ROTATING MACHINERY SERVICES, INC.

VOLUME 8, ISSUE 1

January —March 2012

THE FINISH LINE

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2012 RMS EXPANSION ANNOUNCEMENT

By RMS Principals

Rotating Machinery Services is proud to announce that we will be expanding our facility. We are currently in the architectural drawing and approval phase and expect to be under construction in late Spring of 2012. Plans include an additional 9000 square foot high bay shop that will become our main assembly and disassembly area. The shop will be serviced by a double hook 30 ton gantry crane.

Also planned is a 5500 square foot office expansion that will allow for 30 more offices, another conference room and utility space.

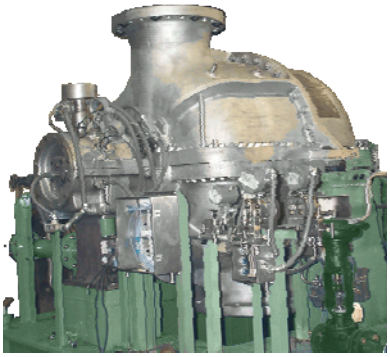
We are excited that the new space will allow us to add staff to meet the growing needs of our customers. Updates of our expansion progress will be announced in our upcoming newsletters.

Expansion is not only happening to our facility in Bethlehem, PA, but we have expanded our Sales team with an office in Baton Rouge, Louisiana. The Baton Rouge office telephone number is 225-291-4972. Our #1 priority is serving our customers!

I-R NITRIC ACID EXPANDERS—REBUILT TO RUN!

By Robert Klova, P.E.

As many end users will attest, Ingersoll-Rand E-5XX nitric acid (tail gas) expanders are notoriously finicky pieces of turbomachinery. There are a number of reasons for this; one is the basic configuration of the machine. Having a beam-style rotor suspended between two bearing housings that are supposed to remain aligned to each other through a hot casing is a tall order. There are other factors as well. Chief among them is a rotor design that relies on Curvic Couplings to locate and transmit torque between disks. The Curvic design originally selected does not allow for relative growth between disks, yet the rotor uses high expansion alloy disks for the first two stages and a low expansion alloy for the cooler last three disks – a basic incompatibility that highly stresses the Curvics.



Finally, because of the high inlet pressure, a long, very tight clearance HP seal is used. While it is a honeycomb design, its locational control in the casing is inadequate, so frequent rubs combined with the large surface area can induce significant rotor vibration. ***Con't Page 3***

DETAILS IN NEXT ISSUE

POWER RECOVERY TRAIN ROUND TABLE CONFERENCE AT RMS— LATE OCTOBER / EARLY NOVEMBER 2012

What's Inside

UPCOMING CONFERENCES

April 23—25
SYNGAS CONFERENCE
TULSA, OK
Stop by our Booth!!

May 7—8
GG4/FT4 INDUSTRIAL SYMPOSIUM
BETHLEHEM, PA
See back cover for details

May 8—10
EASTERN GAS COMPRESSION ROUNDTABLE
MONROEVILLE, PA
Stop by our Booth!!

TURBOMACHINERY RULES OF THUMB

By Neal Wikert

Flange Slotting — The purpose of keyhole slotting the O.D. of a flange in high temperature machinery is to eliminate the ability of the outer portion of the flange to carry hoop stress. Doing this reduces thermal stresses by allowing the cooler outer portion of the flange to expand less than the hotter bore region. The end result is less long-term distortion. Slotting every third bolthole is a good rule of thumb and slotting more often provides safety margin.

Cap Screw removal: Heat the head of the Hex cap screw until cherry red. Allow cap screw to cool momentarily so that heat can soak down the threads. Turn to remove. Cap screw will loosen. On Allen head bolts, heat down in the Allen head and break loose.

Hex nut removal: To remove hex nuts, heat one of the hex flats until red and break nut loose. This heat effectively loosens the nut and gives room for corrodents to move.

Coupling Bluing Minimum Contact

Hub to Shaft	75%
Gauge to Gauge	
Lapping to Lapping	95%
Gauge to Lapping	
Gauge to hub or shaft	85%

Residual Magnetism - 2 gauss max allowable

Inlet nozzle velocity Steam Turbine = 150 ft/sec maximum

Discharge nozzle velocity non-condensing Steam Turbine = 250 ft. /sec. maximum

Discharge nozzle velocity condensing Steam Turbine = 450 ft. /sec. maximum

PROJECT—SPRING OF 2012

By Glenn Gaddis

Spring is here and the flowers are blooming. With the warm weather this spring, golfers and fishermen are getting ready for a new season and so is RMS.

RMS has gone from the close of 2011 to 2012 without missing a heartbeat. I reported in December that we finished 2011 with the completion of over 110 contracts. Good? Yes!!

So far in 2012, we've already surpassed last year's quarter-to-date quota and the quarter isn't over yet. It looks like we are on our way to another promising year. We have over a dozen different rotors in our shop with various degrees of scope. In addition to Rotor work, we have Axial, Gas Turbine, Expander, Steam Turbine, and Compressor projects going through. Pretty much the full menu of possibilities has come to us here at RMS.

Some orders are coming from completely new customers and others are coming from customers from the past which have joined our Team. This is very exciting news.

So, I challenge all of you potential customers out there that read these Newsletters and are waiting for the opportunity…now is the time. We would like to hear from you and we look forward to having you join our Team.

Con't from Pg 1

I-R NITRIC ACID EXPANDERS—REBUILT TO RUN!

By Robert Klova, P.E.

So what can be done? Short of a complete redesign (any takers?), it is a situation that must be managed through proven modifications, and extremely careful build techniques. Rotating Machinery Services is staffed with engineers, designers, and shop personnel that have been making these machines run for nearly 30 years. Over the years, we have developed upgrades and build techniques that minimize the potential for vibration and other operating problems. These modifications can be summarized as follows:

Stabilize the Rotor: We use special balancing procedures, rotor construction techniques, and extremely tight acceptance criteria on Curvic tooth condition and rotor runouts to maximize the chances of the rotor remaining straight and balanced at speed and temperature. We also offer material and geometry upgrades to reduce rotor internal stresses and increase positional control.

Stabilize the HP Seal: We modify the HP seal to assure that the honeycomb remains concentric to the mounting fit area. We also modify the mounting fit geometry for better locational stability.

Special Journal Bearing Design: Based upon extensive rotor dynamics analysis, we offer a unique journal bearing design to maximize rotor stability and tolerate misalignment between bearings.

Keep the Inlet Scroll Concentric: Using a series of modifications to maintain the inlet scroll concentric to the rotor, we minimize the chances of the inlet scroll placing loads on the HP Seal, which can push it into the rotor.

Proven Cold Alignment Recommendations: E-5XX expanders can be sensitive to misalignment. We recommend cold alignment settings based upon field measurements and proven by experience that minimize hot misalignment when these units are at operating temperatures.

RMS has more in-house engineering experience with these expanders than any other supplier in the world. This experience will help your expander run smoother, but we will also apply it to optimize your expander's power output and solve other reliability issues such as joint and flange leaks, blade tip rubs, and bearing housing oil leaks. We would be happy to discuss any issues that you may have, and recommend a proven solution. A site survey by one of our engineers is always a good first step.

RMS POWER SOLUTIONS

By Charles (Chot) Smith

This past quarter, RMS Power Solutions has continued to add improvements to facilitate our growth as a world class rotating machinery service center. Every day, we strive to improve our facility to better support our growing customer base and the reward is obvious. Looking out through our shop at the amount of equipment currently being serviced, it is clear that we will welcome the completion of our expanded facility later this year. Our rotor shop is currently maintaining a steady pace close to capacity with completed projects shipped and new projects received daily.

Our equipment additions included a new Ford flatbed/stake-body truck, a vacuum packaging system for safer and more efficient shipment of hardware and a 50 HP variable frequency IR Screw compressor with air dryer and receiver to meet our growing compressed air needs. We are also very close to the addition of a Horizontal boring mill with a 5 inch bar rotary table.

As always at RMS Power Solutions, we continue to improve our capabilities and capacity to better serve our customers.

STEAM TURBINE ROTOR OVERSPEED TRIP

By Timothy Coull

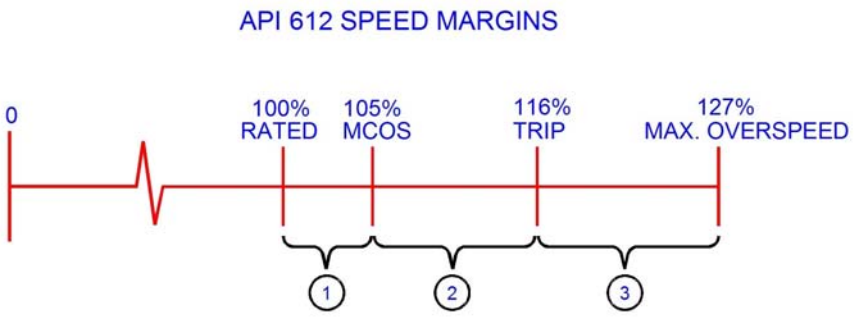
When rerating a steam turbine, determining the trip speed is of great importance to ensure the safety and reliability of the machine. Given the nature of steam turbine design, a number of factors come into play when establishing this critical parameter.

API 612 requires that a steam turbine rotor not exceed 127% of rated speed at an instantaneous loss of coupled load. The figure 127% compiles three different speed margins: 1) 105% from rated to maximum continuous operating speed (MCOS), ensuring that slight variations in operating conditions will not prove detrimental to the long-term operation of the machine; 2) 110% from MCOS to trip speed, allowing for excursions beyond continuous operating conditions without having to cease operation altogether; and 3) 110% from trip to maximum overspeed, accounting for the continued acceleration of the rotor between receiving the trip signal, fully closing the trip valve, and passing the last of the steam through the machine. Practically speaking, every machine has its own unique parameters and conditions, and it can be difficult to fit neatly into API speed margin guidelines. It is sometimes necessary to take exception to API and tweak the speed margins to accommodate individual cases.

Control characteristics and operating condition stability mainly determine a machine's allowable speed margins. However, when setting the trip speed, the two most important parameters to keep in mind are: 1) the maximum overspeed must be defined such that the rotor is temporarily capable of safe operation; and 2) the trip point is set such that the rotor will not exceed that maximum overspeed after instantaneous coupling failure. Ideally, the trip speed should be set such that the machine does not experience nuisance trips, and that the rotor would also be capable of reaching the maximum overspeed without any immediate need for maintenance or repair.

The two parameters that have the greatest affect on the overspeed margin are the rotor inertia and system response time. A low-inertia rotor will reach higher speeds more quickly, and a longer system response allows more time to accelerate to higher speeds. For large rotors, the system response time may not be of great concern and, if other design parameters need to be accommodated, the trip speed could be set a bit closer to the maximum overspeed than what API guidelines recommend. On the other hand, the trip speed on small rotors may need to be set lower and/or the trip system response time may need to be reduced to avoid reaching dangerously high speeds beyond the maximum overspeed.

Of course, there are instances where steam turbines operate with stable conditions, at mechanically-sound speeds, have large rotor inertias, and with quick trip system response time where the trip speed can easily follow API guidelines. However, on a case-by-case basis, this critical parameter often requires more detailed consideration and finesse to achieve the desired outcome of safe, yet effective operation.



REVERSE ENGINEERING IS A TEAM EFFORT

By Richard Pittenger

Reverse Engineering is a fundamental part of our business here at RMS. Components can be as simple as a sleeve consisting of ID, OD and length to more daunting parts with features such as rotor blade root forms and airfoils. Regardless of the simplicity or the complexity of the component, RMS strives to accurately capture the form, fit and function to ensure our customers receive a part that matches the dimensions of the original part.

The responsibility of successfully reverse engineering these components falls squarely on the shoulders of the five individuals that comprise RMS' Drafting Department. Together these five team members have 139 years experience in the rotating machinery business. That averages to 33 years per individual, with no team member having less than 22 years of experience. It is this knowledge and experience, coupled with the literally hundreds of hand held inspection tools, our latest addition of a FARO arm or PCMM (portable coordinate measuring machine) and a system of checks and double checks that make up the recipe for our reverse engineering success.

Con't REVERSE ENGINEERING IS A TEAM EFFORT

By Richard Pittenger

A typical reverse engineering task has several steps. When a component enters our shop, it is first cleaned and prepped for inspection by the RMS Power Solutions shop personnel. Next, Drafting creates the appropriate inspection drawings to capture the dimensions and features of the part. A Drafting team member will then inspect the part using a variety of hand held inspection tools such as micrometers and calipers, which are calibrated annually. The FARO arm, another tool in our inspection arsenal, is often utilized to capture more difficult geometry, such as blades and vanes, which are turned into three dimensional geometry using our Pro-Engineer solid modeling software. After the initial inspection, the information gathered is used to create a full-scale layout of the part. As the layout is being created, shop inspection personnel perform a second dimensional inspection. The results of the second inspection are compared to the initial inspection and any discprencies are reviewed and corrected. A manufacturing drawing is created from the layout. A second Drafting team member and Engineering then review that manufacturing drawing before final release to Purchasing.

Modern inspection capabilities, multiple part inspections/drawing checks and years of experience and knowledge are RMS' ingredients for reverse engineering success to ensure that we deliver an accurate and superior product.

CONSIDERING AN AT SPEED BALANCE

By Tony Rubino, PE

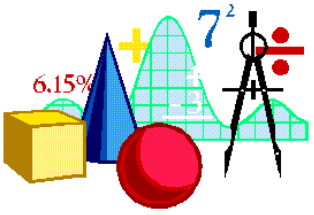
Any rotating body, such as a rotor, has inherent residual unbalance that acts as a forcing function upon that body's support system. The support system includes the structural stiffness of the rotor itself, bearings, housings, casings, pedestals, baseplate, and foundation. When the frequency of the forcing function is sufficiently close to one of the natural frequencies (or even possibly an integral multiple) of the support system, resonance can occur. There are occasions when the geometric constraints of a design prevent obtaining adequate frequency separation between the forcing function and the system's natural frequency by changing stiffness or mass distribution. These occasions are addressed by maximizing damping in the bearings and minimizing the forcing function potential through an at speed balance.

RMS recently completed a rotor overhaul where the as found unbalance was beyond the API allowable of 4W/N. The rotor did not satisfy the rule of thumb for considering an at speed balance: rotor normal operating speed was less than 8,000 rpm and the ratio of length between journal centerlines to rotor body diameter was less than 8. Rotors operating at greater than 8,000 rpm and an L/D of 10 usually receive further scrutiny regarding whether an at speed balance should be considered.

The rotor in question experienced elevated vibration (between 0.002" and 0.003") during operation even though the low speed balance residual was less than 4W/N. After an at speed balance, vibration was below 0.001". Review of the startup vibration trend indicated the rotor system had a second critical speed very close to operating speed. In the final analysis, the determination of whether to at speed balance a rotor should include a review of the machine's rotor dynamics analysis. If an analysis is not available, the vibration trend from a start up should be reviewed to verify whether the rotor is operating near a critical.

QUALITY CONTROL

By Robert Dehart

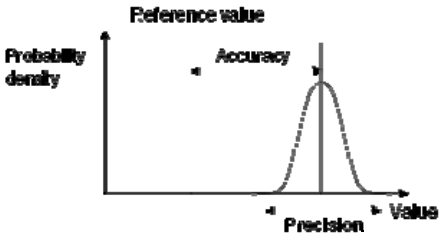


Spring 2012 arrives at RMS. The seeds are being ordered and the planting beds prepared. The checklists are being reviewed, the machinery oiled and sharpened and areas of concern defined and prioritized.

Once priorities are determined, the measurements can begin. The accuracy of data produced is dependent on the adequacy of the measurement process. To sustain progress, measuring instruments are calibrated to assure that they continue to meet accuracy and precision specifications. Calibration is a statistical evaluation of the accuracy and precision of a measuring instrument. The narrower the distribution of a set of measurements and the nearer the mean to the true value, the less the uncertainty we need have about measurements made with that instrument.

Con't QUALITY CONTROL

By Robert Dehart



Parallel to the measurement process, metrics are developed to analyze the results. As the buds begin to open and the design is revealed, the cross pollination begins.

Everyone is anticipating the greening and eager to cultivate and nurture. Experienced gardeners know the importance of nutrients. They know which ones improve growth and which ones do not. It can be a delicate balance due to varying reactions to fluctuating circumstances, but steady hands and an eagerness to innovate and excel make for an invigorating atmosphere.

Spring is alive as we transform how we measure, understand and control our environment, working with energy that clarifies and illuminates the path ahead.

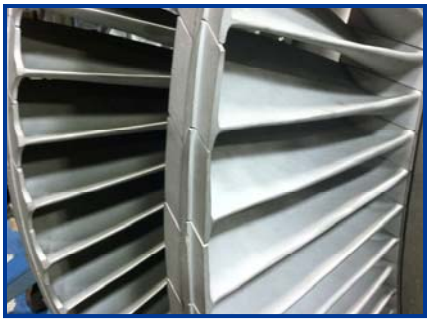
A POWER TURBINE BLADE REPAIR CHALLENGE

By Corey Jones

Often times in after-market turbomachinery services, projects will come along that require full measure of your capabilities and experience. Here at RMS, we view these challenging tasks not as obstacles, but as opportunities to demonstrate and further our expertise. Recently, during the overhaul of a large Worthington ER-224 expander, RMS was able to exhibit its capabilities in repairing extensively damaged blades.

Before

Worthington ER-224 expander units were designed in the late 1960's to serve the power industry as aero derivative peaking gas turbines. Driven by two Pratt & Whitney GG4 gas generators, these units are not necessarily known for their efficiency. Instead, they are capable of quick start and boast a design robust enough to handle large amounts of wear and tear. Due to their robust design, these expanders frequently see continued operation even with significant damage. When repair is finally required, internal damage is often substantial.



After

RMS was contracted to repair and combine two Worthington expanders in poor condition into a single operable unit. As can be seen in the photo, the two Worthington units provided to RMS exhibited significant rotor blade foreign object damage (FOD). While initial visual inspection might deem these as blades scrap, RMS was able to recommend a repair procedure through which damaged blades from the two rotors could be combined into one functional rotor. The repair was complicated by the unusual blade material (Stellite 31) and extensive damage, yet RMS was able to confidently define a repair procedure. The repair scope included detailed instructions for blending and weld repair of the blades, accompanied by appropriate pre- and post-weld heat treatments (including hot isostatic pressing, HIP) along with metallurgical and non-destructive testing.

RMS was able to verify the validity of the repair procedure through extensive analysis and testing. In particular, detailed finite element (FEA) structural and vibration analyses were executed to determine and confirm the allowable depths of blending along the airfoil leading and trailing edges. Additionally, in-depth testing was performed to confirm the effectiveness of the weld repair, which included evaluating both the strength and quality of welded specimens. Due to our years of repair experience and these thorough evaluation steps, RMS can confidently stand behind the repaired rotor blades it provides.

CONGRATULATIONS TO EVA DIAZ ON HER PROMOTION!

We are pleased to announce the promotion of Eva Diaz to Staff Accountant. Eva has been with Rotating Machinery Services for 1 year and previously held the position of Office Receptionist.

In her new position, Eva will be working with the Controller of RMS in the Accounting Department. She is looking forward to taking on the accounting field full force as she is also working toward her Dual major in Accounting and Finance at DeSales University. Please join us in congratulating her on the promotion.

RMS WELCOMES!

By Kathy Ehasz

Donald Shafer
Expander Senior Product Engineer

Thirty four years of engineering and design team leader experience with thirty one years devoted to Turbo Machinery used in the Refining and Petro-Chemical Industry. Experienced in all phases of the design cycle, from concept to testing and installation of the machinery.

Prior to joining RMS, Don held positions at Dresser-Rand, General Electric Oil & Gas, Conmec and Ingersoll Rand. As Lead Design Engineer for FCC Expanders at GE Oil & Gas, Conmec, responsibilities included execution of complete new Expander projects as well as re-rate / repair projects, Expander field installation, start-up and trouble shooting.

Marc Rubino
Design Engineer

Marc recently graduated from Lehigh University with a B.S. in Mechanical Engineering in January 2012. While attending Lehigh, he worked in RMS Power Solutions during summers and gained invaluable experience with all of RMS's current product lines including hot gas expanders, centrifugal compressors, and power turbines. He now looks forward to beginning his career at RMS within the turbomachinery field as a Design Engineer.

Joe Kovacs
Assembler Apprentice

Joe joins RMS as a Assembler Apprentice. Joe graduated Kutztown University in 2003 and held positions with UPS for 5 years in the Shipping / Receiving department and with PQ Energy Controls in the commercial heating and air-conditioning—control systems division.

Kelly Hill
Administrative Assistant

Kelly Hill has joined RMS, Inc. as our administrative assistant. She comes from Hoffman Manufacturing Inc., a sheet metal shop in Fogelsville, PA where she held the position as controller. She has 4 years experience in an industrial environment. She graduated from Northampton Community College in 2004 with an associate's in Business Administration and plans to continue her education and obtain a Bachelor's in Accounting.

Tracey Huffman
Project Management Assistant

Tracey has joined RMS as a support person in Project Management. She graduated with a BA from the University of Iowa. She is married to Bob Huffman and has 2 boys one at Kutztown University and the other will graduate from Parkland High School this year. She comes to us from Distinctive Accents where she worked as a Manager and Home Accessory Consultant.

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RMS

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AXIAL COMPRESSORS • CENTRIFUGAL COMPRESSORS • EXPANDERS • GAS TURBINES • POWER TURBINES • STEAM TURBINES

GG4 / FT4 INDUSTRIAL SYMPOSIUM—MAY 7TH & MAY 8TH

By Kathy Ehasz

Rotating Machinery Services, Inc. will be hosting the 2012 GG4/FT4 Industrial Symposium at the Sands Casino Resort on Monday, May 7th & Tuesday, May 8th. The symposium is free to all End Users and sponsored by the Industry's Suppliers. Special room rates for the Sands Hotel are available for Conference Attendees.

On Monday, May 7th, a private tour of the Bethlehem Steel Stack for 4 pm and a Welcome Reception at 6 pm in the St. James Lounge at the Sands Casino are scheduled. A raffle will be held for attendees at 7 pm and 8 pm. Prizes are two (2) of the newly released IPad's. You must be present to win.

On Tuesday, May 8th, the GG4/FT4 Symposium will kick off with breakfast at 7:30 am. The morning session will consist of Technical presentations followed by a sponsored lunch. The afternoon session will consist of a Round Table discussion for End Users. A RMS shop tour will be held later in the afternoon followed by a dinner at the GreenPond Country Club in Bethlehem, PA.

The Symposium is the only open forum for FT4 Users today. For more information about the conference, please contact Kathy Ehasz at 484-821-0702 or email at kehasz@rotatingmachinery.com.