ROTATING MACHINERY SERVICES, INC.

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THE FINISH LINE

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RMS POWER SOLUTIONS

By Charles (Chot) Smith

Late in the third quarter of 2012, RMS / RMS Power Solutions was again given the unique opportunity to prove our capabilities as world class experts and competitors in the field of turbo machinery.

In August, we were contacted by a refinery in Europe to support an emergency breakdown of their FCC power recovery train. This breakdown was caused by the failure of an Elliott hot gas expander. The challenge consisted of restoring their FCC main air axial compressor service on motor only, as soon as possible. The compressor required an inspection resulting in the installation of the spare rotor.

We were able to restore service in a 10 day period. RMS was than awarded the RCA (root cause analysis) for the expander failure and the rebuild of the damaged expander using an existing spare rotor. During the RCA , it was determined that the entire intake casing assembly was no longer suitable for service.

We were awarded the Intake casing assembly including first and second stage stator housings based on price and delivery beating the competition by a large margin on both requirements. RMS was able to deliver the assembly in an expedited 16 weeks from date of order. Our field service and engineering team is currently in Europe to support the installation of the intake casing and expander assemblies enabling an early February start-up.

All of us at RMS are extremely proud of this accomplishment which not only met, but exceeded the customer requirement.

What's Inside

WISHING YOU

A PROSPEROUS

NEW YEAR!

FROM THE RMS TEAM

RULES OF THUMB - STEAM TURBINES

By Neal Wikert

		Material	Specification
Casing Materials	250psig, 500 deg. F	cast iron	ASTM A-278 Cl. 40
	600psig, 750 deg. F	cast steel	ASTM A-216 WCB
	900psig, 825 deg. F	alloy cast steel	ASTM A-217 WC1
	900psig, 950 deg. F	alloy cast steel	ASTM A-217 WC6 (1¼ Cr, ½ Mo)
Shaft materials	Hot rolled	alloy steel	SAE 4140
	Forged	alloy steel	SAE 4340 (ASTM A291 or A668)
	Integral forged	alloy steel	ASTM A-470 Class 7
Discs	Forged	Chrome Moly	AISI 4340
	Integral with shaft	Chrome Moly Vanadium	ASTM A-470 Class 7
Blades	Bar Stock	12% Chrome S.S.	AISI Type 403
Bearing Housings	Cast Iron		ASTM A-48 CL. 30
	Steel	Carbon Steel	SAE 1018, 1020
	Bearing Shells	Carbon Steel	SAE 1018, 1020
	Liners	Babbit	ASTM B-23 Grade 2

RMS CONGRATULATES DON SHAFER

By RMS Staff

Rotating Machinery Services, Inc. congratulates Don Shafer on his promotion to Product Manager – FCC Expanders.

Don has been very instrumental in the rejuvenation and execution of our FCC Expander Product Line. Don's leadership has enabled RMS to provide a consistent product focus.

Don has thirty five years of engineering and design team leader experience with thirty two years devoted to Turbo Machinery used in the Refining and Petro-Chemical Industry.

We thank Don for all his efforts and look forward to RMS becoming our industry's premier expander manufacturer.

RMS WELCOMES NEW SENIOR PROJECT MANAGER

By RMS Staff

RMS welcomes Dirk Paraschos to the RMS Team, as Senior Project Manager.

Dirk has thirty three years of experience in the International Onshore and Offshore Refining and Petro-Chemical Industry. His experience includes Director of multi-million dollar projects involving Bid Proposal, Engineering, Procurement Construction, Installation, Start-Up including Operation and Maintenance.

Prior to RMS, Dirk held the position as Director of Gas Compression Division at CCC Fabricaciones Y Construcciones, S.A. DE C.V. – Mexico City, Mexico, Senior Project Manager at Conmec and Service Supervisor /Start-Up Engineer at Ingersoll Rand.

We all would like to extend a warm welcome to Dirk!

10TH ANNIVERSARY—SYDNEY GROSS

By RMS Staff

March 12, 2013, marks the 10th anniversary for Sydney Gross, Director of Steam Turbines at RMS.

We would like to take this opportunity to thank him for these past 10 years of fine work. dedication and company loyalty. We know that the growth and success of our company is largely dependent on having strong and capable staff members. We recognize the contribution Sydney has made in helping RMS maintain the strong position we enjoy in the turbomachinery industry.

Congratulations, Sydney!!

CONGRATULATIONS JOE KOVACS

By RMS Staff

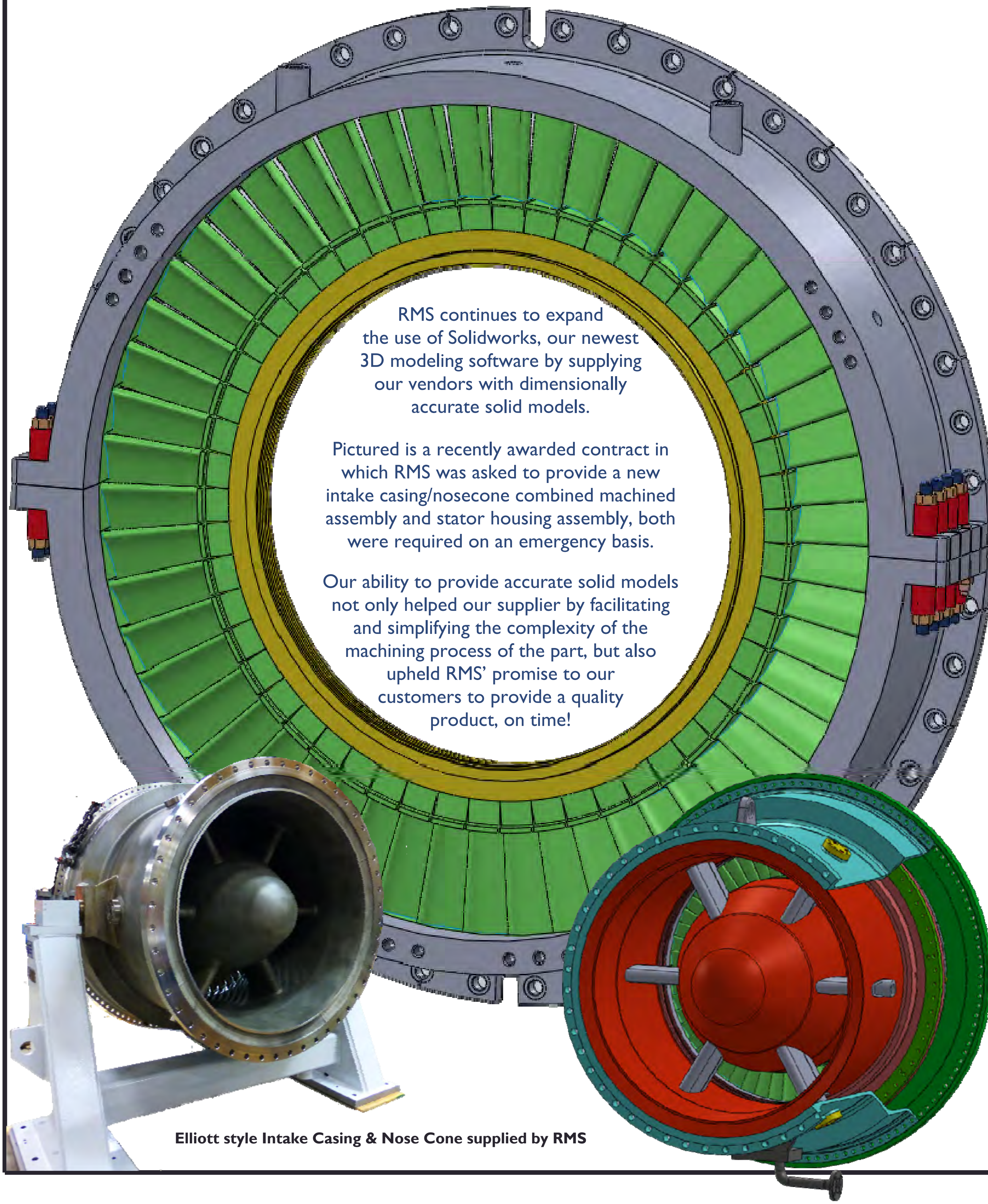
The RMS Staff would like to congratulate Joe & Marla Kovacs on the birth of their son Tyler Joseph Kovacs. Little Tyler made his way into the world on December 13, 2012. He weighed 8 lbs 2 ounces and was 21 inches long. Tyler has one brother, Zakary, 5, and two sisters, Maci, 3 and Kylie, 2.

Tyler is an up and coming fan of the Chicago Bears! Tyler's father, Joe is an assembler in the RMS Power Solutions shop.

Congratulations Marla and Joe!

A MODEL SUCCESS

By Rich Pittenger



RMS continues to expand the use of Solidworks, our newest 3D modeling software by supplying our vendors with dimensionally accurate solid models.

Pictured is a recently awarded contract in which RMS was asked to provide a new intake casing/nosecone combined machined assembly and stator housing assembly, both were required on an emergency basis.

Our ability to provide accurate solid models not only helped our supplier by facilitating and simplifying the complexity of the machining process of the part, but also upheld RMS' promise to our customers to provide a quality product, on time!

Elliott style Intake Casing & Nose Cone supplied by RMS

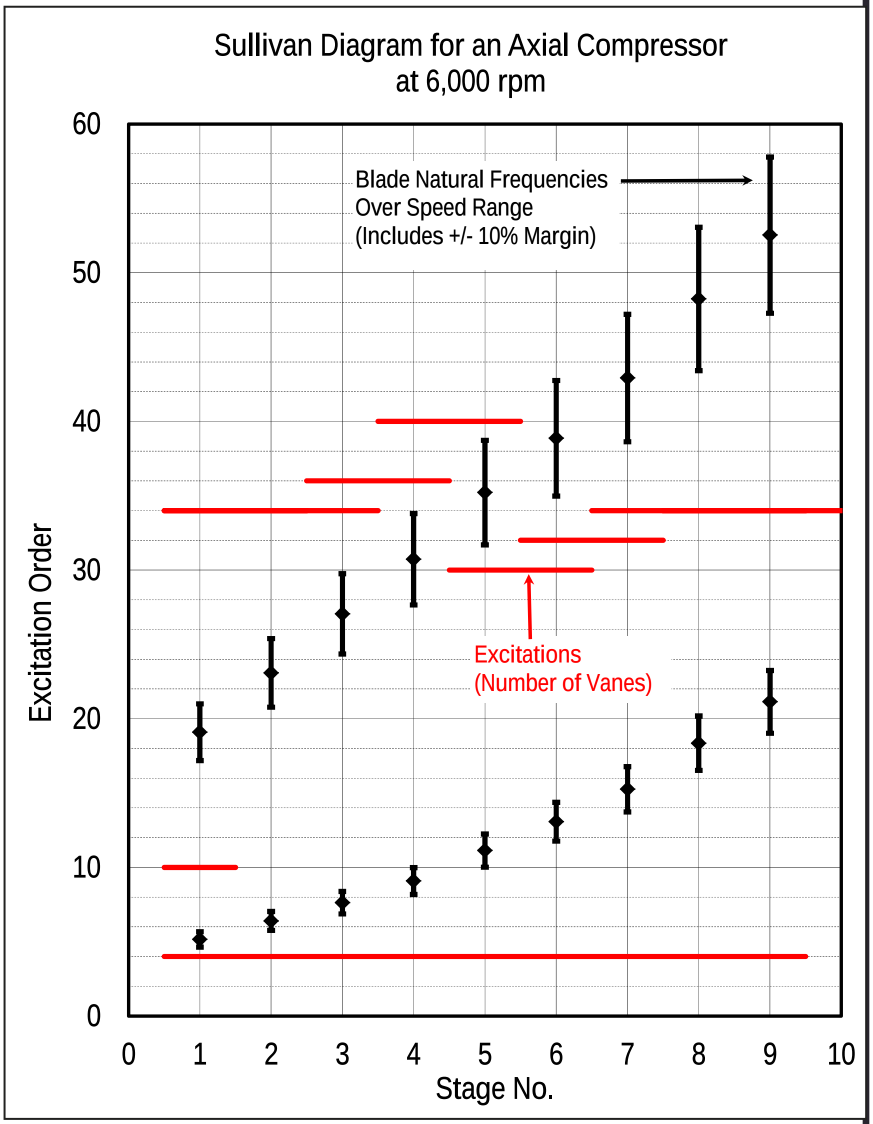
"SULLIVAN" STATOR COUNT DIAGRAM

By William Sullivan, P.E.

The "Sullivan" stator count diagram was developed in order to get all of the frequency avoidance information relating to periodic excitations (e.g., stator vanes) for an axial compressor (or any multi-staged turbo machine) on one page. It is essentially a one-page stage-by-stage Campbell diagram.

With a Campbell diagram, the blade and excitation frequencies vs. rotor speed are presented on a single plot for each stage. Therefore, to review the frequency avoidance situation for a multi-stage compressor one has to flip through as many pages as there are stages (probably taking notes for each stage). Furthermore, for many machines, both the upstream and downstream sources of excitation must be examined. In these cases, trying to keep track of the effects of individual stator counts on the adjoining blade rows can get confusing (and is why the Sullivan diagram was developed in the first place).

Basically, rather than plot the frequencies vs. rotor speed for each stage on a single plot, as is done with a Campbell diagram, The Sullivan diagram has the frequencies for all stages plotted on one chart (Figure 1). What makes the diagram particularly useful for avoiding periodic flowpath excitations is that all of the frequencies are plotted as multiples of rotor speed, thus making the identification of good and bad stator counts immediately evident.



The excitation order equation is $E = 60\ F / N$

Where:
E = Excitation Order, Excitations (Cycles) per Revolution
F = Frequency, Cycles per Second
N = Rotor Speed, Revolutions per Minute

When plotting a particular rotor blade mode of vibration, an excitation order is calculated at the minimum operating speed minus any required separation margin and an excitation is calculated at the maximum operating speed plus the separation margin. The two orders are joined by a thick bar as seen on the sample diagram. The stator counts are plotted directly as excitation orders for whatever stages they affect (or are assumed to affect). For example, for the sample diagram shown, the 30 vanes of the fifth stage affect both the fifth stage blades (upstream) and the sixth stage blades (downstream).

Although this procedure appears rather cumbersome, it is easily adapted to a spreadsheet and has become our preferred tool for setting stator counts for axial compressors.

RESOLUTION OF SPEED SENSOR ANOMALY

By Tony Rubino, P.E.

A refinery FCCU expander recently encountered unexpected overspeed trips during post turnaround startup. Both the speed pickups and the rotor shaft were new. The expander train start was initiated several times and consistently tripped due to false overspeed indication. Replacement of suspected faulty probes did not resolve the problem.

Since the startup turbine probes were functioning normally, it was decided to compare the turbine probe signatures to the expander. The comparison is presented in the photographs below.

Figure 1 - The red arrow points to the turbine speed probe targets. Note the spacing of the targets relative to the target diameter.

Figure 2 - The red arrow points to the expander speed probe targets. Note the expander targets are more widely spaced than the turbine targets.

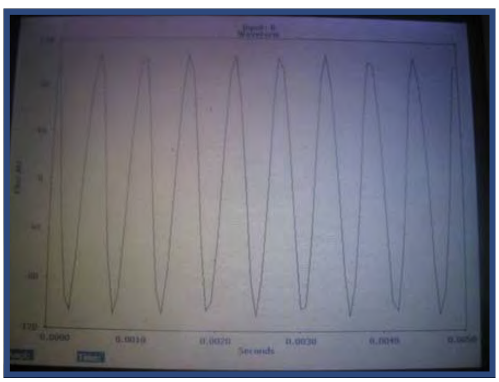


Figure 3 - The turbine sensor waveform from an oscilloscope is almost perfectly sinusoidal due to the configuration of the target. This waveform was taken at full speed (3,600 rpm). The wave form has similar shape but smaller magnitude at slow roll.

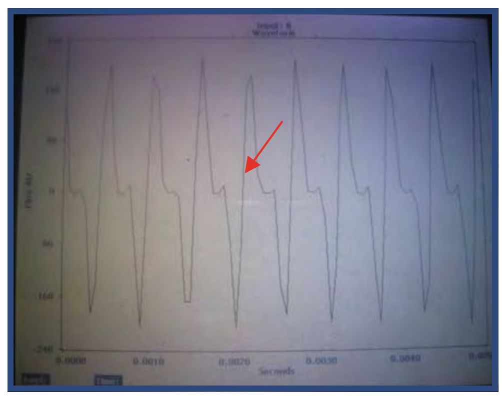


Figure 4 - The expander wave form exhibited a knee or shoulder due to the spacing of the targets. The short peak at the end of the knee (see red arrow) proved problematic at elevated speed.

Figure 5 - The turbine sensor spectrum was very clean exhibiting essentially only the target frequency of 1,800 Hz (30 targets X 60 Hz) at 3,600 rpm.

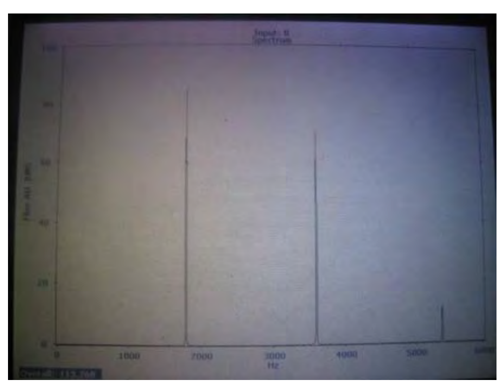


Figure 6 - The expander sensor spectrum was noisy exhibiting the target frequency as well as a strong 2X harmonic.

RESOLUTION OF SPEED SENSOR ANOMALY *Con't*

By Tony Rubino, P.E.

The understanding of three key items led to the resolution of the problem. First, the output of the sensor was a function of target surface speed and gap from the probe to the surface. Higher rotor speed and smaller gap both increased sensor output voltage. Second, increased sensor output amplified the noise as well as the desired target signal. A very sensitive monitor would count the noise as well as the target signal. Third, attenuation of the probe output greatly reduced the influence of the harmonic noise. Accordingly, a 1k Ohm resistor was added to the control circuit and the probe to surface gap was increased to attenuate the signal and to minimize the potential for electrical ringing. The final waveform and spectrum are show below.

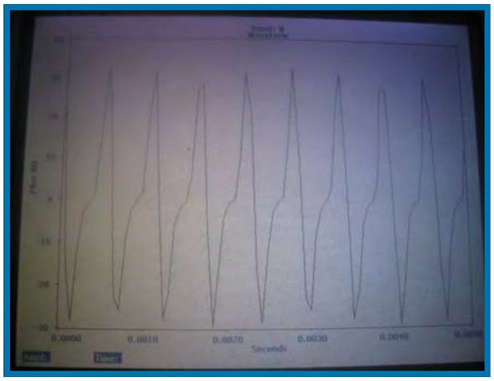


Figure 7 The attenuated signal shows almost complete removal of the "knee".

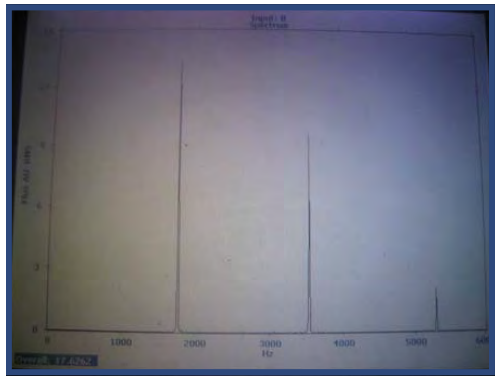


Figure 8 The harmonics are still present but sufficiently filtered to not affect the speed sensor monitor.

The root cause for the phenomenon is still unknown. A possible difference between the two rotor shafts is suspect and will be investigated during the overhaul.

POWER RECOVERY ROUND TABLE

By Don Shafer

Rotating Machinery Services, Inc. was pleased to present our first Power Recovery Train Roundtable on November 13th and 14th of 2012. Despite Hurricane Sandy forcing a postponement from the original dates, the majority of attendees were able to adjust their schedules and attend on the new dates.

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.

The majority of attendees were PRT end users / machinery engineers who during the discussions shared valuable first-hand experience on field problems and issues that affect them at their sites. This type of interaction with the end users helps to improve RMS's ability to provide more reliable PRT equipment.

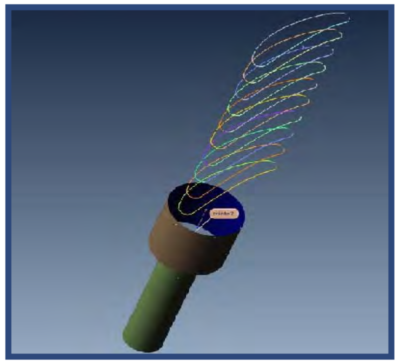
Once again, we would like to thank all the attendees, presenters and RMS staff for making our first PRT Roundtable a success. We would also like to make everyone aware that based on the positive response from the attendees RMS plans to continue to do Roundtables in the future.

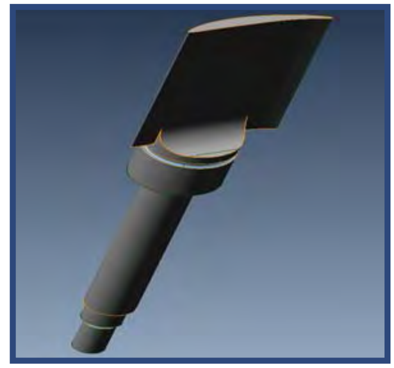
PARTS PROCESSING – AXIAL COMPRESSOR VARIABLE STATOR VANE

By Robert Dehart ASQ CQT

The process of determining whether to repair or replace stator vanes that may have exceeded their serviceability due to wear, damage or obsolescence, begins with a thorough evaluation of the existing parts.

When the parts are received, they are inventoried, identified and cleaned. They are then visually inspected, non-destructively tested and analyzed to determine material composition.





The next step is dimensional inspection.

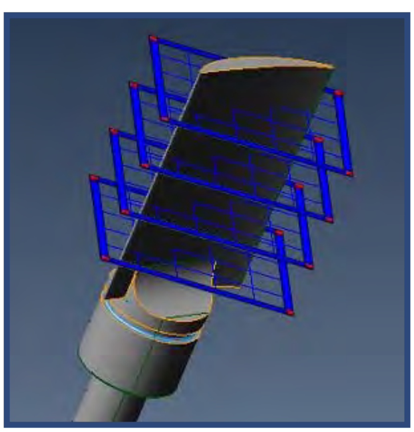
A digital representation including airfoil cross-sections or point clouds is generated using the co-ordinate measuring machine (CMM).

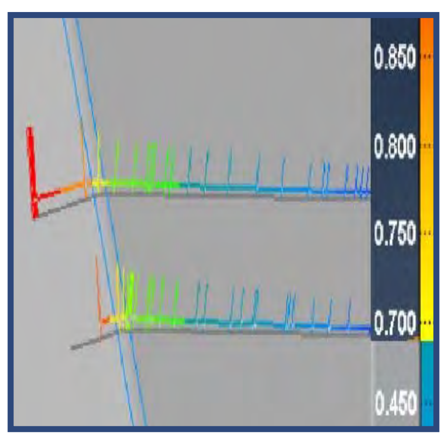
Once the digital data is captured, it is transformed using SolidWorks 3D computer aided design software into a virtual three dimensional solid model.

The solid model can be evaluated in the virtual environment using analytical software. Evaluation may include structural, frequency and fluid flow analyses. The model can be modified to add strength and limit stress, to avoid resonant frequencies and to adjust tangential velocity.

If the decision is to replace the existing parts, the model can be used to control the machine tools that will shape a new part from a solid block of metal.

When the new part has emerged from the virtual realm, it is ready for final inspection. The CMM is used to compare the physical part to the virtual model. First the part is aligned to the model. Then cross-sections can be probed and deviations from design intent reported in the form of a color coded map.



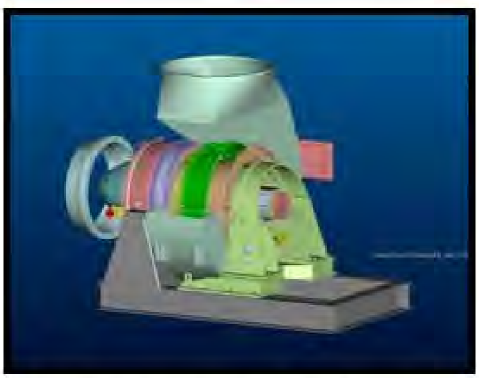


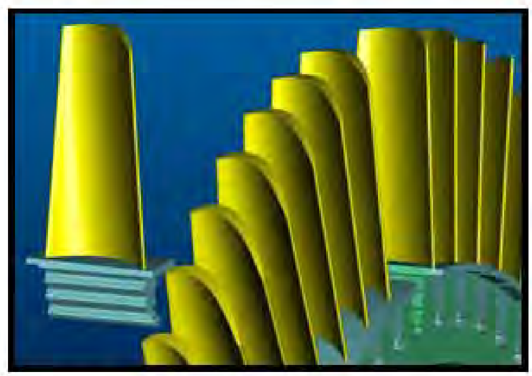
These are the essential steps in the process of assuring that parts provided to our customers have undergone rigorous evaluation and are ideally suited to meet the requirements of the environment in which they will be employed.

FCCU Hot Gas Expander

Rotating Machinery Services is backed by decades of experience in Expander 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.





- *Complete repairs & refurbishment*
- *Component supply & repair*
- *Component & Assembly redesign & upgrades*
- *Rerates for improved performance & reliability*
- *New or replacement units*
- *Flow path optimization for reduced erosion & deposition*
- *PRT auxiliary systems including instrumentation, controls, lube & seal*
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- *TSS evaluations & technical consulting*
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RMS

PRODUCT LINES:

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

CONGRATULATIONS!

Rotating Machinery Services, Inc. 1998 RMS 2013 Celebrating 15 Years

Rotating Machinery Services is very proud to announce that 2013 will begin our 15th year in business of providing aftermarket engineering and turbomachinery services to refineries, chemical plants, gas pipelines, steel mills and utilities.

Over the years, we have expanded to four office locations, which include our Main Office in Bethlehem, PA, and three Sales offices in Texas, Tennessee and Louisiana.

Our staff averages 25 years of turbomachiney experience and are experts in the turbomachinery industry. We perform a wide range of services on turbomachinery, including; reliability improvements, performance rerates, repair, component replacement and supply of upgraded/overhauled surplus equipment. We have experience with repowering of turbomachinery packages and have supplied custom designed equipment skids and lube oil systems. Our primary experience is with axial and centrifugal compressors, expanders, gas turbines, power turbines and steam turbines.

We're in Good Company!

We realize, every day, that our success is dependent on our customers' and suppliers success, and we are in very good company as we celebrate our 15 year anniversary.

We like to thank our management, employees, customers and suppliers for their continued support and confidence in RMS over these years.