ROTATING MACHINERY SERVICES, INC.
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THE FINISH LINE

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2014 YEAR END THOUGHTS

By RMS Team

As the 2014 year comes to a close, we would like to take this opportunity to thank all our customers who have put their faith in our service during the year. We look forward to 2015. We will continue our promise providing quality support to keep your trust. Our staff is proud of the relationships we have with our customers and feel privileged working with all of you.

We wish you all Happy Holidays and safe and prosperous New Year.

UGLY CHRISTMAS SWEATER

By RMS Team

Everyone, once in his or her life has received that special Christmas present of a not so pleasant looking Christmas Sweater. Nevertheless, a gift is a thoughtful exchange, so you graciously thank the giver and smile. Silently thinking "Where will I ever wear this?" Well, we helped solved this problem for our employees and had so much fun doing so. Each year the RMS Principals host a Christmas breakfast for the staff. This year we held our first "Ugly Christmas Sweater" contest after breakfast. Let me tell you, we had some beaut's! The laughs enjoyed by the staff were just PRICELESS!

We all had a great time and would like to congratulate the winners: 1st place - Gabrielle Koltisko, 2nd place - Tom Edwards and 3rd place Herb Fischer.

RMS Provides the Optimum Solution for our Customer's Turbomachinery Needs:
Axial and Centrifugal Compressors, FCC and Expanders, Nirtic Acid Expanders, Gar Turbines, Power Turbines, Steam Turbines

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RULES OF THUMB - TURBOMACHINERY QUIZ

By Neal Wikert

***QUIZ*: TEST YOUR KNOWLEDGE**

1. What would be a good rule of thumb for internal clearances;
   A. Axial Clearance for hard part to hard part _____
   B. Axial Clearance of hard part to soft part _____
2. What would be a good rule of thumb for the axial clearance of a steam turbine diaphragm to the rotating blade in terms of axial vane width in percentage_____
3. What would be a good rule of thumb for percent contact of a coupling hub to the shaft (50%, 60% or 75%) _____
4. Which joint sealant would be a good choice for an application above 800 degrees F. (Silver Seal or Turbo R)_____
5. What would be a rule of thumb for determining a bearing clearance (.001" per inch of diameter or .002" per inch of diameter) _____
6. At what percent of normal bearing clearance would a bearing be considered worn (125%, 140%, or 175%) _____
7. What is a good rule of thumb for shutdown temperature on a thrust bearing (200 deg. F., 250 deg. F, or 300 deg. F) ___

Answers on page 8

STEAM TURBINE COATINGS

By Scott MacFarlane

Industrial steam turbines are susceptible to corrosion, erosion and deposit build-ups on almost all components of the turbine where steam is present. These problems may occur throughout the entirety of the turbine in both condensing and non-condensing steam turbines so no one machine is safe. Since these problems can lead to failures and expensive replacement parts, coating the turbine components can be a cost effective prevention measure. Several coating methods and materials have been tested to reduce the amount of damage on the turbines, although damage prevention isn't the only reason to coat turbines. Coatings can be used for material build-up and clearance control to improve efficiency and provide a sacrificial protection again rubs.

Coatings for damage prevention are usually applied after a rotors campaign to determine the appropriate type of coating for the environment the machine is facing. For example, if the blades of a rotor are subjected to corrosive conditions, a certain coating would be used to help recover the blades and to extend the blades' life cycle. If the blades are encountering heavy erosion, another coating can be used as a sacrificial layer of material to slow down the effects of erosion on the blades. Finally, if the blades have an excess of deposits on the airfoils, an alternative coating can be used to reduce the amount of contaminants that stick to the blades.

There are several coating options to choose from based on the turbines specific needs, but a few main types of coatings used in the steam turbine industry for damage prevention include a Titanium nitride (TiN), an Electroless nickel (EN), a Tungsten carbide (WC) and a metallic slurry coating. These coatings have been tested and proven to be more efficient in terms of build-up resistance, erosion resistance and extending the lifecycle of rotor components when compared to base materials.

The application and adhesive properties of these coatings varies based on material and thickness required. Common industry application processes include bath dipping, plasma spray, and high velocity oxygen fuel (HVOF). Bath dipped coatings such as Electroless nickel allows the coating to reach areas that cannot be accessed through line of site for spraying processes. Plasma spray is more versatile as it is capable of spraying a wider range of materials while HVOF can produce a superior quality coating and greater adhesion to the base material. The application process to use is based on the type of coating, the turbines' specific needs, the turbines mechanical properties and the turbines' operating conditions.

REFINERY MAJOR TURNAROUND SUPPORT

By Eric Dunlap

RMS is proud to have successfully executed a Fall 2014 Turnaround for a major European refinery. RMS provided Field Supervision, Project Management, Engineering Support, and Millwright Labor for the overhaul of an FCC Power Recovery Train and a Wet Gas Compression Train. The scope of work included a pre-turnaround spares inventory review, scheduling, disassembly of the machinery trains, inspection, repair and re-build of each machine, as well as testing and start up support.

The five-body Power Recovery Train consisted of a hot gas expander, axial compressor, steam turbine, gearbox, and motor/generator. RMS was responsible for the overhaul of the expander, axial compressor, steam turbine, and gearbox. The first ten days of the turnaround saw two crews of millwrights working 12 hour shifts for around the clock coverage during the disassembly and discovery phase of the turnaround. Once through disassembly and with no major discoveries the working schedule was relaxed to a single shift each day. An additional millwright crew worked a single shift to overhaul the two-body Wet Gas Compression Train.

Once the machines were disassembled the top halves were transported to the refinery main workshop for inspection, repair, and overhaul while the bottom halves were overhauled on the machinery deck. The expander was replaced with a complete spare unit which was pre-assembled prior to the start of the turnaround.

The turnaround was planned for an aggressive five week timeframe. Through diligent pre-turnaround planning, efficient execution of tasks, and RMS' expertise all of the work was completed safely, on budget, and on schedule. RMS is pleased to be capable of providing our customers with this type of high quality turnkey outage support.

A BUSY YEAR FOR RMS SHOP

By Tom Edwards & Charles "Chot" Smith

We, at Rotating Machinery Service and RMS Power Solutions, are thankful for the business that our customers have afforded us in 2014. It was a very challenging and very successful year.

In addition to our long standing customers, RMS received several orders from new customers, who moved away from the OEMs, and were in need of expert/experienced engineering, quality products and service.

Besides performing several unit overhauls in our Bethlehem, PA facility and expanding our shop an additional 10,000 sq. ft, RMS supported several major on-site turn-a-rounds around the world this past year. As part of our on-going goal to reduce project outage/cycle-time for our customers, we plan to continue to expand our in-house capabilities and capacity through the acquisition of key machine tools and additional key manufacturing and engineering personnel.

As we enter in to the New Year, RMS wishes you a very Safe and Happy New Year. We are looking forward to new opportunities to provide our customers with superior products and services in 2015.

RMS HAS BROKEN INTO THE CHILLER MARKET - N.Y.C.

By Bill Velekei

RMS has recently broken into the Chiller Market in New York City. Turbines are used throughout the city to drive chillers that provide air conditioning for the tall buildings, including skyscrapers, hospitals, universities and high rise apartments. RMS recently completed an overhaul of an Elliott turbine, which drives a York chiller, for air conditioning of their building at a client's site in NYC.

The turbine was experiencing high vibration. RMS teamed up with a mechanical contractor to pull the rotor, diaphragms and TG governor. Upon disassembly at site, the diaphragms were seized in the turbine case. The decision was made to pull the entire turbine from the site and send to our repair facility. Hydraulic jacks and heat were used to remove the diaphragms from the case. The diaphragms and reversing ring were glass-bead cleaned, NDT'd and dimensionally inspected. The diaphragms had minor pitting. The reversing ring had major erosion and corrosion. The diaphragms were repaired and reversing ring replaced.

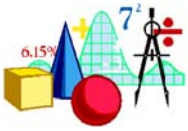
The rotor was check balanced, glass-bead cleaned, NDT'd and dimensionally inspected. It had extensive pitting on the buckets, erosion and corrosion on the inter-stage seal areas and bearing journals. The rotor was de-stacked. The shaft was undercut, coated and ground to finish size on the bearing journal, seal packing areas and inter-stage seal areas. The rotor was then re-stacked via a progressive balance and final balanced.

The casing had extensive rust and scaling. The steam chest had extensive internal cracking and wear. The seal boxes were severely corroded. The case was glass-bead cleaned, horizontal joint was stoned, blue checked and prepared for reassembly. The steam chest and seal boxes were replaced with new.

All components were reassembled and fit to the casing. All clearances and thrust dimensions were taken and recorded. Turbine was then disassembled and ship back to site for ease of installation. A Final report was then issued. The turbine was reassembled on-site and a test run of turbine was conducted. The turbine ran fine with minimal (acceptable) vibration.

Our customer was very pleased with the total turbine overhaul; the repaired condition of all parts, delivery of the repaired turbine ahead of schedule and within budget (no change orders).

QUALITY CONTROL



By Bob Dehart ASQ CQT

Our objective is to ensure that our measurement processes have adequate resolution and are both precise and accurate.

One of the elements of measurement uncertainty is temperature variation. Due to their different coefficients of thermal expansion (CTE), different materials used in the manufacture of parts for turbo machinery vary widely in their response to temperature variation. When parts and measuring instruments are given sufficient time to acclimate to an environment in which temperature fluctuations are controlled within +/- 2 degrees Fahrenheit of standard temperature (68 degrees Fahrenheit), this element of measurement uncertainty is neutralized.

When acquiring measurements in an environment other than the inspection lab however, it is essential to understand the purpose and importance of thermal scaling.
Unless otherwise noted, a drawing or model is scaled at 1, or 68°F.

Imagine an aluminum bar that measures 48 in. in a 68°F controlled inspection lab. A measuring instrument will measure the bar at 48 in., but placing it in an environment that is 90°F would cause the bar to experience a thermal linear growth of approximately 0.013 in. Obviously, when compared to its actual design length, the measurement would be incorrect by 0.013 in. The correct approach would be to compensate the measured data based on the CTE of aluminum and report the part as meeting the design length. *(Con't next page)*

QUALITY CONTROL *(Con't)*

By Bob Dehart ASQ CQT

Another way to look at thermal error is to consider the difference between precision and accuracy. Precision tends to focus on repeatability of measurements, while accuracy is concerned with exactness of conformity to specification. A group of measurements that were very close together but not to specification could be considered precise even if they weren't accurate. Thermally corrected measurements can preserve the precision of measurements while increasing their accuracy.

Our FaroArm co-ordinate measuring machine is able to compensate by means of software menu selections. Using an algorithm that incorporates the CTE and the differential between ambient and standard temperatures, the software scales the data as it is acquired eliminating the uncertainty and inaccuracy of less systematic compensation methods.

IMPELLER PERFORMANCE CONSIDERATIONS WHEN SPECIFYING WELDING TOLERANCE

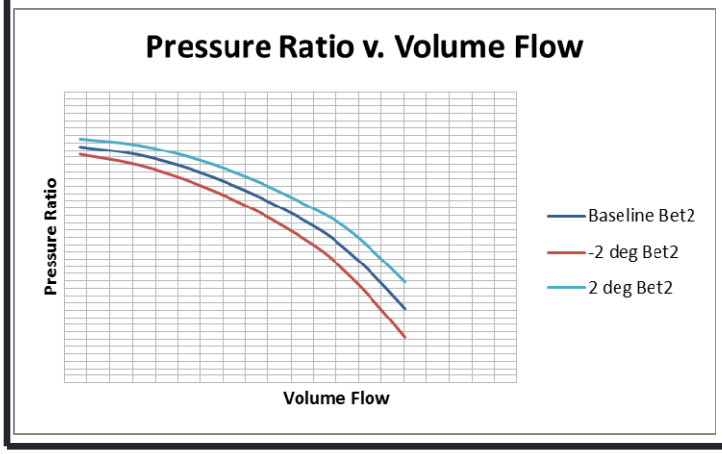
By Ryan Montero

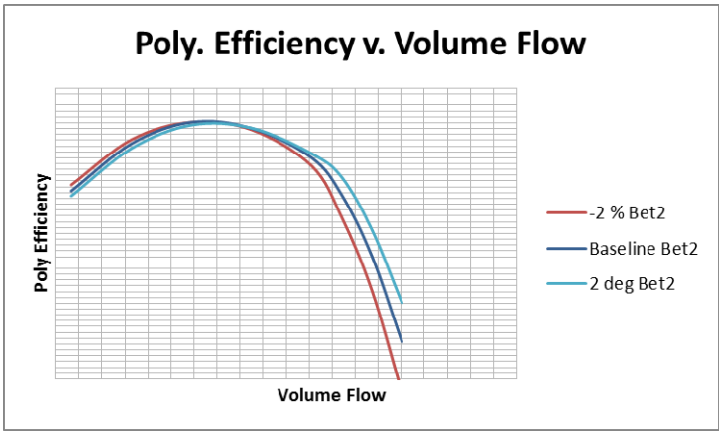
A unique, and sometimes troublesome, feature of centrifugal compressors is the complex shape of the working flowpath. Most other typical turbomachine configurations such as steam turbines, axial compressors, and expanders have more simple and "straight through" flowpaths where the machine is adding or deriving work from the gas. For many of these, the blades can be connected to the rotating shaft via slots which connect the root of the blade to the rotating disc. In the case of centrifugal compressors, especially those with covered impellers, the blades are typically welded in place onto the disc hub because of the unique and relatively complex shape of the flowpath. Much like the blades in simpler flowpaths, important parameters such as incidence angle, throat area, and discharge angle significantly affect machine performance. In order to ensure impeller performance, the specifications for the allowable deviation on the fabricated part from the drawing must be considered relative to the impact that deviation on each parameter would have on the impeller performance.

A brief study was performed to evaluate the sensitivity of centrifugal compressor stage performance to small changes in impeller geometry. This study gave valuable information on necessary tolerance values that minimize adverse effects on performance. A baseline case was generated and then each parameter was changed and compared to the original. The analysis for this study was completed using a meanline analysis package geared towards centrifugal compressors. A centrifugal compressor stage with a vaned diffuser and elliptical volute was created and was refined to match, within reason due to time constraints, the impeller performance of the third stage impeller in a known machine.

The parameters varied were: throat area, discharge passage width, inlet blade angle, and discharge blade angle. Throat area and discharge passage width were varied up to +/- 2% of the initial value while inlet and discharge blade angles were varied by +/- 2 degrees. Machine speed and inlet operating conditions were held constant while machine pressure ratio and polytropic efficiency were compared. The changes in inlet angle and throat area had very little effect on discharge conditions and machine flow rate (<< 1% difference).

The geometric parameters that showed the greatest sensitivity were discharge passage width and the blade discharge angle. The rate of flow change for deviation of discharge passage width was 1% of flow per 2% of width change. As seen in the figures below the discharge angle was much more sensitive at 2.2% of flow for every 1 degree deviation.





WINTER WEATHER SAFETY

By Tom Edwards

Extremely cold temperatures often accompany a winter storm, so you may have to cope with power failures and icy roads. Follow these important steps to protect yourself and your family. Although staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, you may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system isn't adequate for the weather. The use of space heaters and fireplaces increases the risk of household fires and risk of carbon monoxide poisoning. Tips to protect yourself and your family.

Indoor Safety

1. Use fireplaces, wood stoves, or other combustion heaters only if they are properly vented to the outside and do not leak flue gas into the indoor air space.
2. Install a battery-operated carbon monoxide detector in your home.
3. Keep as much heat as possible inside your home.
4. Check the temperature in your home often during extremely cold weather.
5. Leave all water taps slightly open so they drip continuously when temperatures drop below freezing.
6. Eat well-balanced meals to help you stay warmer.
7. Never use a charcoal or gas grill indoors—the fumes are deadly.
8. Never use a generator inside the house, in the basement, in the garage, or near a window.
9. Never leave lit candles unattended.

Outdoor Safety

1. Dress warmly and stay dry.
2. Wear a hat, scarf, and mittens.
3. Avoid frostbite.
4. If you have to do heavy outdoor chores, dress warmly and work slowly.
5. Avoid walking on ice or getting wet.
6. Notify friends and family where you will be before you go hiking, camping, or skiing.
7. Avoid traveling on ice-covered roads, overpasses, and bridges if at all possible.
8. If you are stranded, it is safest to stay in your car.

10 Tips for Safe Driving In Winter Weather

When the weather gets frightful, particularly in the Northeast, it's best to avoid driving if possible. But for those who need to get behind the wheel, AAA and the National Highway Traffic Safety Administration have provided lists of tips to stay safe while on the road. Some are pretty obvious ("Always look and steer where you go;" wear your seatbelt), but others are more useful. Here's some of what you need to know before driving in winter weather.

From the NHTSA:

Fill your windshield wiper fluid reservoir; it can go quickly in snowy conditions. Keep an extra supply in the car.

Electric vehicle batteries lose power more quickly in the cold, so be sure they are fully charged before heading out.

Keep extra distance between yourself and other cars, to account for slow braking. With antilock brakes, apply steady pressure. With non-antilock brakes, gently pump the brakes.

In the event of a skid, ease off the gas, do not brake (until the car is under control), and carefully steer in the direction you want the front of the car to go.

Keep abrasive material (like sand) in the car, to use for extra traction if the car gets stuck.

From AAA:

Keep your gas tank at least half full, to avoid gas line freeze up (when moisture in the air in the tank freezes, clogging the line).

Properly inflate your tires.

If stranded, tie a brightly colored cloth to your car's antenna or in the window, to alert rescuers. In the dark, keep the dome light on, if possible.

Accelerate slowly, to improve traction.

Avoid stopping fully, and do not stop when driving uphill.

MODAL IMPACT TESTING TECHNIQUES & USES

By Christopher Sykora

This is the 1st in a two part series. Modal impact testing is one example of the experimental modal analysis techniques used to find the natural frequencies of vibration of a structure. Impact testing uses an instrumented hammer to deliver an impulse force to a structure while the vibrations are measured with other instrumentation. It is important to determine the natural frequencies of turbomachinery structures like airfoils in order to be able to avoid matching the natural frequencies and the excitation force frequencies from objects like stator & strut vane wakes. This is because resonance occurs when frequencies are matched and vibrational energy significantly amplifies even small excitation forces to much higher levels, potentially causing high cycle fatigue stresses. Although finite element analysis (FEA) is often used to simulate structure vibrations, the natural frequencies can also be found experimentally with modal impact testing.

The typical equipment used for testing is the instrumented impact hammer to apply the force, a small accelerometer to record the vibrations, an analog to digital signal converter, and signal analyzing software capable of converting the vibrations from the time domain to the frequency domain. It is important to have a basic understanding of the proper setup and adjustments possible (such as frequency range, windowing, averaging, etc.) in the software in order to capture the correct data. Although modal impact testing can be applied to any structure, the most common example of use at RMS is on individual rotor blades. Pictures of the equipment and process flow are shown below in Figure 1.

The basic testing steps include the following: 1) Connect all the equipment with cables and adhesively mount the accelerometer to the blade at a location of high motion during vibration. 2) Put the structure in either a "free state" by suspending it with elastic cord or placing it on a very soft cushion. This will closely simulate being unrestrained so that it will vibrate freely all over. Or put it into a "fixed state" by constraining the structure as it would be in operation. For the case of rotor blades held in a spinning disc, the "fixed state" is difficult to simulate since the constraint gets much tighter when the rotor is spinning than at assembly. Therefore, blades are typically tested in the "free state" and are used to calibrate to an FEA vibration model also with "free state" constraints.

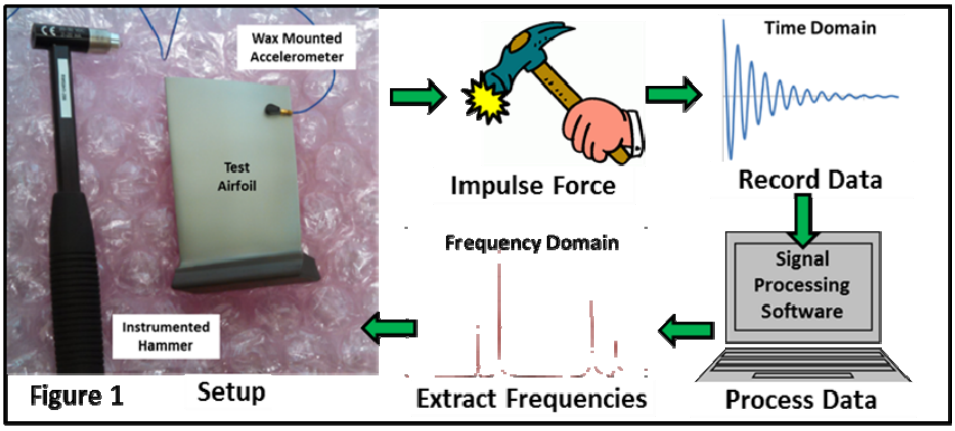


Figure 1

3) Strike the structure with the hammer while the accelerometer records the vibrations. Watch the impact signal to make sure a very short duration impulse force input has been achieved and not a double impact. 4) Signal analyzing software processes the accelerometer data from the time domain in which it was collected and converts it into the frequency domain with a Fast Fourier Transform (FFT). The details of signal processing math are beyond the scope of this article, but viewing the signal in the frequency domain enables a much easier identification of the largest components of vibration (the natural frequencies).

5) Typically the impact test is repeated and data gathered without changing the setup multiple times in order to be able to average the data together inside the software to reduce "signal noise". 6) Finally, the structure natural frequencies are extracted by finding the locations of the highest responses from a plot of acceleration vs. frequency. RMS has developed peak find macros to automate this processing. An example plot with frequencies identified is shown in Figure 2.

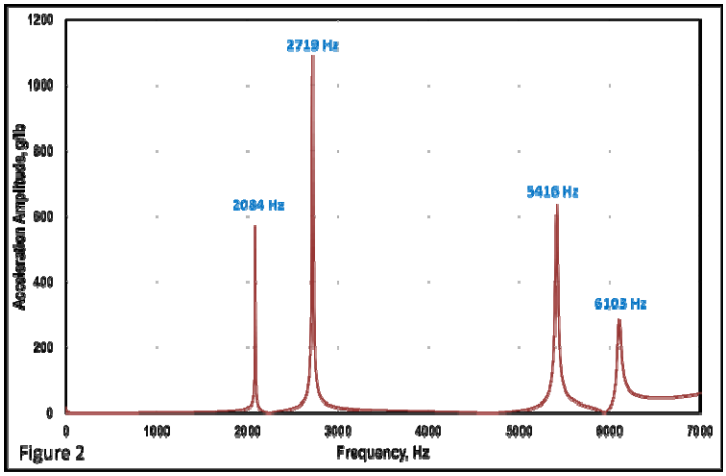


Figure 2

FALL 2014 PRT OUTAGE

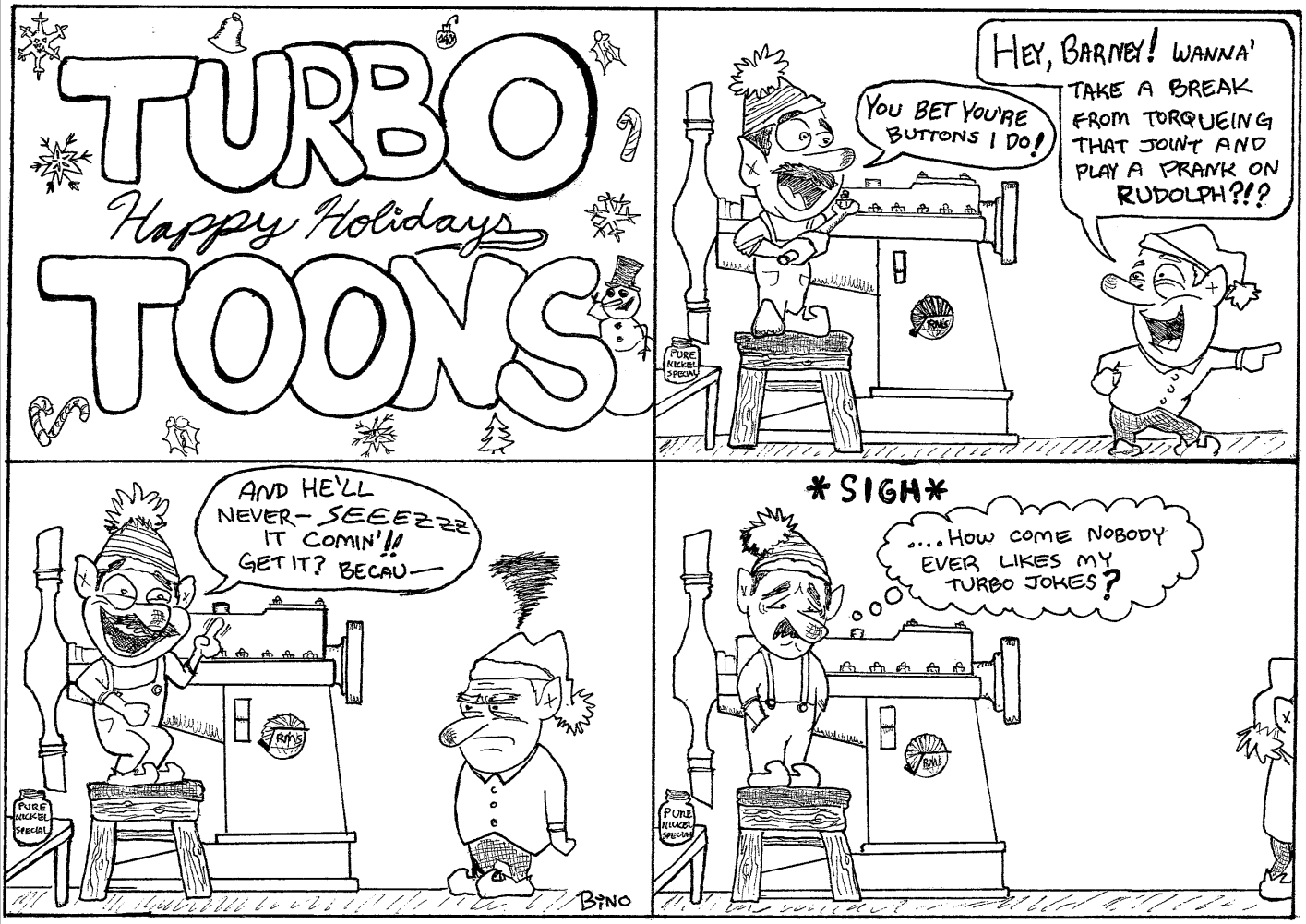
By Jim Campana and Don Shafer

In the fall of 2014, a mid-Western refinery undertook an outage on its power recovery train (PRT). The refinery required a significant number of high temperature fasteners in order to assemble one of the train's drivers. RMS received the order from the refinery with a four (4) week lead time. The high temperature fasteners normally require upwards of eight (8) weeks to process. As the outage proceeded, it became apparent that the fasteners were needed sooner than the four week lead time. The majority of the fasteners were received within two (2) weeks, but the studs and nuts shipping window could not be improved.

In order to save time, RMS dispatched a vehicle to pick up incoming studs & nuts. RMS worked twelve (12) hour shifts to non-destructively test (NDT) over 300 components. When four (4) studs were needed to be replaced, RMS ordered the four replacement studs that were manufactured overnight. After completion of NDT on the replacement studs, the complete order of fasteners was overnight couriered, arriving at the customer's facility the next day allowing the outage to continue without delay. RMS also manufactured several extra studs for the customer's store room. All of this work was accomplished at no extra cost to the customer.

TURBO TOONS

By Marc Rubino



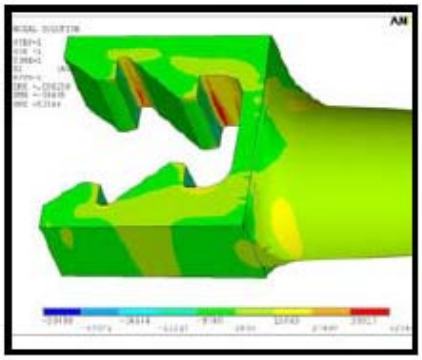
ANSWERS : Turbomachinery Quiz on Page 2

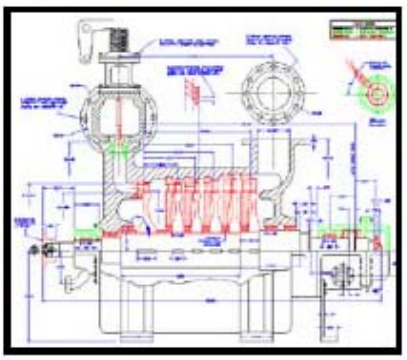
1A) **1/4** 1B) **1/8** 2) **10%** 3) **75%** 4) **Silver Seal** 5) **.001** 6) **140%** 7) **250**

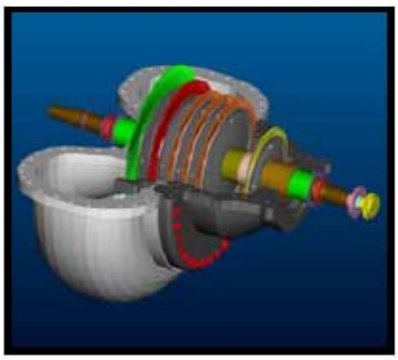
Steam Turbines

Rotating Machinery Services is backed by decades of experience in Steam Turbine design, analysis, manufacture and service. Our Key staff averages over 25 years experience.

Rotating Machinery Services is available to our customers 24 hours, 7 days a week. Visit our web site at www.RotatingMachinery.com to view all our capabilities.







- *Spare parts inventory review & optimization*
- *Complete rotor, nozzle block & diaphram reconditioning*
- *Component supply & repair*
- *Turnaround Support*
- *Field Supervision*
- *Maintenance engineering support*
- *Performance testing*
- *Rerates for improved performance & reliability*
- *Component failure analysis*
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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 CONGRATULATES GERRY NAU, CEO LAFAYETTE BANK

On Wednesday, November 12th, RMS was honored to attend and contribute to the 2014 Good Scout Breakfast of South Mountain District at the Northampton Country Club. The fund-raising breakfast was held to honor Gerry Nau, Chairman and CEO of Lafayette Ambassador Bank for his contributions to "Scouting and the Quality of Life" in the Lehigh Valley. Gerry Nau was presented with the Good Scout of the Year Award.

We at Rotating Machinery Services would like to congratulate Gerry on contributing so much to our local area.

RMS IN THE COMMUNITY

Rotating Machinery Services, Inc. sponsors and supports projects and programs that improve the quality of life. We are fortunate to have a caring and compassionate team that encourages and enjoys community involvement.

In 2014, members of our staff participated in the following events/activities:

Blood donations for Miller Keystone Blood Bank, the Lehigh Valley Health Network Via Relay Race, American Red Cross Grand Prix Race, food collection for the Second Harvest Food Bank and toy collection for the Toys for Tots Foundation.

RMS Executive Management donated to the following charities in 2014:

The Great Newark Boys & Girls Club, American Cancer Society, Special Olympics of Pennsylvania, March of Dimes, Nazareth Baseball Homerun Club, American Red Cross, Tots for Tots, United German Hungarians, Source de Vie, Action for Animals Humane Society, and Minsi Trails Council.