ROTATING MACHINERY SERVICES, INC.

VOLUME 4, ISSUE 3

June 2008—Dec. 2008

# THE FINISH LINE

PHONE 484-821-0702 FAX 484-821-0710 WWW.ROTATINGMACHINERY.COM

## POWER SOLUTIONS

We proudly introduce RMS Power Solutions. Created to supply the kind of first-class, comprehensive shop and field services to our customers that they have come to expect from our engineered products. We provide a one-stop solution that will cover every aspect of a large project or handle your hottest emergency breakdown services.

## LARGEST RMS PROJECT TO DATE AXIAL COMPRESSOR TRAIN RERATE & REPLACEMENT

A large Nitric Acid Unit in the US operates a train consisting of an axial compressor driven by a steam turbine and a process waste gas expander. The current axial compressor performance was not capable of accommodating the flow and pressure requirements for a 700 ton/day future case. RMS is providing a surplus axial compressor with a surplus steam turbine driver. RMS is designing, rerating and refurbishing the axial compressor, steam turbine, existing expander and spare rotors to maximize reliability and maintainability and meet new plant requirements. The entire train will be packaged on an RMS supplied baseplate including oil piping, electrical wiring and instrumentation. A surplus lube oil console is also being refurbished to API 614 standards. RMS will provide installation service supervision and on-site engineering support. In addition to the equipment, RMS is providing a train documentation package including arrangement drawings, assembly drawings, compressor performance maps, expander performance map, assembly clearance drawings and operating instructions.

We've Expanded

**Best wishes for a Happy, Healthy Holiday and a Prosperous New Year!**

***from all of us at Rotating Machinery Services, Inc.***

## What's Inside

# RULE OF THUMB - COUPLINGS

**By Neal Wikert**

Couplings

Pull up Taper of .750"/ft.

| Size | Keyed Hub | Keyless Hub |
|---|---|---|
| 1.5 | .018" | .048" |
| 2 | .024" | .064" |
| 2.5 | .030" | .080" |
| 3 | .036" | .096" |
| 3.5 | .042" | .112" |
| 4 | .048" | .128" |
| 4.5 | .054" | .144" |
| 5 | .060" | .160" |
| 5.5 | .066" | .176" |
| 6 | .072" | .192" |
| 6.5 | .078" | .208" |
| 7 | .084" | .224" |
| 7.5 | .090" | .240" |
| 8 | .096" | .256" |
| 9 | .108" | .288" |
| 10 | .120" | .320" |

O-ring Materials:

O-ring: Buna-N, 70 Shore A durometer. (Parker: N-0674-70)

Back-up Ring: Buna-N. (Parker: N-300-90)

Coupling bolts are weighed and corrected to be the same. As a general practice, bolts and nuts should be kept together since the entire coupling assembly was balanced.

Coupling bolts can be turned end for end if needed for torquing. Bolts can be torqued from the bolt end or the nut end. Coupling torques are lubricated values.

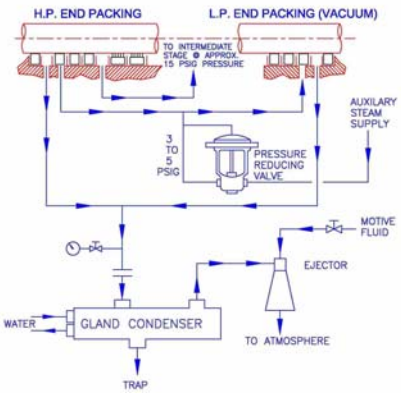
Coupling Hub Minimum Contact – Blue Check

| | |
|---|---|
| Hub to Shaft | 75% |
| Gauge to Gauge<br>Lapping to Lapping<br>Gauge to Lapping | 95% |
| Gauge to hub or shaft | 85% |

# STEAM TURBINE SEAL SYSTEMS

**By Sydney Gross**

In the last issue, we discussed shaft seals and how they function. We know that we can't stop all steam from escaping the casing past the shaft or, in the case of a condensing turbine, prevent leakage into the exhaust casing 100%. High pressure and temperature steam leakage can be a safety issue and contaminate the lube oil with water. Air leakage into a surface condenser dramatically degrades its performance. So how is this leakage handled?




There are many different arrangements for accomplishing this task depending on the type of turbine and the amount of pressure being sealed. They are generally referred to as gland seal systems. The glands are areas between shaft seals where steam is injected or leaked off. A gland seal system is typically composed of two systems: a regulated injection of low pressure steam called sealing steam and a vacuum system that draws leakage from the seals typically called the gland condenser system.

The gland condenser system is typically made up of a small condenser, an ejector and the associated piping valves and gauges between these components and the turbine seals. The ejector uses air or steam as a motive fluid to draw a vacuum on the steam side of the condenser, which is relayed to the seal glands through the piping.

The steam that is drawn off is condensed in the gland condenser. The system is regulated such that a slight vacuum is maintained at the seal glands to draw off the leakage and maintain some level of flow directionality within the seal. Sometimes, the gland condenser and ejector are eliminated from the system and an eductor is used in their place. The leaked off steam is drawn directly into the eductor body and condensed by mixing with the eductor motive fluid, which is water.

One might ask why steam would be injected into the seals when that is precisely what we are trying to eliminate. There are two main reasons why the sealing steam system exists. The gland condensing system is designed for only a slight vacuum at the seals, on the order of ½ psi vacuum. Condensing turbine condensers, called surface condensers, generally draw a very strong vacuum, on the order of 1 to 2 psi absolute. The surface condenser would easily overwhelm the gland condenser system capability and draw in air from the shaft end seals. To prevent this from happening, steam is injected at a pressure of a few psi gage between the turbine exhaust casing and the gland condenser. The injected steam flows in both directions along the shaft to the exhaust casing and the gland condenser. The additional injected steam does not have a measurable impact on the surface condenser performance. Air is still drawn into the gland condenser with the sealing steam but its vacuum is supplied by the ejector and not affected by the introduction of air.

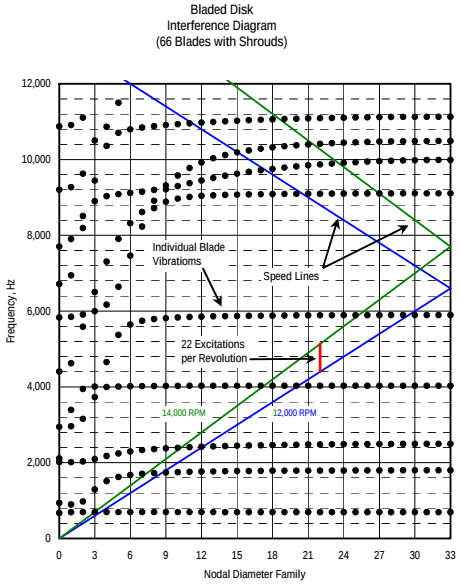
## STEAM TURBINE SEAL SYSTEMS *(con't)*

The other reason for steam injection occurs at the high pressure end of the turbine during startup and very low loads. At these times, it is possible for a vacuum to be drawn inside the turbine at the high pressure shaft seals. To prevent air from entering the turbine casing during these transient conditions, steam is injected in the seals between the turbine casing and the gland condenser system. When sufficient pressure exists within the casing, injection is stopped either manually or by a check valve.

## The ALIASING EFFECT and the INTERFERENCE DIAGRAM

**By William Sullivan**

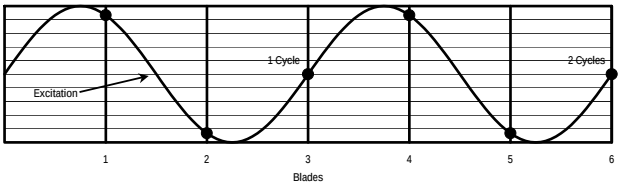
Since it's introduction in the mid 1970's, the interference diagram has become the preferred tool for displaying the interactions of rotor blade natural frequencies with periodic flowpath excitations for bladed disks with shrouds or tie-wires (typical of both compressor impellers and steam turbine stages). The interference diagram, shown below, uses the "aliasing" effect of increasingly high frequencies on a finite number of blades to allow a great deal of information to be presented on a relatively small chart. On the interference diagram, the mode shape, in terms of disk nodal diameters, is plotted on the X-Axis while both the blade natural frequencies and excitation frequencies are plotted on the Y-axis. The speed line (or lines for a speed range) starts at 0,0 and runs diagonally up and to the right of the chart until it "reflects" off the right boundary of the chart and continues to the upper left. The reflection off the right boundary of the chart is due to the aliasing mentioned above. (As frequencies increase, the speed line will eventually reflect off the left boundary of the diagram (at 0 nodal diameters) and this back-and-forth reflection will continue up the chart.)

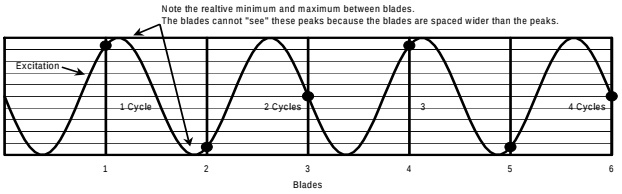



"Aliasing" is the phenomenon, commonly seen in digital signal processing, where higher frequencies are interpreted as lower frequencies because the time between the samples (or the space between individual blades) is too great to resolve the true, higher frequency. It turns out that an array of blades can "see" excitations per revolution of up to ½ the number of blades. Excitations greater than ½ the number of blades are interpreted by the blades as if there were fewer excitations.

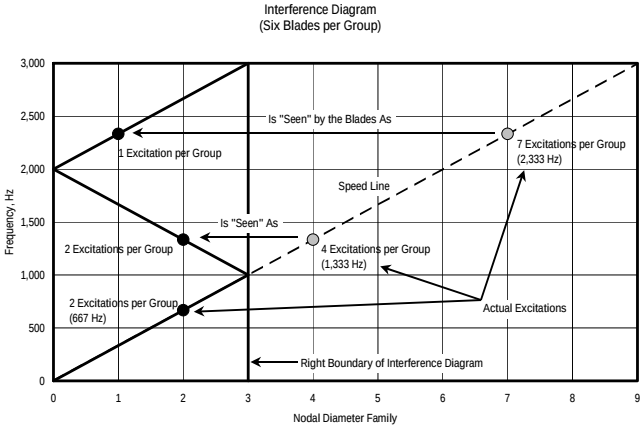
The plots on the upper right should help one to visualize what is happening. Each plot contains a group of six blades. Therefore, each group can properly detect an excitation of up to three cycles per group. The first plot has an excitation of two cycles per group. Note that there are black dots where the excitation amplitude levels cross the blades. The next plot has an excitation of four cycles per group.

The amplitude levels of this excitation cross the blades exactly where the two per group excitation crossed. Therefore, the effect of the excitations on the blades is the same whether there are two cycles per group or four cycles per group.



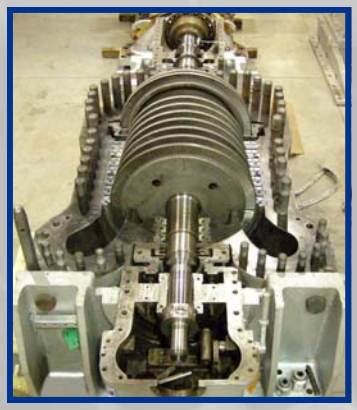




The aliasing phenomenon is what allows the speed lines of the interference diagram to "reflect" off the right (and left) boundary of the diagram and it is why only ½ of the blade count is used on the X-Axis of the diagram. An illustration of this is shown below using the six-blade example described above.



# ROTATING MACHINERY SERVICES, INC.

# ENGINEERING EXCELLENCE



## Steam Turbine Services

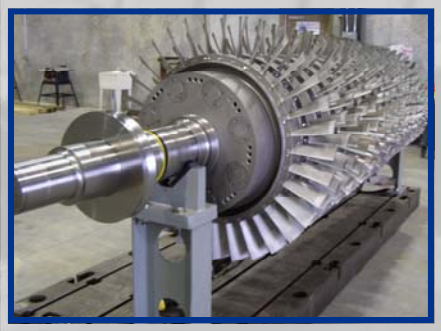
- Rerates for improved performance and reliability
- Component mechanical redesigns
- Structural and frequency analysis
- Component Failure analysis
- Valve rack design upgrades and repair

- Custom lifting fixtures
- Field Performance Testing
- On-site training
- Turnaround Support
- Field Supervision
- Maintenance engineering support

- Spare parts inventory review and optimization
- Complete rotor, nozzle block and diaphragm reconditioning
- Component supply and repair

## Axial Compressor Services

- Component redesigns & manufacturing for greater reliability and maintainability
- Failure investigation, root cause failure analysis and engineered solutions to prevent recurrence
- Site surveys for assessing machinery performance compared to industry norms and site specific potential
- Component and train rerates for optimized performance and improved reliability
- API Compliant overhaul and inspection services



- Turnaround support and field supervision
- On-site, customized training for operators and reliability / maintenance staff

MAIN OFFICE: 484-821-0702 · SALES OFFICE: 281-340-8520 · www.rotatingmachinery.com

## FCC EXPANDER FLOW PATH EROSION

By David Linden

One of the most interesting aspects of the Fluid Catalytic Cracking (FCC) hot gas expander is the area of flow path erosion. In the FCC application, the expander turbine is subjected to a dirty gas that few turbines would survive in, never the less operate for 4 or more years continually.

The abrasive in the flue gas is an aluminum-silica catalyst used in the FCC process. The catalyst aids in breaking down the heavy oil feed stock into the more desirable/useable end products such as gasoline and heating oil. FCC catalyst has the appearance and consistency of a fine powder.

A vast majority (>98%) of the FCC catalyst is removed from the flue gas via cyclone separation in the main process vessels and with the addition of a separate third stage catalyst separator. While only a small percent of catalyst that is carried over from the process, it represents a significant amount of the abrasive to the gas expander. A typical FCC expander can be subjected to 100 lbs of the abrasive ever hour. Think about that! Who would subject a piece of critical machinery to 2 ½ bags of sand every hour while the machinery is in service and expect it to last? Over the last 45 years of FCC expander operation, the expander turbine has evolved from a turbine that wore out in 3 months of operation, to one that can operate continually for 5 or more years of operation with minimal, if any performance degradation.

Typical FCC Expander Installation

Over the next several issues of the RMS Finish Line, we will explore the subject of expander blade erosion further, the changes that have evolved and the future of expander flow path erosion minimization.

# RMS WELCOMES...

### PAUL POLEY
### Field Services Product Manager / Shop Operations Supervisor

**Twenty-five years of experience in technical supervision, project management, troubleshooting, maintenance, field machining, testing and training for Wood Group, Sermatech Klock, Preco Turbine Services and General Electric.**

**Responsibilities included technical field support for turbomachinery. Developed procedures for scheduled maintenance of specialty equipment. Held position as Mechanical Supervisor and Machinery Shop Foreman providing working supervision for machine shop, specialty welding, brazing and machining. Also worked as a machinist and certified welder.**

### JEFF HELLEFINGER
### Sr. Shop Assembler—Team Leader

**Thirty years experience in the manufacturing field. Experience in shop supervision, electrical, machine shop fabrication, welding, forming metals, machinery and equipment repairs. Certification and qualifications in OSHA Safety, including but not limited to 10 Hour OSHA Safety certified.**

**Held positions as Production, Manufacturing and Building Maintenance supervisor/Shop Foreman and Lead Electrical Technician at Sartorius Stedim Systems.**

**His responsibilities include shop operation and day to day direction to shop floor.**

### RICHARD ANDERSON
### Shop Assembler

**Twenty years experience in the electrical field, assembly, installation, maintenance and customer service. Experience in isometric drawings, electrical and mechanical design schematics, construct pump and motor control cabinets, troubleshooting, installation of mounts and motor alignment. 10 hour OSHA safety training certified. Held positions as Electrician and Electrical Assembler at Sartorius Stedim Systems.**

**Rotating Machinery Services, Inc.**

**2760 Baglyos Circle**
**Bethlehem, PA 18020**
**Phone: 484-821-0702**
**Fax: 484-821-0710**

"Quality Service from Start to *Finish*"

Editor: Kathy A. Ehasz

**We're on the Web!**

**www.rotatingmachinery.com**

**If you would like to receive our newsletter via email, please contact Kathy Ehasz at 484-821-0702 or kehasz@rotatingmachinery.com.**

# RMS COMMUNITY INVOLVEMENT

Rotating Machinery Services, Inc. strongly believes in the philosophy of "Giving with a Purpose." We seek to enhance quality of life in the communities, in which we operate and to serve humanity by supporting and inspiring involvement with causes that make a profound social impact.

We support organizations both financially and through volunteerism, by helping to build awareness of their mission and goals, and by inspiring our employees, customers and associates to become involved in their good work.

We would like to acknowledge and extend our thanks to Jodi MacKenzie, RMS Controller, Neal Wikert, RMS Vice President—Projects and Robert J. Klova, Vice President—Chief Engineer for their volunteerism. On Saturday, November 29th, they participated in the 5K "2008 Turkey Trot Run and Fitness Walk" in Bethlehem, PA. Proceeds benefit the Historical Downtown Bethlehem.

Organizations RMS has supported in 2008 are:

National Multiple Sclerosis Society • American Diabetes Association • Action for Animals •
United German Hungarians • Bethlehem Area School Newspaper Reading Enrichment Program •
Special Olympics • Big Brothers Big Sisters of South Texas

# CONGRATULATIONS!!

### *5TH ANNIVERSARY*

Sydney Gross, RMS Product Manager—Steam Turbines celebrates his 5th Year Anniversary with Rotating Machinery Services, Inc. We would like to thank Sydney for his outstanding performance and past and continuing dedication to our team and our customers.

### *INC 5000—RMS MAKES LIST 2ND YEAR*

We are proud to announce that for a second consecutive year, Rotating Machinery Services has made the Inc. 5,000 list of the fastest-growing private companies in the country.

The Inc. 5,000, as extension of the Inc. Magazine's annual Inc. 500 list, catches many businesses that are too big to grow at the pace required to make the Inc. 500, as well as a host of smaller firms. Taken as a whole, these companies represent the backbone of the U.S. economy.

***The smallest act of kindness is worth more than the grandest intention. ~Oscar Wilde~***