ROTATING MACHINERY SERVICES, INC.
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THE FINISH LINE

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Letter from Board of Directors

Rotating Machinery Services would like to extend our gratitude and appreciation to all our customers and suppliers for their business, support, loyalty and continuing confidence in our turbomachinery expertise.

We continue to expand our technical expertise and shop capabilities to meet the needs of our customers. The RMS team and our Suppliers are made up of dedicated, hardworking and experienced professionals who are committed to achieving excellence in performance, supplying quality engineering, services and hardware to our customer.

RMS would like to wish you, your team and families a very safe and happy holiday season. We look forward to working with you all in the New Year.

Regards,
Jerry Hallman, Robert Klova, and Neal Wikert

THE UNEXPECTED BENEFITS OF BREAKING IN A NEW HUNTER

By Steve Moser

I must admit that when my son expressed interest in hunting I was a bit apprehensive. I was more than willing to give him a chance and see what hunting was all about. I was fully expecting a lot of grumbling about the early alarms, the long hikes (all uphill of course) the cold, the rain, and all the other things that I complained about to my dad when I pestered him to take me hunting. What I did get, however, was a pleasant surprise.

This past year has been one of the most exciting for me since I began hunting almost 30 years ago. Over the years I've taken home my share of deer, turkeys and even a PA black bear. Sure, those were good times and I'll always remember them but I have to say that of all of my hunting experiences the most memorable were being with my son and watching him harvest his first spring gobbler and, more recently, his first buck. To see him be successful and be rewarded for his efforts was as big of a deal for me as it was for him. I found that I was far more excited for him than I had ever been for myself.

I am thankful for the time my son and I have been able to share in the outdoors and I'm looking forward to, hopefully, many more years of the same. I know that there are many that can relate to these experiences and hopefully this brings back fond memories. To others, I hope you take advantage of any chance to share something you love to do, whatever it is, with a kid. It's likely to be as rewarding for you as it is for them.

Good luck, take lots of pictures, have fun, be safe and good hunting!

What's Inside

RULE OF THUMB - TURBOMACHINERY

By Neal Wikert

Coupling Bluing Minimum Contact

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

Residual Magnetism - 2 gauss max allowable

Inlet nozzle velocity: = 150 ft/sec maximum

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

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

Helical Gears are generally manufactured from 4340 through hardened to a Brinell range of 340 – 370. Above a surface speed of 7000 ft./min. the gear teeth need to be ground to give the part the accuracy needed for spinning at these speeds.

Carbon Ring Seals – Limited to 15-psig drop across ring and a shaft speed of less than 200 feet per second

Labyrinth seal – Can be subjected to a pressure differential of 4-6 times that of a carbon ring seal with no shaft speed limitation. A stepped laby can reduce leakage by up to 30 % over a straight laby.

CONTROLLED AND UNCONTROLLED EXTRACTION

By Sydney Gross

Steam turbines are custom machines for the most part. They are designed around the steam conditions and needs of the plant. Non-condensing or backpressure turbines are an efficient method of driving a load while letting down high-pressure steam to some pressure above atmospheric that is needed in the plant. When there is no use for the intermediate pressure steam, a condensing turbine may be used to derive the most power practical from the steam. Turbines with essentially the same exhaust mass flow as inlet mass flow are referred to as straight through, either straight through backpressure (fig 1) or straight through condensing (fig 2).

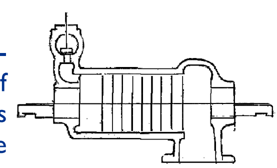


Figure 1

However, there are many instances where steam is required at intermediate conditions for process heating. For this purpose, steam is bled off or extracted from the turbine at an appropriate location or locations to suit the heat load need. We refer to these machines as extraction turbines. Depending on the heat load, the extraction may be either controlled (automatic) or uncontrolled (nonautomatic).

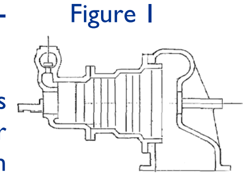


Figure 2

A controlled extraction turbine usually has a second valve rack that controls the flow to the back end of the turbine (fig 3). By adjusting the second valve rack in conjunction with the primary control valves, this turbine provides excellent flexibility in handling a wide variation of process steam load and base load.

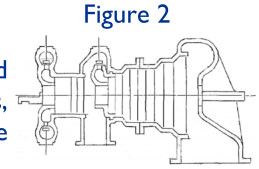


Figure 3

An uncontrolled extraction is not valved inside the turbine (fig 4). Rather, the extraction rate is controlled externally by the heat load. Typical uncontrolled extractions go to feedwater heating cycles. The flow from the turbine is controlled by the rate at which the steam condenses in the feedwater heater. Feedwater heating reduces thermal shock to the boiler and greatly improves overall power plant cycle efficiency.

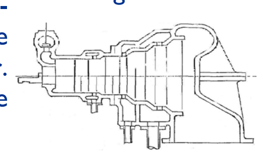


Figure 4

OVERHAULING SOME HEAVY IRON!

By Robert J. Klova, PE

A major North American utility recently awarded RMS a contract to inspect and overhaul a large Worthington ER-224 Expander. In modern terminology, these units would be classified as aero-derivative power turbines, as each expander-turbine is driven by two Pratt & Whitney GG4 gas generators. Expander shaft output is approximately 40 MW (54,000 hp). These turbines are typically installed in peaking power service, and have been in operation since the late 1960's. Two turbines were shipped to RMS with the goal of combining the most serviceable components (after repair) to assemble one machine suitable for long-term, reliable operation.

As can be seen in the accompanying photograph, these units are quite large by power turbine standards, and weigh over 70,000 lbs. Construction is also very unique. A GG4 gas generator is mounted to each side of the large annular casing at the center of the machine, and feeds the power turbine with high temperature, pressurized (1190 degF, 44.5 psia) gas. The annulus routes the inlet gas around a radial array of inlet guide vanes (stators), which direct the gas into a cavity feeding the center of a double-flow, two-stage (four stages total) rotor. The radial stator and the rotor can be seen in the second photograph. Gas then exits from a diffuser at both ends of the turbine and into a single exhaust plenum (not shown) and stack to atmosphere.

RMS' disassembly and inspection work scope included the following steps:

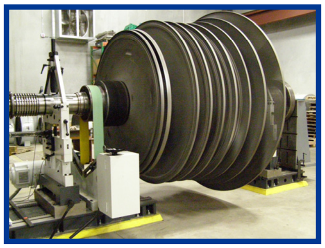
- Complete disassembly of the turbine
- Rotor check balance
- Rotor runout and dimensional inspection
- Complete disassembly of the rotor
- Contact check of the curvics couplings
- NDT inspection of all rotor components
- Casing dimensional inspection
- NDT inspection of all hot casing components
- Stator throat checks
- NDT inspection of the stators
- Bearing and seal inspection

Based upon the results of our inspection, the following work is planned for a completion date in the second quarter of 2011:

- Weld repair rotor blade foreign object damage (FOD).
- Weld repair stator foreign object damage.
- Weld repair or blend casing cracks and re-heat treat.
- Remachine casing
- Replace all high temperature fasteners
- Replace bearings
- Replace shaft seals
- Replace honeycomb tip shrouds
- Reassemble rotor and balance
- Reassemble complete unit, reestablishing all critical fits and clearances

ROTORS, COMPLETE MACHINES - ALL SHAPES, SIZES AND APPLICATIONS!

By Glenn Gaddis



Over the past several months, RMS has had lots of rotors to work on. At one point, we had over 23 rotors waiting for either a complete disassembly inspection rebuild, repair or balance.

As you might expect, most of the rotors we work on are from Refinery applications. However, recently we had the opportunity to balance the rotor from a 3000 HP Locomotive Motor. (*See picture on right*) Balance weights were manufactured in our shop and final balance was completed without any problems.

To the existing 15,000 lb. balance machine, which RMS already possessed, a second 40,000 lb balance machine was added to the shop and was quickly put to use to balance a large 30 MW ST rotor for a steel mill. The repair of this particular rotor required rework of damaged blades and replacement of several strips, all done in-house.

REMAINING LIFE ASSESSMENT

By William Sullivan, PE

Turbomachinery rotors and related high temperature components typically have an expected life that is specified in hours of operation or in some specified number of cycles (stop to operating speed to stop, for example) or both. At the end of the time period or when the number of cycles is reached, the machine is expected to be removed from service and either replaced or completely refurbished.

However, replacement or a full refurbishment can be expensive, both in the direct cost of the new machinery or refurbishments, and in the cost of lost production while replacement or refurbishment is being conducted. This can be particularly expensive in times when cash reserves are low and the turbomachinery users are trying produce as much product, and positive cash flow, as possible.

An untimely replacement or refurbishment can have an unneeded and unwanted impact if the replacement or refurbishment is not really necessary, as often is the case. This could be because either the original design criterion was overly conservative or the actual operation parameters (rotor speeds temperatures, etc.) were less than the design parameters. Actually, the two are the same thing. The turbo machine did not exceed its useful life because it did not accumulate sufficient the time or cycles.

Fortunately, there is a way to obtain a reasonable estimate of the remaining life of a turbo machine. The process is called a Remaining Life Assessment and it involves visual inspections, non-destructive testing and metallurgical evaluations of the components, and a stress analysis of the rotor. The stress analysis, which is the subject of this article, involves calculating the original life using temperatures and stress levels in the machine during actual operation; estimating actual life (time and cycles) based on the actual operating conditions and materials of construction; and establishing the current life, which usually is done by examining the operating records. The remaining life is simply the difference between the original life and the current life.

Whether or not a remaining life assessment can be performed on a particular machine depends on several things including the availability of the dimensions and materials of the parts, flowpath conditions, cooling system details, actual operating conditions and time spent at specific operating points. Acceleration and deceleration rates may be required for cycling units as well.

Someone who routinely performs remaining life assessments often will have the appropriate geometry and material data from past projects. Flowpath conditions can be estimated using standard equations for isentropic closed systems with efficiencies based on experience or ascertained from actual operating data. If there is blade or disk cooling, those parameters generally are supplied in the instruction book for the turbine. If not in the instruction book, cooling flow parameters will have to be be obtained from the customer or based on experience with earlier assessments for the same turbine model. Operating conditions and history must be obtained from the customer. *(Continue on next page)*

REMAINING LIFE ASSESSMENT *Con't*

By William Sullivan, PE

Once all of the data is collected, performance calculations will be performed to establish the temperatures and pressures in the flowpath. Next, the analyst will conduct heat transfer analyses to determine the temperatures of the blades and disks and the thermal gradients in the disks. The heat transfer analyses generally will include disk pumping analyses, along with the heat transfer analyses, to establish the temperatures in the inter-disk cavities and to estimate the film heat transfer coefficients in the disk surfaces. Depending on the disk rim sealing arrangement, some amount of flowpath gas will enter the inter-disk cavities if the disk pumping flow requirement is not met by the cooling flow to the cavities.

When the heat transfer analyses are completed, the analyist will have blade and disk temperatures and disk thermal gradients at various stages in the operating cycle of the turbine. With this information the analyst can determine what points in the operating cycle will have the most severe combinations of stress and metal temperature. Stress analyses will be conducted at these most severe points in the operating cycle. Average stresses and temperatures will be tabulated for various sections around the disk and peak stresses and local temperatures will be tabulated for all high-stress locations on the disks. The high stress locations typically will include the blade attachment fillets, the minimum section through the disk, holes in or through the disk and various fillets around the disk.

The stresses and temperatures, along with the disk mechanical properties at various temperatures, will be used to estimate the maximum life of the disk. Time typically will be based on creep-rupture analyses and the number of operating cycles will be based on low cycle fatigue calculations. Finally, using the operating history of the turbine, which will include both time and operating cycles, the current life of the disk will be estimated. Depending on the extent and quality of the operating data, additional life may be added to the estimated life to better ensure that the true current life is not underestimated. The remaining life is simply the current life subtracted from the maximum life.

In the next newsletter, we will explore some aspects of the disk pumping and heat transfer analyses.

RMS POWER SOLUTIONS

By Caleb Guhlin

2007

In May 2007, Rotating Machinery Services, Inc. opened their 14,000 foot new facility in Bethlehem, Pennsylvania. The initial 14,000 square foot included office space and shop floor. In the short time since 2007, we have expanded our shop floor space an additional 15,000 square feet. This expansion has been vital to providing support to our first-class engineering solutions. This additional space has allowed us to increase our inspection, assembly, balancing, and machining capabilities by 150%. We have added several experienced shop personnel, 2 balance machines of 15,000 and 40,000 lb capacities, a lathe, 4 overhead cranes with up to 25 ton capacity, welding capabilities, and a quality control inspection area currently under construction. This quick and continued growth facilitates the quality workmanship and expedient turnaround time for critical projects and applications our customers have come to rely on.

2010

"The difficult we do right away. The impossible may take a little longer."...anonymous

APPRECIATION TO OUR SUPPLIERS

By Frank Marrone, Jr.

2010 proved to be another challenging year with many growth opportunities for RMS. Working along with our strong supply base, we were able to achieve exceptional results to support our customer's critical requirements. On behalf of all of us at RMS, we would like to thank all our suppliers for their most important contributions in making 2010 another successful year. We look forward to continuing our growth and working with our suppliers on new projects in 2011.

TURBOMACHINERY SYMPOSIUM 2010

By David Gober

RMS was again an active participant in the 39th Turbomachinery Symposium held October 4th to 7th in Houston, Tx. We hope you had a chance to stop by our booth.

The 2010 Symposium was another outstanding event for our Turbomachinery community that was well represented with good attendance by both the visitors and hosts. We at RMS always enjoy meeting and interacting with both old and new friends and we all are optimistic for an improved business climate, as we begin 2011. Thank you and kudos to Martha Barton and her staff for a job well done ! We look forward to seeing everyone in 2011.

EMPLOYEES COMMUNITY PARTICIPATIONS

By Kathy Ehasz

Community volunteerism and interaction is what it is all about. This year, Neal Wikert, Bob Klova and Donna Schanzenbach participated in the 8th Annual Historic Turkey Trot 5K Run and Fitness Walk. The proceeds benefit to help preserve Bethlehem's 250-plus years of rich history and culture, including 2 National Historic Landmarks, 19 historic buildings, 20 acres of land, 40,000 artifacts, and countless stories for future generations! Donna Schanzenbach placed 2nd in her division. Congratulations Donna!!

Our employees, not only involve themselves, but also their families. Amy and Elsie Klova, daughters of Bob Klova, also participated in the Turkey Trot.

Donna Schanzenbach's daughter Emma who along with her cheerleading squad at Saucon Valley High School donated their time and talent in designing and selling T-Shirts to help raise money for the Susan G. Komen Foundation and breast cancer awareness. The team raised $4,900.34.

Throughout the year, RMS Employees, Neal Wikert, Tony Rubino and Bill Sullivan donate blood to the Miller Blood bank to help those in need. The American Heart Association, Action for Animals and local churches are other charities that RMS contributed throughout the year. We at RMS are quite proud of our employees and their families dedication. Thank You to All.

RMS 2010 HOLIDAY PARTY

By Kathy Ehasz

In recognition of the RMS employees hard work and dedication at RMS and to our customers, the RMS Principals hosted a Holiday Party for the staff and their spouses / significant others. The party was held at the Green Pond Country Club in Bethlehem, PA on Friday, December 17th.

RMS President Jerry Hallman kicked off the evening by expressing gratitude and appreciation to the employees and their partners. Great Food, Great Fun and a lot of dancing transpired throughout the night. Much relaxation and joy was had by all.

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RMS NEWS...

NEW SALES OFFICE IN TENNESSEE

RMS is proud to announce the opening of our new Tennessee Sales Office. We opened in November of 2010 to better serve our growing customer base in the East and Southeast US. Please feel free to contact Mike Spangler, our Regional Sales Manager - Eastern US, on his cell phone at 484-896-8438 or you can reach him in the Tennessee office at:

Rotating Machinery Services, Inc.
607 Smithview Drive
Maryville, Tennessee 37804
Office: 865-981-9831

As always, our goal is to meet all of our customers Turbomachinery needs!