ROTATING MACHINERY SERVICES, INC.

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THE FINISH LINE

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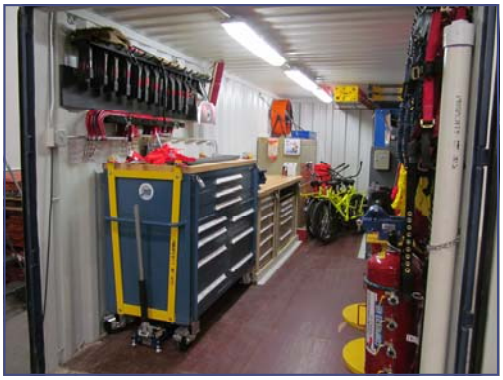
NEWEST ENHANCEMENT - FIELD SERVICES By Paul Poels

On August 25th, RMS Field Services was able to display and launch their newest enhancement that will improve work efficiencies as our national and international work continues to expand. The purchase of a twenty foot long Sea Container has allowed RMS to have a tool container that can be mobilized and shipped by truck or sea freight to any location. A great job was done by our Shop staff who spent many hours welding and fabricating tool racks and planning the best layout in the limited space.

This tool container was put together with turnarounds and large equipment in mind so that it carries enough tools to work multiple pieces of machinery that may be spread throughout a work site. With a permanently mounted complete tool chest and two equally equipped roller tool chests, the work and manpower can be distributed to minimize lost hours due to millwrights needing something from another box. Also included in the Sea-Can is the rigging equipment, air manifolds, hoses, hydraulic tooling, precision measuring tools and five bicycles.

RMS staff of Engineers, Project Managers and Field Services were provided a 4-hour presentation and hands on demonstration of the capabilities of the laser equipment.

The trailer made it's maiden voyage a few weeks ago overseas and is proving a valuable asset to Rotating Machinery Services, Inc.



What's Inside

RMS IMPORTANT NUMBERS

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484-821-0702 (O)
484-896-8569 (C)

RULES OF THUMB - TURBOMACHINERY

By Neal Wikert

Flange Slotting

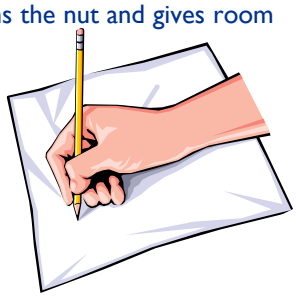
The purpose of keyhole slotting the O.D. of a flange in high temperature machinery is to eliminate the ability of the outer portion of the flange to carry hoop stress. Doing this reduces thermal stresses by allowing the cooler outer portion of the flange to expand less than the hotter bore region. The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

SHCS removal:

Heat the head of the 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.

Hex nut removal:

To remove hex nuts, heat one of the hex flats until red and break nut loose. On Allen head bolts, heat down in the Allen head and break loose. This heat effectively loosens the nut and gives room for corrodents to move.



NPT drill sizes

Size	Drill size
½" NPT	45/64
¾" NPT	29/32

Clearances, internal

A good rule to follow for **axial** clearance is 1/4" for hard to hard parts and 1/8" for hard to soft parts.

Diaphragm Clearances – Steam Turbines

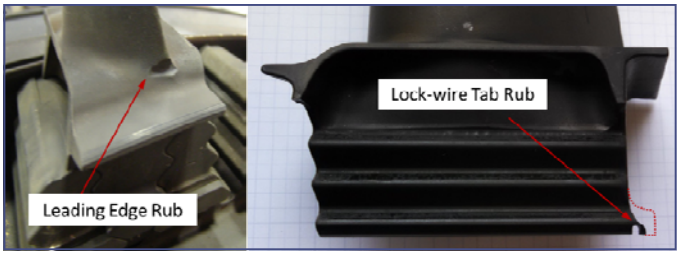
For back stages, a good rule of thumb is to make the axial spacing equal to 10% of the axial width of the vane. A good tolerance would be from 5 to 15%. At about 20% you would be able to detect an efficiency loss of 2 to 3 %.

NEW TOOLS USED FOR D-R 61 PT BLADE REPAIR ANALYSIS

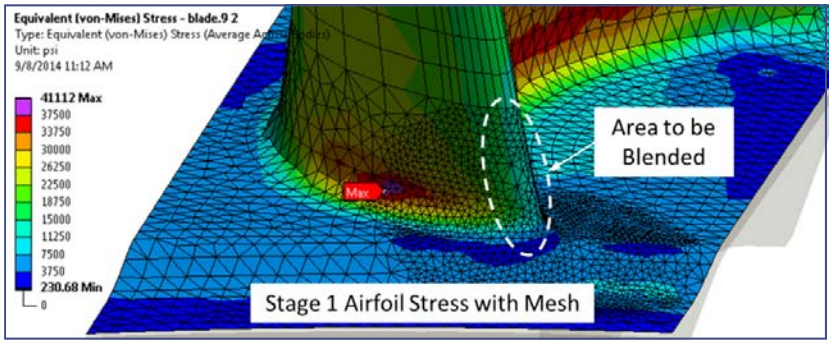
By Chris Sykora

In order to perform a stress and/or vibration analysis via the finite element technique, one has to discretize the geometry into many calculation points called a "mesh". RMS is now leveraging new capabilities in the ANSYS® Workbench package to create that "mesh" directly from the solid model of turbomachinery part geometry. This can enable "meshing" almost any geometry. These techniques add another tool to our analysis toolbox in addition to the "classic" methods you have previously seen at RMS. Both techniques are entirely valid and can provide accurate results. The new "meshing" techniques just provide more options. A recent example of their use was demonstrated on a job for a North American peaking power plant customer.

The power plant operates a D-R 61 two stage power turbine. During rotor overhaul, rub damage was discovered on both stages of rotor blades. Stage 1 had rubbed the leading edge of the airfoil near the base. Stage 2 had rubbed the lock-wire tab area such that the tab was extremely thin. RMS performed finite element structural analysis to predict the stress impact of two proposed repairs. These included blending the damaged area on the 1st stage blade where it traditionally would not be allowed and machining a slot in the bottom of the 2nd stage blade for mechanical retention of a lock-wire tab replacement instead of scrapping the entire set of blades. In both cases, "meshing" the repaired geometry would have been more difficult with the "classic" methods.



NEW TOOLS USED FOR D-R 61 PT BLADE REPAIR ANALYSIS (Con't)



On the 1st stage blade, the analysis was used to compare the stress levels of an original, undamaged blade vs. a blade blended smooth in the damaged area. Traditionally, blending the blade near the base of the airfoil is not allowed due to highest stresses found at the platform to airfoil fillet. However, structural analysis can provide more insight into the areas even in the fillet where stress might be low enough for some blending. In this case, we found that stress in the airfoil was minimally changed at the front leading edge since the highest stress was actually located further aft on the suction side of the blade. Therefore a blend repair of the 1st stage blades was recommended instead of expensive replacement.

On the 2nd stage blade, the analysis was used again to compare the stress levels of an original, un-slotted blade vs. a blade with a tangential slot machined in the bottom of the blade fir tree area to be used for retention of a separate lock-wire tab replacement piece. In this case, the analysis was used to iterate on multiple slot configurations to find one that had the lowest impact on blade stresses. We were able to use the same basic analytical model to evaluate 8 different slots by slightly changing the geometry and re-meshing. Ultimately a slot shape was found that only had a maximum increase in stress of 1.3%. Since this was a very minimal increase, that shape was recommended for replacing the lock-wire tabs instead of an expensive replacement of the entire blade.

WATER DROPLET REMOVAL TECHNIQUES

By Scott MacFarlane

When steam flows through a steam turbine it expands while its temperature and pressure decrease along the same flowpath. At a specific point through the flowpath, the steam can expand across the saturation line and water can form. As stated in previous editions, the steam flow through the last few stages of a steam turbine can be wet, meaning it contains a mixture of steam and water. This wet condition can cause severe erosion to the rotors blades.

For steam turbines that are subjected to these wet conditions in the flowpath, it may be desirable to remove as much of this water as possible. Mainly this is required to decrease the rate of erosion damage to the inner turbine components and furthermore to improve blading efficiency. There are two common water extraction methods that can be utilized in the steam turbine. The first method is designed to remove the water droplets directly away from the steam path. The second method is designed to separate the water droplets from the steam altogether.

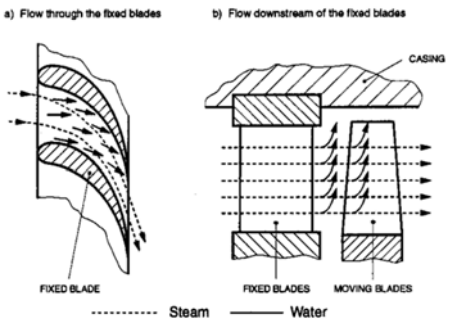


FIGURE 1

Overshooting the last few stage blades or incorporating water traps are the primary designs for water droplet removal from the steam path. With a specially designed overshooting nozzle, the water, which is centrifuged outwards because of its higher density, will travel through the gap between the blade tips or shrouds and the turbine casing. Figure 1 shows the steam and water trajectories in a steam turbine stage. Water traps are pockets usually placed in the casing after the rotating blades. When the water droplets are centrifuged outwards they collect in these pockets instead of re-entering the steam path. The water traps will drain off to the turbine condenser in most cases. These modifications to the turbine can cause significant penalty to the turbines last stages performance however. Increasing gap clearances and disrupting the continuity of the casing walls will cause unsteady flow patterns.

To separate the water droplets from the steam, slotted hollow diaphragm vanes or solid drilled vanes are used to separate the

WATER DROPLET REMOVAL TECHNIQUES *(Con't)*

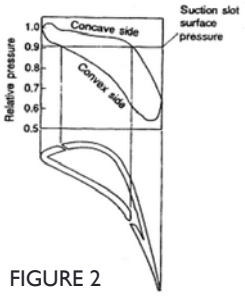


FIGURE 2

water film from the nozzle surface. The internal vane spaces are drained to the turbine condenser in most cases. The slots can be place on the suction side and pressure side of the vane but should be place where the steam pressure is equal to avoid a water pumping scenario. An example of a slotted hollow vane can be seen in Figure 2.

Based on the size range and the trajectories of water droplets as well as the operating conditions of the steam turbine, the above moisture removal methods can vary to suit your needs. If moisture is an issue, there are several other modifications, such as Stellite Shields, that can slow the rate of erosion on the last stages of blades that were discussed in a previous edition.

2014 AXIAL PROJECTS

By Dirk Paraschos

Axial Rotor and Axial stationary component repairs and replacements made up a significant portion of our business this year. In just the first eight months of 2014, we have repaired the following three axial rotors: One 14/15 stage 4000 frame, one - 17 stage 4000 frame and one 13 stage 5000 frame. In the RMS queue is a partial destack/restack of a 13 stage 3000 frame and a complete destack/restack of a 15 stage 4000 frame.

Our typical axial repairs consisted of: weld repair of the shaft, reworking of dents or dings in the discs, re-burnishing probe tracks, lance peening and coating of the rotor. Rotor blades were blended, polished, non-destructive tested and coated while some blades had to be machined completely new and coated. We then rebladed the rotors, performed final balance, dimension and runout checks, after which the rotors were prepped for shipment.

Along with the repair of all these rotors, was the repair/replacement of the axial stationary components. These components fell into two categories: either replace with newly machined components or repair the items that were deemed salvageable during the inspection phase. In some cases, we machined new: variable stationary vanes, stator cartridges (including bushings), spring links (including monoballs), fixed stator seals strips; inner shroud ring seal strips, and associated hardware. If parts were deemed salvageable, we reworked them by replacing buttons and drive posts on variable stator vanes, replacing bushings in stator cartridges, weld repairing or blending the fixed stators and inner shroud rings. All of the new and repaired items had to pass non-destructive testing.

During this same time period, we were also tasked with providing the stationary components in support of two axial rotor turnarounds. In just 8 short weeks we provided one new set of IGV's, one set of reworked IGV's, two sets of reworked variable stator vanes, designed and machined new inner shroud ring segments, new stator cartridges, new spring links and all new hardware. It was quite a feat to accomplish in such a short time.

It's been a very busy year and we look forward to filling our queue with even more axial compressor projects as we continue to bring new and returning clients into the RMS fold.

RMS BLADERUNNERS LEHIGH VALLEY HEALTH NETWORK VIA RELAY

For the fourth consecutive year, RMS participated in the Lehigh Valley Health Network Via relay race on September 7th. The race, which benefits children and adults with disabilities like Autism, Cerebral Palsy and Down Syndrome in a certified marathon course from Allentown to East PA along the scenic Lehigh Canal and River.

The RMS Blade Runners consisted of Sydney Gross, Eric Dunlap, Bob Klova, Joan Berg and Neal Wikert. They ran in the Men's Corporate Cup division and finished at 3:38:25, 48th overall and 7th in their division. Last year. they finished in 3:42:48, 67th overall and 13th in their division.

After Sydney passed off to Eric Dunlap, Sydney proceeded on to run the whole marathon 26.2 miles in 3:50:34 beating his last years time of 4:08:36. Congratulations to Sydney for having his fastest marathon this decade!

"You have not lived today until you have done something for someone who can never repay you." - John Bunyan

NEW EMPLOYEES - WELCOME

By Kathy Ehasz

DORA MONTALVO
Senior Staff Account

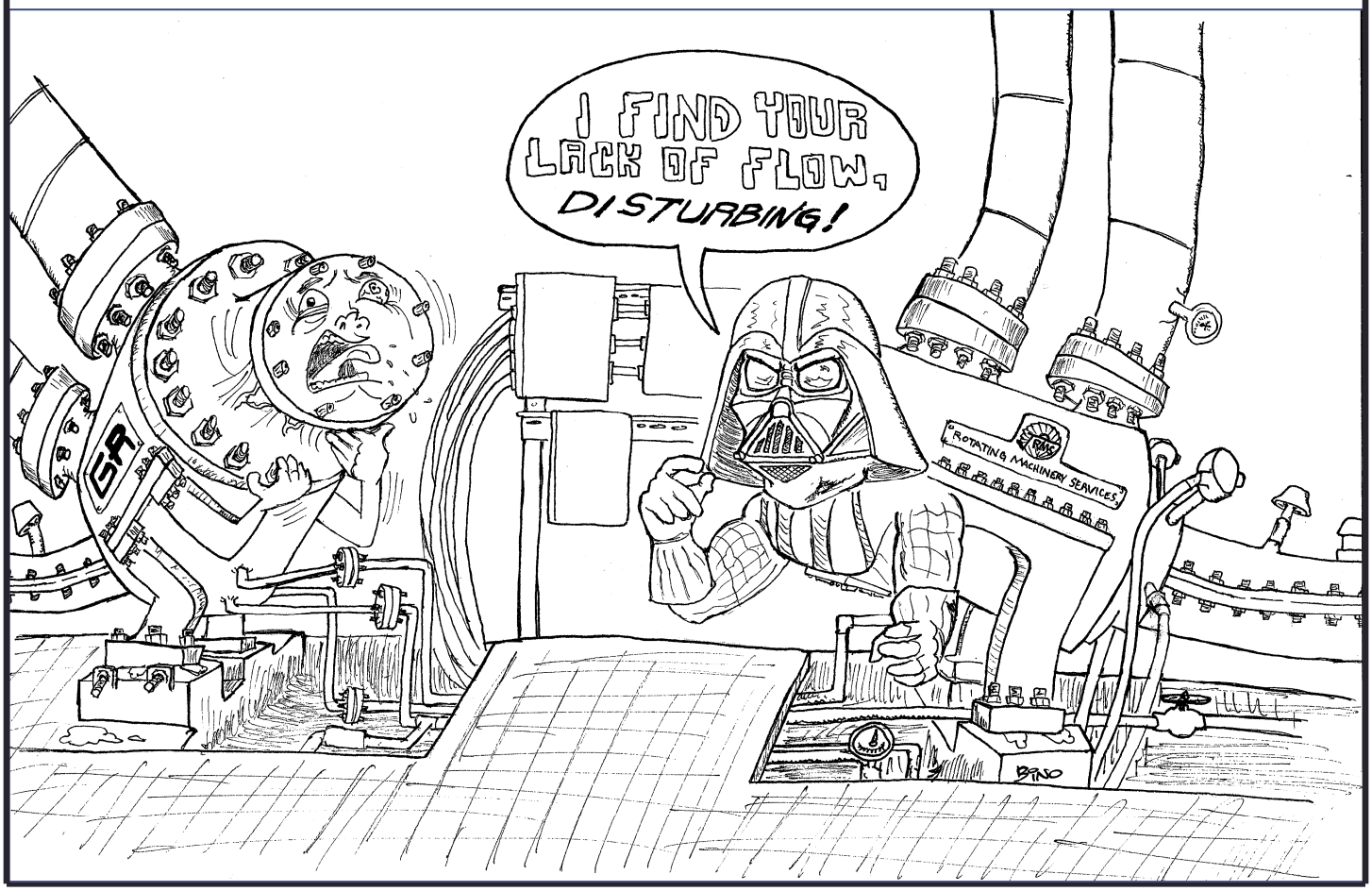
After a 16 plus year career in public accounting, Dora has made a career change to the private industry. She has a B.S. from DeSales University in Accounting. She joins the RMS team as a senior staff accountant. Dora's passion is accounting. She brings with her expertise with QuickBooks and a love for learning new things. Dora is excited to learn more about the Turbomachinery industry and to grow with RMS.

GABRIELLE KOLTISKO
Administrative Assistant

Gabrielle has recently joined the RMS team as their Administrative Assistant. She graduated from Kutztown University in May of 2014 with a Bachelor's degree in Pre-Med/Biology, as well as Lehigh Carbon Community College in 2012 with two Associate degrees in Life Science and Chemical Technician. She brings with over five years' experience in the customer service field. Gabrielle looks forward to becoming a part of such a successful growing company while continuing her educational goals.

TURBO TOONS

By Marc Rubino



SAFETY PRACTICES

By Tom Edwards

Workplace safety cannot exist on best practice guidelines and policies alone. A safe working environment is based on how well the people, in management, in the office and on the shop floor, adhere to -- and communicate about -- safety standards.

The foundation of any successful workplace safety effort is one that encourages employees to identify unsafe behaviors and opportunities for improvement while also making well-informed safety decisions during daily routine tasks.

The following are the *Top 10 Workplace Safety Tips Every Employee Should Know* to help you inform your own workers and create a workplace safety environment based on shared responsibility:

1. Be Aware Of Your Surroundings
This step requires knowing the particular hazards of your job or workplace. Once you've learned these risks, you are able to keep clear of potential hazardous areas, and potential hazardous situations. Also, always be alert of machinery.

2. Keep Correct Posture to Protect Your Back
If you work at a desk, keep your shoulders in line with your hips to avoid back problems. If you're picking things up, use correct form so your back doesn't get hurt. Avoid stooping and twisting. If possible, always use **ergonomic designed furniture and safety equipment** so everything you need is within easy reach.

3. Take Regular Breaks
So many work-related injuries and illnesses occur because a worker is tired, burned out and not alert to their surroundings. Taking regular breaks helps you stay fresh on the job. One trick to staying alert is to schedule the most difficult tasks when your concentration is best, like first thing in the morning.

4. Use Tools and Machines Properly
Take the proper precautions when using tools, and never take shortcuts. Taking shortcuts is the leading cause of workplace injury. It's a huge safety risk to use scaffolding as a ladder or one tool in place of another for a specific job. Using tools the right way greatly reduces the chance of workplace injury.

5. Keep Emergency Exits Easily Accessible
In case of an emergency, you'll need quick, easy access to the exits. It's also recommended to keep clear access to equipment shutoffs in case you need to quickly stop them from functioning.

6. Report Unsafe Conditions to Your Supervisor
Your supervisor needs to be informed about any workplace safety hazards or risks. They are legally obligated to ensure their employees have a safe working environment and will take care of the unsafe conditions and make them safe for you and your coworkers.

7. Use Mechanical Aids Whenever Possible
Instead of attempting to carry or lift something that's really heavy in an attempt to save a sliver of time during your workday, take the extra minute to use a wheelbarrow, conveyor belt, crank or forklift. Too many injury risks are involved with trying to lift something that weighs too much.

8. Stay Sober
Around three percent of workplace fatalities occur due to alcohol and drugs. When a worker's ability to exercise judgment, coordination, motor control, concentration or alertness is compromised, this leads to any number of risks for workplace injury and fatalities.

9. Reduce Workplace Stress
Stress can lead to depression and concentration problems. Common causes of workplace stress include long hours, heavy workload, job insecurity and conflicts with coworkers or managers. Take your concerns about workplace stress to your supervisor to see how they might help you address them.

10. Wear the Correct Safety Equipment
If you're not wearing the correct safety equipment for a task, you may get injured. Depending on the job, equipment like earplugs, earmuffs, hard hats, safety goggles, gloves or a full-face mask greatly reduce the risk of workplace injury.

(source - Arbill Safety BLOG)

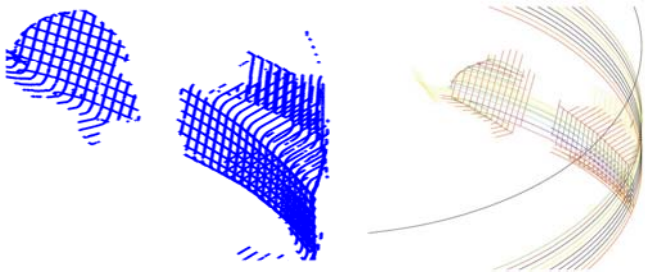
CENTRIFUGAL COMPRESSOR IMPELLER

By Dean Curtis

RMS is pleased to announce we are constructing our largest centrifugal compressor impeller to date. We secured a contract to replace a 50" diameter closed wheel impeller. As the original drawings were not available we are reverse engineering the impeller wheel from what little OEM data was available and the existing heavily eroded wheel shown in Figure 1.

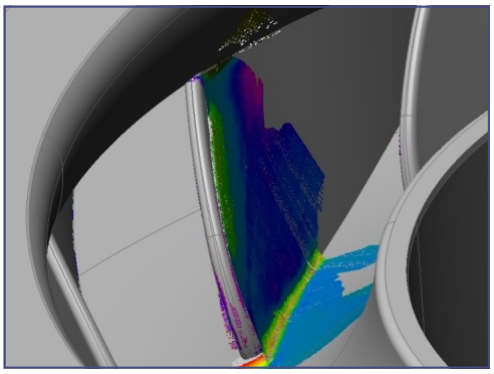
FIGURE 1

The job is complicated by having to reproduce the complex curves of the rather inaccessible blade geometry. Our process enables us to reverse engineer the wheel in parallel with manufacturing it which greatly reduces lead times. Our depth of experience makes the finished product work.



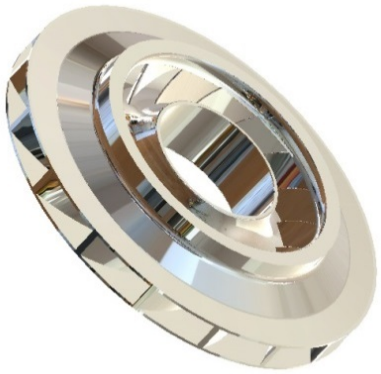
We inspected the wheel using several different methods which we then compared to each other to both validate our process and determine which features were most well preserved to base our new design upon. We took measurements using a combination of methods: Traditional precision measurement using standard shop equipment, our Faro arm for single point and laser scans, a Repro Rubber mold of an entire impeller blade, and an experimental foam mold of impeller blade geometry. The molds were also Faro arm scanned and validated. Our data was checked against itself, exported as a point cloud to SolidWorks, and used to create a solid model.

Upon creation of final models, those features were exported to AutoCAD and detailed for sourcing to our vendors. IGES files were created for structural analysis in house. Our experienced design team has a depth and breadth of abilities in many different design methodologies that enables us to leverage several different software packages, and cross check results, using the best of each to our and our customer's advantage. Simultaneously, our in house X-ray fluorescence materials analyzer enabled us to rapidly identify and source the right steel for the job.



Critical airfoil geometry such as exit angle, chord width, and inlet throat geometry were measured several different ways. Those measurements were used to create a solid model in SolidWorks. That geometry was aligned to our original scan data using our inspection modules in Polyworks. The graphical representation of those results shows an excellent correlation between the SolidWorks geometry we created for this preliminary model, and the scanned geometry of the wheel, with appropriate deviations where we added material to compensate for the erosive wear.

A particularly difficult challenge is flattening the compound blade geometry for our suppliers to replicate the blade geometry in flat plate, and then bend and twist it into shape. We developed AutoCAD drawings by "flattening" the blade geometry using differing mapping techniques adapted from cartography and sheet metal work. One of RMS's unique advantages is the diverse knowledge base of its leadership, employees, and suppliers. We can attack a problem from many different angles at once, working along parallel paths to shorten lead times, and proved a superior product in a shorter time frame. Our responsive, creative approach uniquely positions us as a 'go to' source for complex engineering challenges in the industry.



INLET AIR FILTRATION SYSTEMS

By Tony Rubino, P.E.

Inlet air filtration systems are critical to sustaining long term compressor performance and reliability. Unfortunately, these same systems, if not properly maintained, can eventually contribute to poor compressor performance and possibly even compressor failure. Filters that are not renewed on a methodical basis can reduce compressor efficiency in numerous ways:

- excessive pressure drop requiring increased pressure ratio by the compressor
- excessive pressure drop causing implosion door to open allowing entry of unfiltered air and possible foreign objects
- accumulated debris "washing" downstream during heavy rainstorms.

Filtration system components are susceptible to corrosion and fatigue mechanisms which can lead to breakage and possible ingestion into the compressor. Below are photographs from three different compressor installations. In these cases, filtration system components were not satisfactorily inspected during turnarounds and led to foreign object entry into the compressor. Fortunately for two of the three end users, only one resulted in airfoil failure.

Specification of corrosion resistant materials is highly recommended during the procurement of a filtration system. Even more critical, the thorough inspection of inlet system components (especially filter frames, retention hardware, debris screens, implosion doors, etc.) should be planned and executed with the same rigor as the turnaround of the turbomachinery.

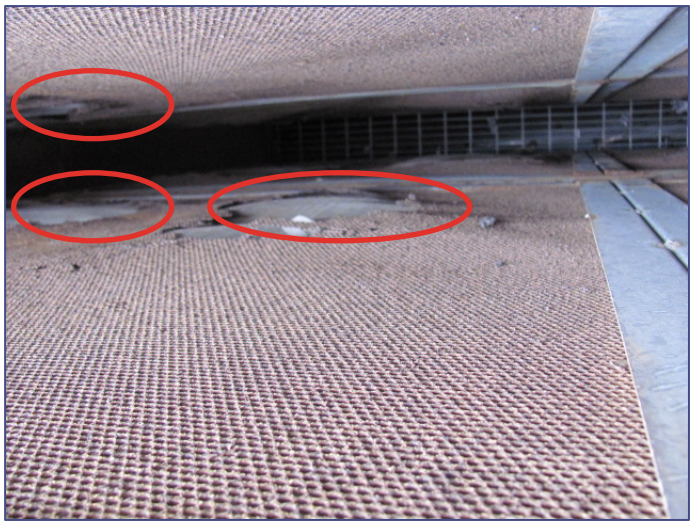


Figure 1 Note torn screen encapsulating the silencer material. The screen material was found at numerous locations in the flow path.

Figure 2 A section of inlet silencer screen was found near the inlet guide vanes.

Figure 3 The arrow points to pulverized screen material that was centrifuged by the rotor and deposited on the stationary surfaces including variable guide

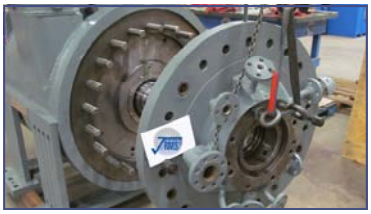
UNIT REFURBISHMENT OF A DELAVAL 6B26 CENTRIFUGAL COMPRESSOR

By Marc Rubino

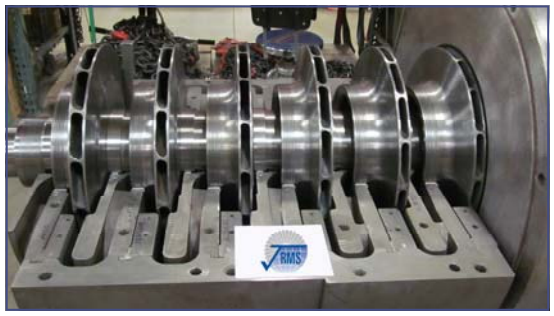
Rotating Machinery Services Inc. (RMS) was contracted to refurbish a DeLaval 6B26 centrifugal barrel compressor for a US based refinery. The completed machine was shipped during the second quarter of 2014 following an extensive repair and part replacement scope.

This 1970s vintage compressor was previously in operation at a Midwest US refinery until site shutdown. After sitting idle for an unknown number of years, the compressor was pulled from the refinery, disassembled, and placed in storage. The fully disassembled compressor was sent to RMS for inspection and reassembly feasibility. All components arrived at RMS corroded and disheveled. After cleaning and evaluating the received compressor parts, a repair plan was developed and executed:

- Weld repaired impellers as needed, shaft reworked, rotor reassembled, and balanced
- New Fluorosint interstage (eye and shaft sleeve) and balance piston seals
- New aluminum labyrinth shaft seals
- Repaired process gas Kaydon seals
- New radial tilt-pad bearings with retrofitted RTDs (thermocouples previously installed)
- Repaired thrust bearings with retrofitted RTDs (thermocouples previously installed)
- New radial and axial proximity probes, cable seals, and enclosures
- New casing vertical joint studs and nuts
- Repaired outer casing connections
- Majority of fasteners and all O-rings replaced
- Complete unit reassembled and painted with corrosion inhibitive coatings
- Compressor stored and shipped in "dog house", or top-hat style, nitrogen pressurized container



Through the collaborative effort of RMS and its dedicated network of suppliers, the compressor was completely overhauled and reassembled at RMS Power Solutions. RMS anticipates this refurbished compressor to provide many years of successful operation and meet or exceed OEM online reliability. This recent project demonstrates RMS has the expertise and capabilities to provide custom engineered solutions to restore your equipment despite its condition.



Just Around the Corner!

POWER RECOVERY TRAIN (PRT) ROUND TABLE IN NOVEMBER 2014

The RMS Power Recovery Roundtable is just around the corner! Seating is very limited. If you have not reserved your seat yet, please do so soon, A welcome reception will be held on Wednesday, November 12, 2014 at the Marriott Courtyard. The Round Table will be held on Thursday, November 13 and Friday, November 14. If you are interested in attending please contact Don Shafer or Kathy Ehasz at 484-821-0702.

If you have a topic, question or problem area for the Round Table, please email Don Shafer at dshafer@rotatingmachinery.com.

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CONGRATULATIONS RMS!

Ranked #2838 in 2014

Inc. 5000

6 years on the Inc. 5000 list.

PRODUCT LINES

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

RMS SUPPLIER GOLF OUTING

By Frank Marrone

RMS held our 4th supplier appreciation Golf Outing on September 17th 2014 at Riverview Country Club in Easton, PA. We were very fortunate to have wonderful weather with a cool morning breaking into mid-seventies in the afternoon. We finished the day off with cocktails and dinner followed by awards, prizes and some laughs.

The outing was attended by 137 RMS employees and suppliers representing over 50 different companies.

The focus of our outing was to thank those organizations for the quality products; service and effort that help propel RMS into the success we have enjoyed in our industry. It is the extraordinary hard work and enthusiasm of all our supply chain that ultimately helps achieve the results that RMS brings to our customers.

We look forward to continuing our growth through the support and excellence provided by each of our suppliers.