ROTATING MACHINERY SERVICES, INC.
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THE FINISH LINE

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RMS POWER SOLUTIONS

By Charles (Chot) Smith

It is hard to imagine that 2013 is coming to an end so quickly. It has passed by at what seems like lightning speed due to the record 142 projects that have run through the shop this year. With all the projects, the commissioning of new equipment, and the planning and layout of the shop there certainly was no leisure time in our schedule. Our field service division has also grown at a rapid pace with over thirty projects this year due to our customers' increasing demands for door to door turnkey services.

We are excited to announce that Tom Edwards has joined our team and will be managing our quality control department. Included in his quality roll, Tom will be responsible for bringing all Non-Destructive Testing in house. This task will include the purchase of state of the art NDT equipment and the addition of at least one level II inspector. Tom has also assumed the director position on our safety committee and has already implemented numerous safety improvements in our facility.

The shop expansion is well underway with the footers in place and the concrete walls scheduled to be set on the 2nd week of the New Year.

RMS PROJECT MANAGEMENT

By Projects Team

2013 was one for the records for the Projects Department at RMS. Three new faces graced the Projects halls. Joan, Dirk and Tracey took on a strong backload of projects from last year and a record number of new projects this year including: repairs, emergency turnarounds, inspections, overhauls, rerates and service work both in country and abroad. The size and complexity of the projects along with the many different types of equipment vary greatly, offering a multitude of challenges to overcome to meet our commitments to you our customers.

One of our favorite highlights to the year was the opportunity to meet and work with customers at our facility or onsite. This gave us the chance to know each and everyone of you better, allowing us the opportunity to better understand the problems you face and the goals you are seeking to achieve. We are always proud to show our customers first hand the vast capabilities of our shop resources, Engineering and RMS support staff.

We have thoroughly enjoyed the opportunity to work with each and every one of you and look forward to meeting your rotating machinery needs in the New Year.

What's Inside

RMS IMPORTANT NUMBERS

HOUSTON SALES OFFICE:
Kurt Diekroeger
281-340-8520 (O)
713-898-1015 (C)

TENNESSEE SALES OFFICE:
Mike Spangler
865-981-9831 (O)
484-896-8438 (C)

Wishing all our customers and suppliers a happy and prosperous New Year!

RULES OF THUMB - TURBOMACHINERY

By Neal Wikert

Wet Gas Compressors

Performance:

Moderately heavy mole weights, therefore high head rise per stage.
Treat as a real gas in performance analysis.
Nozzle loadings: 10% of sonic equals 100 fps for this mole weight range.
Quantity constants are in the 100 to 300 range. At 250 and above you are maxed. 100 and above there is a lot of room.

Design:

Typically two bodies or two sections, 3-4 stages in each, with intercooler in between. Older units may have one body with no intercooler.
H2S environment. Materials are as follows:
- Casing: carbon steel
- Diaphragms: cast iron or carbon steel
- Rotor: low yield strength carbon steel
- Do not use copper based seal materials.

Field Testing:

Gas Samples should be taken while taking data, max 20-30 minutes from test (not the next day).
Samples should be kept heated to avoid condensation.
Samples should be taken at the compressor inlet and at the condenser discharge.

Application:

Typical Model #s:
Elliott: 29M or 38M
Should be driven by steam turbine (variable speed driver) because of mole weight swings.
Polymerization (coking) is a problem if temperatures get too high.

DIFFERENTIAL EXPANSION

By Scott MacFarlane

Temperature always seems to be a prevalent factor when discussing steam turbine operations and it should be. The temperature of the casing, machine components, steam and rotor always play a crucial role in the turbines performance. From start-up to shut down, the steam turbine's temperatures should always be closely monitored for both safety and reliability reasons.

Temperature fluctuations cause differential expansion in machines which alters axial clearances and alignments of internal components. Calculating differential expansion rates helps identify these variations to protect against axial rubs between rotating and stationary components. If the differential expansion gets too severe, it can lead to a failure which results in either expensive repairs or entire machine replacement. Steam turbines were designed for axial fluctuations when following proper procedures from start-up, through transient conditions to stable operation and back to shut down.

DIFFERENTIAL EXPANSION *(con't)*

By Scott MacFarlane

The rotor position is fixed at the thrust bearing to restrict its axial movement within the turbine casing. This means the rotor will thermally grow away from the thrust collar and contract towards thrust collar during differential expansion. This is important to remember when setting rotors and determining start-up and shut down time periods.

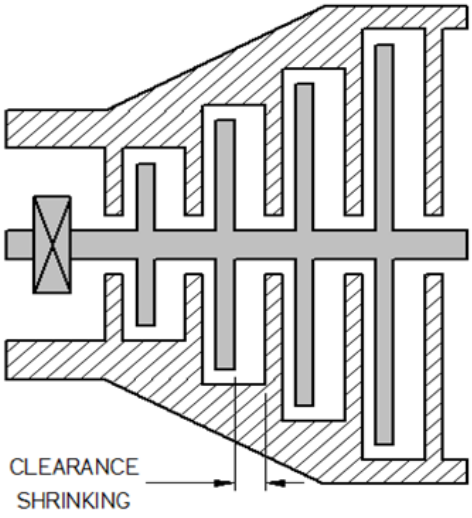
There are two main conditions that can occur for differential expansion. There is the rotor long condition and rotor short condition. Both conditions can negatively affect the internal clearances of the turbine which can lead to failures. These internal clearances include the axial distance from the rotor blades to the casing diaphragms as well as axial clearances between stepped seals.

Rotor long condition is referred to when machine temperature is increased rapidly. This causes the rotor to thermally expand at a faster rate than the casing due to the difference in masses and materials of components. This rotor long condition can mainly be seen during start-ups when both the casing and rotor start at the same temperature and experience the greatest thermal excursion. Manufacturer specified start-up procedures help control the thermal growth and maintain internal clearances as needed. Steam temperatures, flow and start-up time or soak period can be controlled to help maintain a safe rate of thermal expansion for both the rotor and casing simultaneously.

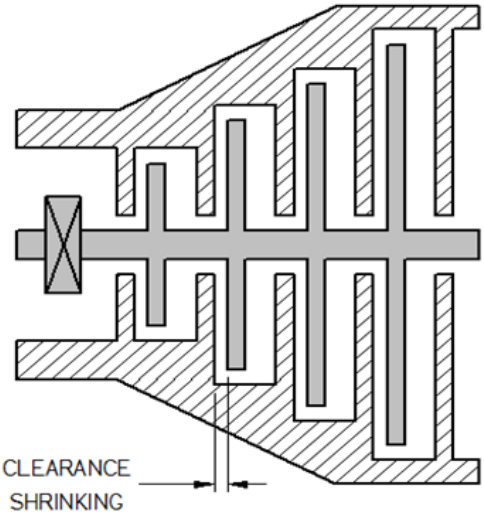
Rotor short condition is similar to rotor long condition but occurs during shut-down. When the turbine is subjected to rapid cooling, the rotor contracts at a faster pace than the turbine casing, which can lead to axial rubs. This rotor short condition can mainly be seen during emergency shut downs when steam is shut off to the turbine in an uncontrolled manner. Rotor short condition is usually of greater concern because clearances upstream of the wheels are generally smaller than downstream for stage efficiency purposes.

To help prevent axial interferences due to thermal transients, it is important to maintain the manufacturer's design rotor axial positions and turbine internal clearance specifications during rebuilds. Dimensions outside of the tolerance should be considered with thermal expansion in mind. Follow published start-up procedures and take a common sense approach to start-ups after an emergency shut-down.

ROTOR LONG CONDITION



ROTOR SHORT CONDITION



OUR COMMITMENT TO SAFETY

By Tom Edwards

Rotating Machinery Services has an ongoing commitment to provide a safe and healthful workplace for their employees. Over the 15 year plus span that Rotating Machinery Services has been in business, we have experienced 0 loss time injuries / work related illnesses. We believe that;

- ⇒ Safety is everyone's responsibility
- ⇒ Safety has no quitting time
- ⇒ Safety doesn't slow the completion of a task but accidents will
- ⇒ All accidents are preventable

Our excellent safety record is due to our continuous commitment to identify, report and address all health and safety concerns. Our Safety Committee meets on regular basis to monitor the status of the Safety Program and report progress in addressing any open concerns.

QUALITY CONTROL

Robert DeHart ASQ CQT

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

Reducing Uncertainty –

Of the alloys used in turbo machinery, all are composed of precise percentages of elements that, in combination, impart essential characteristics to the alloy.

As with super alloys, reducing uncertainty in the realization of our designs requires an array of essential elements.

One of those elements must be a standardized system for formally documenting and resolving non-conformances and for making corrections in order to prevent the recurrence of those non-conformances.

The objective is to use the system as leverage to continuously shift our operational paradigm toward a more robust system ecology.

BUILDING BLOCKS IN AUTOCAD

By Barry Ruch

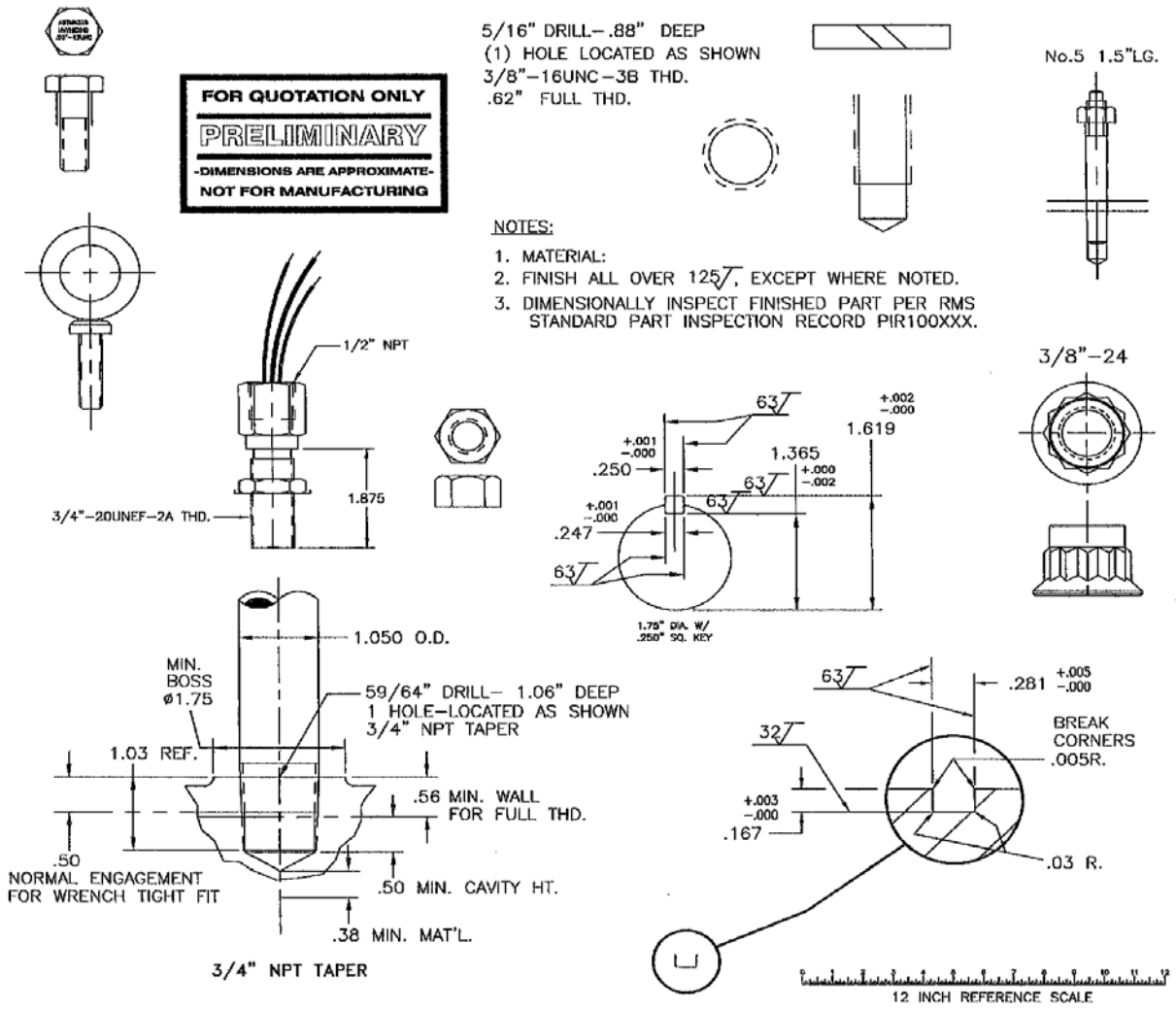
To further utilize the benefits of computer generated layouts and drawings, the implementation of "blocks:", at Rotating Machinery Services, assures repetitive, error free work.

From creating the initial concept by "pasting" commonly used geometry into a new layout design, to inserting repetitively used notes into manufacturing drawing for supplier issue, blocks are used every day in our RMS Drafting department.

RMS has established, over a fifteen year period, a directory in which hundreds of items can be attained and used for this purpose.

The process of using these existing available items not only eliminates the human error factor, but also produces a much quicker turnaround of proposed designs along with the completion of drawings in a fraction of the time vs typing notes and drawing unique views from scratch. Supplier defined blocks of hardware, and various specialty items are also available to expedite the process and ensure dimensional accuracy.

Using AutoCAD to its fullest is just one example of how, we here, at RMS respond to our customer's needs and expectations to the level they depend on.



SOLIDWORKS DESIGN TABLES INCREASE RMS CAPABILITIES

By Corey Jones

Over the past several years, RMS has continued to expand its utilization of SolidWorks 3D modeling software. Increasingly, RMS is providing SolidWorks geometry directly to our vendors for the development of 3D tool paths for CNC machining. These models achieve greater dimensional accuracy, decrease human errors, and help to decrease our vendors' delivery times; however, the development of 3D models from scratch can be a labor intensive exercise. With the use of Design Tables in SolidWorks, RMS has managed to greatly reduce the time required to create new 3D part geometry, helping RMS increase efficiency and decrease delivery times to customers.

RMS is currently overhauling three different Ingersoll-Rand axial compressor rotors. Between these three rotors, nearly 300 new rotor blades will need to be manufactured which will require the creation of dozens of new SolidWorks models. While no two stages between the three machines have identical blading, almost all differences between rotor blades can be summarized with a handful of characteristics, including airfoil style and frame size, rotor hub diameter, root design, rotor disc broach angle, and blade tip crop height.

With the use of Design Tables within SolidWorks, RMS is able to create 3D models that have dimensional values linked directly to Microsoft Excel worksheets. Each 3D model contains multiple "Configurations", each of which defines 3D geometry for separate part numbers. The only common feature required between configurations is airfoil shape. By linking 3D dimensional values to an Excel spreadsheet, creation of 3D geometry for a new blade is as simple as typing a few numbers into a table. When the SolidWorks model is next opened, a new configuration (representing the new blade model) will be created reflecting the dimensional values previously entered into the Excel spreadsheet. A process that used to take several hours can now be completed in about 15 seconds!

RMS has already employed Design Tables in creating axial compressor rotor blade models for 4000 frame size NACA 65 and DCA airfoil shapes. And the use of Design Tables isn't limited to axial compressor blades; a model for RMS low-erosion rotor blades for the EX48 expander is already complete, and models for axial compressor variable stators are in development.

So what does this mean for our customers? Decreased delivery times will be a direct result of increased internal efficiency. Additionally, RMS has amplified its capacity to create 3D geometry, which will increase efficiency and accuracy across a plethora of applications, including aerodynamic studies, structural and vibration analyses, and part inspections, just to name a few.

S28

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		$COMMENT	$PARENT	Stagger Angle@Sketch_Blade Rotation	Dhub@Sketch_Radial Planes	Dist. Width@Sketch_Root Hub	$$TATE@T Slot Machining	W1@Sketch_T Slot Length	Depth@Sketch_T Slot Length	W2@Sketch_T Slot Width	$$TATE@Blade Cropping	X1@Sketch_Blade Cropping	X2@Sketch_Blade Cropping	R1@Sketch_Blade Cropping	R2@Sketch_Blade Cropping	
2	**102204**	23.5° Stagger Angle, 60" Hub dia. (Machining)		23.5	30	3.375	U	0.38	0.08	0.436	S	1	1	27.5	27.5	
3	105128-4	23.5° Stagger Angle, 60" Hub dia. (Cropping)	102204	23.5	30	3.375	U	0.38	0.08	0.436	U	1	1	21.092	20.942	
4	105128-5	23.5° Stagger Angle, 60" Hub dia. (Cropping)	102204	23.5	30	3.375	U	0.38	0.08	0.436	U	1	1	20.786	20.642	
5	105128-6	23.5° Stagger Angle, 60" Hub dia. (Cropping)	102204	23.5	30	3.375	U	0.38	0.08	0.436	U	1	1	20.503	20.443	
6	105128-7	23.5° Stagger Angle, 60" Hub dia. (Cropping)	102204	23.5	30	3.375	U	0.38	0.08	0.436	U	1	1	20.207	20.189	
7	105128-8	23.5° Stagger Angle, 60" Hub dia. (Cropping)	102204	23.5	30	3.375	U	0.38	0.08	0.436	U	1	1	20.058	19.926	
8	**102205**	18° Stagger Angle, 60" Hub dia. (Machining)		18	30	3.375	U	0.38	0.08	0.436	S	1	1	27.5	27.5	
9	105128-3	18° Stagger Angle, 60" Hub dia. (Cropping)	102205	18	30	3.375	U	0.38	0.08	0.436	U	1	1	21.389	21.253	
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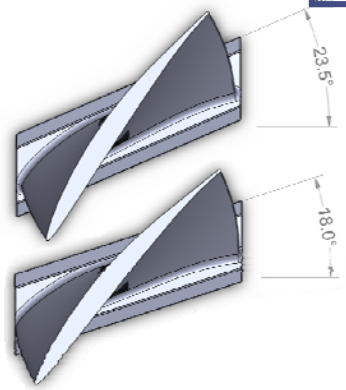
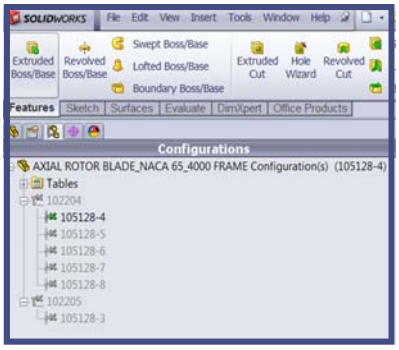


Furthermore, since RMS has been using a FARO laser scanner to scan all axial compressor rotor blades that pass through the shop, RMS now has the capability to take orders for new rotor blades for any inspected rotor, even after it has left the building. Through continued adoption and implementation of cutting-edge technology, RMS is constantly increasing its capabilities, helping us deliver the best products and services possible to our customers.



WELCOME RMS NEW EMPLOYEES

By RMS Staff

HERB FISCHER - SR. APPLICATIONS ENGINEER

Herb has over 30 years of application engineering, marketing, commercial and sales experience in Turbomachinery and Emissions Monitoring Products and Markets. He has had various positions including Business Development Manager, Commercial Director, Sr. Technical Consultant, Director of Marketing and Sales, and Product Manager. His background has been with the Babcock & Wilcox Company, GE Energy, Dover Diversified, CONMEC and Ingersoll Rand.

Herb graduated with BS in Mechanical Engineering from Lafayette College and an MBA from Moravian College.

TOM EDWARDS - MANAGER - QUALITY OPERATIONS

Tom Edwards has 40 years' experience in the Turbomachinery Industry. Tom began his career at Ingersoll-Rand Turbo Division in Phillipsburg, New Jersey, where he held roles in Inventory Control, Production Control, Quality Assurance and Quality Control. Tom left I-R in 1987 to join John Deere Technologies as a Chief Inspector. In 1989, Tom left John Deere to join CONMEC where he held various leadership positions in Quality, Sourcing and Project Management. Tom was part of the transition team that moved the GE CONMEC operations from Bethlehem and Easton, Pennsylvania to the GE Oil & Gas Service Center in Houston, Texas. Tom retired from GE Oil & Gas in October 2013. Tom's retirement was short lived. Tom has joined Rotating Machinery Services as their Manager – Quality Operations.

RYAN MONTERO - AERODYNAMICIST

Ryan Montero has joined RMS, Inc. as our Staff Aerodynamicist. He is a recent graduate from Virginia Polytechnic Institute and State University with a Masters degree in Aerospace Engineering with a focus in Aero/Hydrodynamics.

Ryan looks forward to beginning his career at Rotating Machinery Services, Inc.

MIKE LOUREIRO - DESIGN ENGINEER

Mike Loureiro joined RMS on November 4th, 2013 as a Design Engineer. He graduated from Lehigh University in May, 2013 with a B.S.M.E. and a minor in energy engineering. Mike's background has been in machining, as his past six years have been spent working as a toolmaker in a local factory. He is excited to be beginning his engineering career in the field of turbomachinery and looks forward to learning and solving problems.

CHRISTINE RASICH - STAFF ACCOUNTANT

Chris has joined the RMS team as their Staff Accountant. She brings with her 15 plus years of tax accounting experience working for the City of Bethlehem. She worked in the Tax Office doing local tax returns and employer's quarterly returns for local 1% wage tax. Chris became a tax auditor in 2000 where she worked on delinquent taxpayer and employer returns until joining the RMS Team. She is very excited to be a part of such a successful growing company.

Rotating Machinery Services, Inc.

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www.RotatingMachinery.com

PRODUCT LINES

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

POWER RECOVERY TRAIN ROUNDTABLE

By Don Shafer

Rotating Machinery Services, Inc. was pleased to present our second Power Recovery Train Roundtable on October 29th and 30th of 2013. Fortunately, this year there were no hurricanes to disrupt the schedule and all the attendees arrived as planned.

During the presentations over the two days, the presenters provided information on all aspects of Power Recovery Train design, reliability and operation. Some of the key topics of discussion were FCC Expander Design, Axial Compressor Design, Expander Deposition and Erosion, Online Monitoring, Structural Analysis, Rotor Dynamics and Field Service / Outage Planning. A tour of the RMS shop was also given on the last day to highlight our shop capabilities and upgrades.

All of the attendees were very experienced PRT end users / machinery engineers who during the discussions shared valuable first-hand experience on field problems and issues that affect them on a day to day basis at their sites. The shared experiences provided for some very detailed technical discussions and lessons learned. This type of interaction with the end users helps to improve RMS's ability to provide more reliable PRT equipment.

Once again we would like to thank all the attendees, presenters and RMS staff for making our second PRT Roundtable an even bigger success. We would also like to make everyone aware that based on the positive response from the attendees RMS plans to continue to do Roundtables in the future.