressors with upgraded barrel type casings to solve the split line leakage problem. The complete units utilized new RMS casings and diaphragms with the customer's existing rotors, bearings and inner seals. Dry gas seals and a new common oil system were also included as part of the upgrade. The new compressors were installed in the spring of 2014, completely eliminating the chronic leakage problems.

FCC expanders can experience significant erosive wear due to catalyst particles entrained in the flue gas. Using computer fluid dynamics (CFD)-aided state-of-the-art aerodynamic design, RMS developed a number of unique features that have significantly improved blade and disk lives. These include low-erosion rotor and stator airfoils, blade platform seals, and a unique overlapping platform design upgrade that shields the rotor disk from the harmful effects of catalyst laden flue gas. The low erosion design doubled the life of the rotor disk and blades to six years at one customer site. "RMS' significant experience in all aspects of FCC expander design, service and support has earned it a strong and growing place in the FCC expander aftermarket, where numerous refineries rely on us to support their FCC power recovery trains," Klova said. CT2