ROTATING MACHINERY SERVICES, INC.

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THE FINISH LINE

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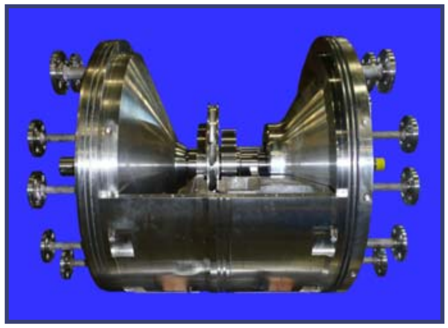
RMS POWER SOLUTIONS

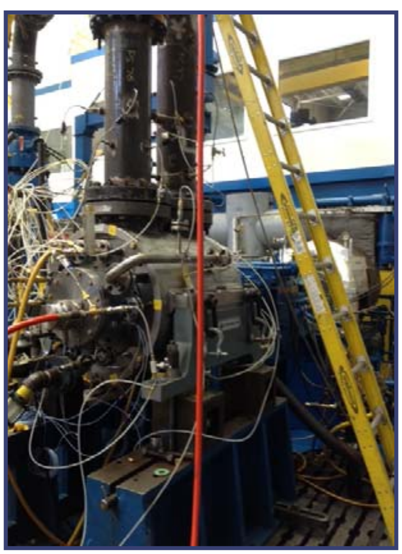
by Charles (Chot) Smith

During the third quarter of this year the ***RMS Power Solutions*** shop has accomplished the task of manufacture and assembly of (2) ISO butane recycle gas compressors for a large chemical plant in Texas. RMS was contracted to redesign the existing horizontally split compressors to resolve chronic leaking issues. The current units will be replaced with modularly designed barrel compressors. These units include gas seals, a new gas seal panel and also a complete new oil supply console. The compressors have been successfully hydro tested and assembled and shipped to ***River Flats Testing*** facility in Appleton Wisconsin for a ***PTC10 performance*** test. Both compressors including a complete spare bundle, the gas seal panel and oil console will be completed and ready for shipment meeting a tough expedited schedule and fulfilling our customer requirements.



Bundle Assembly (minus top half)

Bundle Installation



On test stand at River Flats Test Facility

What's Inside

Come Join Us...

41st TURBOMACHINERY SYMPOSIUM

SEPTEMBER 24—27, 2012

George R, Brown Convention Center
Houston, TX

BOOTH 740

STOP BY TO SAY HI, LET US TELL YOU WHAT IS NEW AT RMS, AND MEET OUR STAFF OF EXPERTS!

RULES OF THUMB - BEARINGS

By Neal Wikert

Bearings – Tilt Pad

A minimum bearing clearance should be the shaft diameter plus .001". Another way of determining bearing clearance would be .00125" per shaft diameter.

Bearings are considered worn when it is 140% of maximum clearance.

To determine the actual clearance of a tilt pad bearing use the following formula:
Actual clearance = Bump check (x) .89

Bearings – Sleeve

The normal bearing clearance is .001" per inch of shaft diameter + .001", i.e. 5" shaft = .006" (5.006"). Alternately, the clearance should be .00125"/inch of shaft diameter.

Bore of normal Babbitt bearings carries a 32 finish and is turned. No grinding is done on Babbitt because it will clog the grinding wheel. Babbitt begins to melt at 450 degrees F, creeps at 275 degrees F.

Bearings - Thrust

Copper backed shoes and offset pivots can add 20% to typical load capability because of better heat transfer.

Thrust Float – Use .0015" (x) the bearing O.D. For example a 12" O.D. thrust bearing should have .018".

Lubrication

Most common oil is an ISO 32 (150 SSU at 100 degrees F.)

Oil is usually supplied at 110-120 degrees F. and 15-25 psig. Bearings are designed/orificed for specific oil supply temperatures and pressures. Off design supply conditions can starve the bearing and cause overheating.

Temperature Monitoring

Temperature detector placement should located 1/16th inch below the Babbitt bond line – Avoid placing into the Babbitt. Alarm at 235 deg. F., shutdown at 250 deg. F.

DRAFTING AT RMS

By Barry Ruch

The drafting department, here at RMS, is again on track to match or exceed our busiest 'drafting production' year of 2011. With last year being our busiest year to date, the drafting department produced a total of six hundred and thirty production or manufacturing drawings. This did not include sketches, inspection forms or quotation illustrations.

This year to date, we have already produced 540 drawings and with the anticipated work load we have on the horizon we'll be right there with last years total number. Key reasons we attained the numbers that we have is that we've produced several complete centrifugal compressors and rerated a large number of rotor assemblies requiring extensive part replacement.

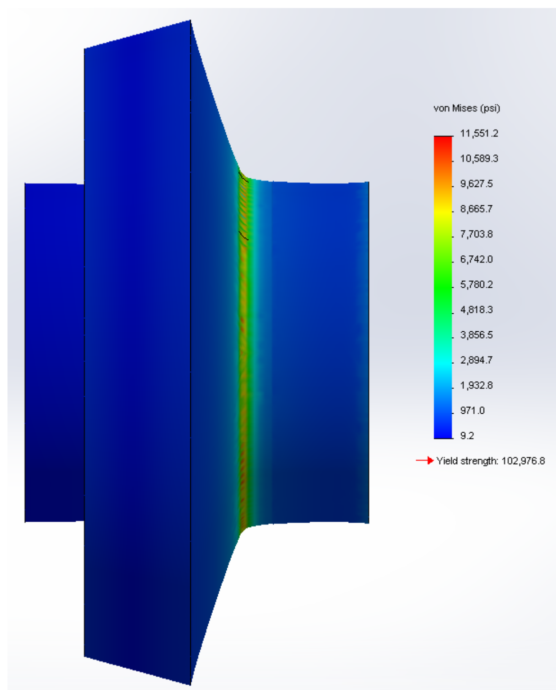
If the economic picture portrays a slow business market, we sure don't see it here at RMS! Deadlines need to be met and the pace never leaves a dull moment.

STEAM TURBINE ENGINEERED REPAIRS

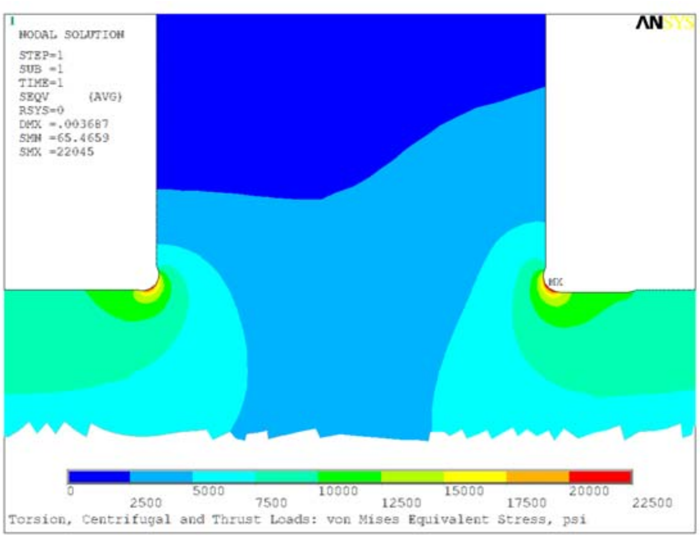
By Tim Coull

RMS recently received a 13-stage integral steam turbine rotor that had previously been inspected by a competitor who had recommended significant repair work to be done prior to returning the rotor to operation. This recommendation was based on overly conservative OEM criteria rather than a sound investigation of the machine geometry and actual operating conditions. RMS was contracted to perform our own thorough inspection of the rotor. Upon inspection and through FEA analysis and experiential engineering judgment, RMS found that less invasive and therefore more financially attractive repairs were a better option.

Our competitor's inspection showed linear indications in the thrust-collar, and significant material was previously machined off in order to remove them. Furthermore, hardened material was encountered on the thrust-collar during machining, which was subsequently halted. Any additional machining to remove the hardened material would have pushed the OEM beyond their lower limit for thrust-collar thickness. Therefore, their recommendation for the thrust-collar was to machine it down, weld it back up, and final machine to a thickness acceptable per their criteria. Such repair also would have required simultaneous weld build-up and machining of the journal to counteract any distortion from welding the thrust-collar. Not to mention that any distortion could potentially introduce large runouts of the shaft-end or even bowing of the shaft.



RMS conducted a preliminary finite element analysis (FEA) using SolidWorks SimulationXpress. A 3-D model was created using real geometry less .100" material removal from the thrust-collar, and an axial load applied using the ultimate load for standard bearings of similar size. Preliminary analysis showed that peak stresses were well below yield with a design factor of about 7.5. A more in-depth ANSYS 2-D axisymmetric model with out-of-plane loading capabilities was built to get higher resolution in highly stressed areas. A base-case model confirmed the SolidWorks results within a reasonable amount of accuracy. Another model was built to account for centrifugal and torque transmission loads, since the coupling on this machine is on the thrust-end. These results obviously showed higher max stresses than the base case, though still well below yield, with a design factor of about 4. These analyses clearly showed that further material removal would not pose a problem during operation.



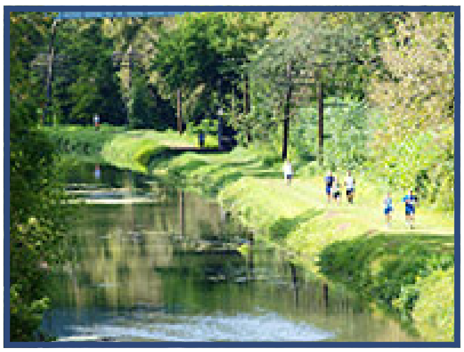
Significant material removal obviously requires manufacturing a large shim to keep the bearing against the collar. However, this plus a single machining operation is clearly a more attractive option than three machining and two welding operations, plus the possibility of significant shaft distortion. With a little forethought, abandonment of presuppositions, and utilization of modern technology, RMS leveraged its experience to deliver reliable machine repair options with our customer's best interest in mind.

RMS IN THE COMMUNITY— RUNNING FOR THE CAUSE

For the second consecutive year, the RMS Bladerunner team participated in the Lehigh Valley Health Network Marathon for VIA, a relay and marathon that benefits children and adults with disabilities such as autism, cerebral palsy and Downs syndrome. The event was held on September 9th, a beautiful clear day in the Lehigh Valley and is the last qualifying marathon for the upcoming Boston Marathon in the spring.

The relay is split into five legs. Starting in Allentown and ending in Easton PA, it winds along the scenic banks of the Lehigh river and canal, past the historic Bethlehem Steel plant. The RMS Bladerunner team, in order of race legs, is Sydney Gross, Kelly Hill, Corey Jones, Bob Klova and Neal Wikert. RMS Bladerunners placed comfortably in the middle of 220 relay teams at 105th with a time of 4 hours, 44 seconds.

Sydney went on from the first leg to complete the 26.2 mile Marathon in 3 hours and 59 minutes. Team spirit mirrored the beautiful weather and all went on to enjoy a well deserved pint after the race!



METAL & ALLOY ANALYSIS, IDENTIFICATION, AND TESTING MADE ELEMENTARY

By Bob DeHart ASQ CQT

The Riddle - How can the percentage of gold in the emperor's crown be determined expeditiously by means other than subjecting sample populations to tests of relative buoyancy?

The Principle - Occam's razor, the law of economy or succinctness. It is a principle urging one to select from among competing hypotheses that which makes the fewest assumptions.

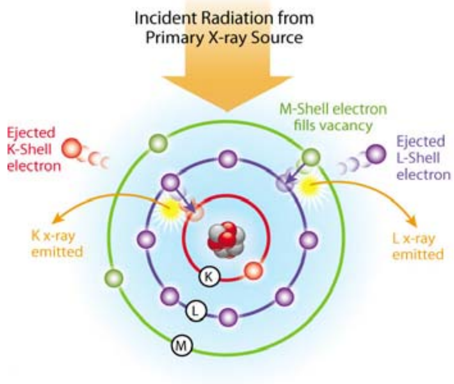
The Decision – Bring in-house the capability to identify the chemical composition of alloys using a portable energy-dispersive x-ray fluorescence analyzer, commonly known as an XRF analyzer and eliminate assumptions based on the availability, the cost and the accuracy of alternative methods.

Elemental Analysis - A Unique Set of Fingerprints

How does x-ray fluorescence work? The analyzer excites the surface of the target sample by bombarding it with high-energy x-rays (the primary or incident beam), from a miniaturized x-ray tube. Some of the energy is scattered, but some is also absorbed within the sample in a manner that depends on its chemistry.

The excited sample then emits characteristic "secondary" (or fluorescent) X-rays. The x-ray is created by dislodging an electron from one of the atom's inner orbital shells (usually K and L) energy levels. The atom regains stability, filling the vacancy left in the inner orbital shell with an electron from one of the atom's higher energy orbital shells. *(Contined on Page 5)*

METAL & ALLOY ANALYSIS, IDENTIFICATION, AND TESTING MADE ELEMENTARY *CON'T*

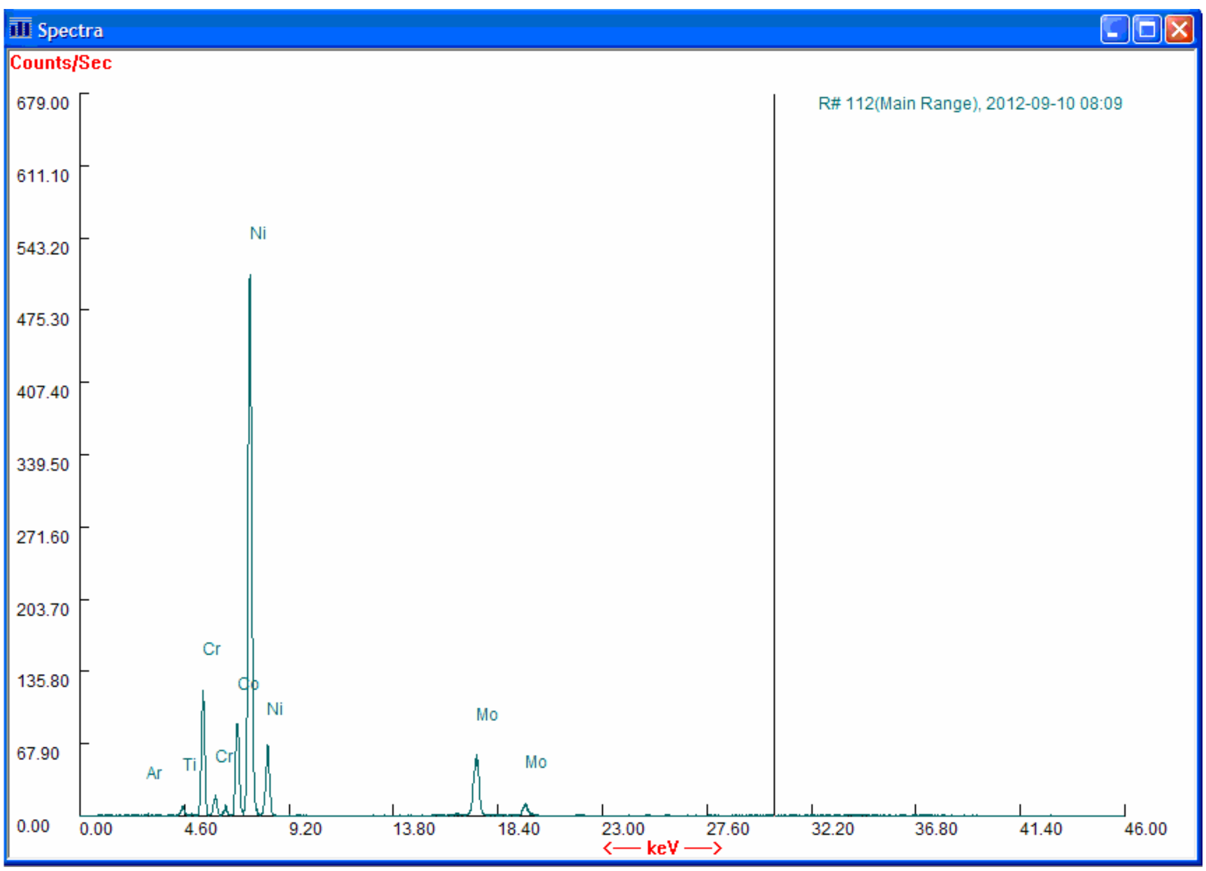



Niton XL2 XRF Analyzer

Each of the elements present in a sample produces a unique set of characteristic x-rays that is a "fingerprint" for that specific element.

By simultaneously measuring the fluorescent x-rays emitted by the different elements in the sample, the analyzer can rapidly determine their relative concentrations - in other words, the elemental chemistry of the sample.

Alloy1	Ni	Cr	Co	Mo	Ti
Waspaloy : 1.47	57.377 ± 0.718	19.289 ± 0.470	13.263 ± 0.493	4.026 ± 0.169	3.095 ± 0.354



3-D TECH TEAM UPDATE

By Corey Jones

In late spring of this year, RMS expanded its capabilities by introducing SolidWorks, a 3-D computer aided design package. By implementing SolidWorks, RMS has committed to the world of 3-D technology, vowing to continue delivering the best services and support to our customers, both now and in the future.

To aid the in transition to SolidWorks, RMS established the “3-D Tech Team”. The team’s objective was not only to initiate familiarity with SolidWorks, but to also to support all aspects of 3-D technology, including empowering users, supporting 3-D skill development, ensuring proper support systems are in place, and developing RMS 3-D capabilities. The 3-D Tech Team looks to efficiently and appropriately leverage current 3-D technology software and investigate further cutting-edge 3-D opportunities.

One of the first actions of the 3-D Tech Team was initiating and enacting SolidWorks skill development. Throughout this summer, RMS draftsmen and engineers underwent an 8 week training course designed to provide basic training for SolidWorks’ part and assembly modeling. Developed and supported by the 3-D Tech Team, lesson plans aimed to cultivate specific skills required in modeling turbomachinery. Upon completion of the lesson plans, participants had modeled an entire power turbine rotor, with individual part models, sub-assemblies, and a final rotor assembly.

As planned, after SolidWorks training, RMS has seen a drastic increase in the utilization of SolidWorks software, from 3-D airfoil modeling to entire stator assembly models. The implementation of SolidWorks has improved RMS accuracy, enhanced quality control, and facilitated communication with suppliers and customers. Combined with the FARO Arm portable coordinate measuring system, RMS is personally performing detailed reverse engineering inspections that would otherwise not be possible. Furthermore, by employing SolidWorks and custom-developed modeling tools, RMS has been able to properly support CFD aerodynamic modeling, cutting the time to complete and run a CFD model from weeks to mere days.

While all of the aforementioned progress is extremely significant and invaluable, RMS and the 3-D Tech Team view these accomplishments as the tip of the iceberg. The 3-D Tech Team is constantly investigating opportunities in 3-D technology to better support the engineering and manufacturing processes. With a focus on increasing quality and efficiency, the 3-D Tech Team supports and explores the world of 3-D technology here at RMS, with the end-goal of providing you, the customer, with unsurpassed products and services to support all of your turbomachinery needs.

CENTRIFUGAL COMPRESSORS

By Robert Huffman

The previous newsletter started a series of articles discussing specific components with in a centrifugal compressor. In that newsletter we touched on the inlet guide vane and impeller. Now we move on to what components are after the impeller. (refer to Figure 1 for reference)

Diffuser: The gas leaving the impeller has a high kinetic energy that we wish to convert back into static pressure within each stage. If we do not do that, then the velocity in subsequent stages would become quite high. This would lead to high frictional losses and gas mach numbers approaching or in excess of 1.0. The diffuser is the section of the compressor that is primarily responsible for slowing the gas back down and converting dynamic pressure (kinetic energy) to static pressure. Recall the total pressure = static pressure + V^2/2g, If we assume there are no frictional losses and there is no work done in the diffuser then total pressure is constant and if we reduce the velocity the static pressure must rise. Most industrial multi-stage industrial compressors utilize vaneless diffusers. This then implies that there must also be vaned diffusers. A vaned diffuser places vanes with in the diffuser passage to in effect create a physical barrier for the tangential velocity component there by taking that component of the flow velocity away. This improves the pressure recovery but typically at the expense of range of the stage, as there is now a throat that the flow can reach sonic velocity with in. This throat is analogous to a flow orifice that when the gas mach number reaches 1.0, the flow becomes choked. A more recent development, though they have been used for some time now is what is called a low solidity diffuser. This type of diffuser has a reduced vane count to increase the throat area and thus the range of the vaned diffuser while providing better pressure recovery than a vaneless diffuser. Typically vane diffusers are primarily used on single stage compressors or they can be found in the last stage of a multistage compressor.

Cross Over Bend: The gas flow moves radially outwards from the impeller and diffuser. It needs to be re-directed back inward radially towards the next stage. The cross over bend is there to turn the flow 180 degrees and direct the flow leaving the diffuser back inwards towards the return channel.

Return Channel: The return channel's primary purpose is to take out the tangential component of the gas velocity leaving the diffuser. Most industrial compressors today are designed for the flow exiting the return channel vane to have no tangential velocity such that an IGV is not required going into the next impeller. On some older compressor models, the design philosophy was for an IGV to always be present at the exit of the return channel so the compressor designer could adjust the IGV exit angle to "tweak" the tangential velocity going into the next stage to customize the sizing of a compressor while still using standard impeller designs.

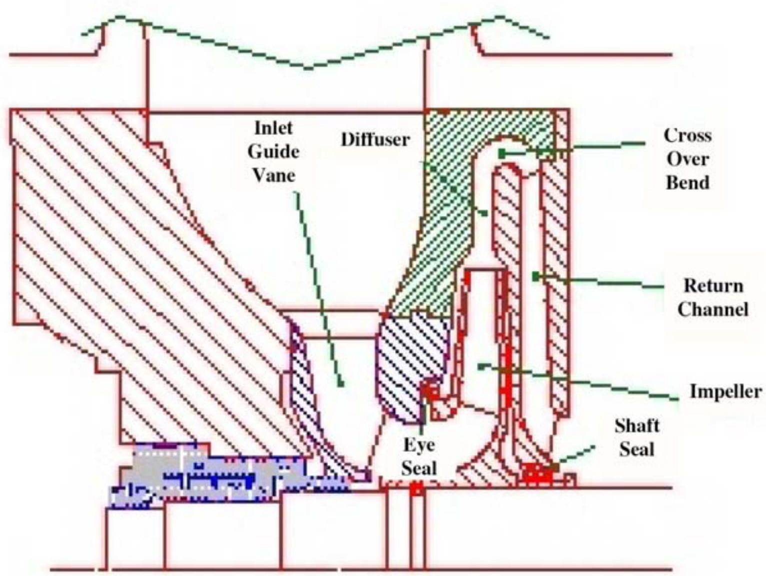


FIGURE 1

On single stage compressors or the last stage of a multistage compressor, a cross over bend is not present. In these configurations the flow leaves the diffuser and typically is directed directly into a discharge collector or discharge volute.

The next newsletter article will discuss the discharge collector and volute.

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RMS

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POWER RECOVERY TRAIN (PRT) ROUND TABLE

Rotating Machinery Services will be hosting a Power Recovery Train Round Table on October 30 and October 31, 2012. A Welcome Reception will be held for attendees on Monday evening, October 29, 2012 at 6 pm – 8 pm at the Marriott Courtyard Hotel, 2220 Emrick Blvd, Bethlehem, Pa.

The FCC Expander Discussion Group is geared towards expander end users and is headed by a moderator supported by 3 to 4 experts from the key Expander manufacturers. Various topics addressing the operation, maintenance and technology of FCC Expanders are discussed. This forum allows the end users to pose questions to the experts and share problems and experiences they have encountered with other end users.

A general overview discussion topics:

- Process and PRT Overview
- Expander Reliability Overview
- Axial Compressor Theory of Operation
- Motor / Generator and Steam Turbine Overview
- Field Service / Technical Advisor Support during outage

For more detailed information on the Topics of Discussion, attending, or discounted hotel rates, please contact Don Shafer, Expander Senior Product Engineer or Kathy Ehasz at 484-821-0702.

PRT Attendee packets are also available on our website at www.RotatingMachinery.com. If you plan on attending, please send in your RSVP form as early as possible to reserve your spot. Seating is limited. We look forward to seeing you there!