ROTATING MACHINERY SERVICES, INC.

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THE FINISH LINE

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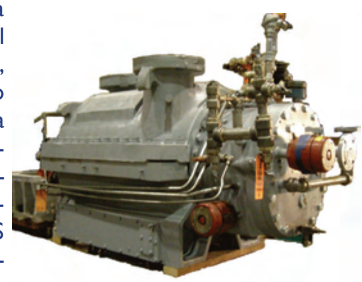
EVENTS AND HAPPENINGS AT RMS

IMechE INTERNATIONAL CONFERENCE ON COMPRESSORS & THEIR SYSTEMS

By Robert J. Klova



RMS will be jointly presenting a paper with a representative from a major international refinery in the UK at the IMechE International Conference on Compressors and their Systems, on September 9, 2009. in London, England The paper is titled "Reliability changes to a multistage refrigeration compressor", and describes upgrades to a four stage centrifugal compressor that dramatically improved machine reliability. Previously, the compressor had experienced failures on multiple, successive start-up attempts that required complete overhauls. Improvements designed and implemented by RMS have resulted in zero failures during numerous starts since the machine was reinstalled in March 2008.

To find more on this conference, please visit the IMechE web site at www.imeche.org/events

API 687 SEMINAR SCHEDULED AT RMS IN NOVEMBER

By Kurt Diekroeger

The API Rotor Repair Course will be held at our facility on November 2 through Friday, November 6, 2009. The course is based on API standard 687, covering the minimum requirements for the inspection and repair of rotating equipment rotors, bearings and couplings used in the petroleum, chemical and gas industry services. The 4 1/2 day course, starts at 7:30 am on Monday and finishes at noon on Friday. If you are interested in attending, more information is available on the API website at http://www.api-u.org/rotorrepair.html. Hotel rooms at the Marriott Courtyard, Emerick Blvd, Bethlehem, PA are available at our Corporate Rate of $119.00 per night.

INC 5000—RMS MAKES LIST 3RD YEAR

We have recently been informed that for a third consecutive year, Rotating Machinery Services has made the Inc. 5,000 list of the fastest-growing private companies in the country. We will be notified in August of our ranking.

The Inc. 5,000, an 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.

PRIDE—INSIDE AND OUTSIDE THE WORKPLACE

The RMS Management and Staff take pride in their accomplishments on both a professional and personal level.

Recently, Jerry Hallman, RMS President was awarded First Place in the Class J - Austin-Healey 100 and 3000 division at the 6th Annual British Motorcar Gathering. An All-British Car show hosted by the Keystone Region MG Club in Hellertown, PA.

Congratulations Jerry!

What's Inside

Up Coming Conferences 3rd Quarter

IMechE International Conference, Wales UK
Sept. 7 – 9

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38th Turbomachinery Symposium, Houston, TX
Sept. 15 - 17

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GRC 2009 Annual Meeting
Reno, Nevada
Oct. 4 - 7

HAPPY BIRTHDAY AMERICA

RULE OF THUMB - LUBE CONSOLE TESTING

By Neal Wikert

The oil system needs to be run in a shop to test operation and to confirm sound levels and cleanliness. The oil used for testing must be compatible with the (intended) site oil.

Testing must include detailed cleanliness testing with recirculation and screen checking. The console must be run in a normal operating mode and be performance tested. Tests must be able to confirm design pressure and temperature levels and should also include the following:

1. Leakage test (repair and eliminate all leaks)
2. Proper operating at set point of all relief and pressure limiting valves.
3. Transfers of filters and coolers without the auxiliary pump starting due to low pressure.
4. Successful pump and system performance in both (auxiliary pump on/off) directions.
5. Successful operation at defined normal flow conditions with only one pump running.
6. Operating checks of all warning, protective and control devices.
7. Tests of plug leakage across transfer valves.

To conduct testing, screening is needed, as is a recirculation flow meter for measuring the oil flow rate. The (steam turbine) main pump driver needs to be replaced with an electric motor with a suitable motor control. The auxiliary pump driver also needs a suitable motor control, one that provides for automatic startup and shut down.

Provisions must be made to power up electronic transmitters, as there are few pressure gauges in the system.

Since the main valves are electronically driven by the control system, local controllers need to be purchased and programmed as substitutes for the more critical control system functions that will not exist at the test facility. The requirement for cooling water is unlikely to be needed since the system should not be picking up too much heat.

Most console shops are equipped to and experienced in conducting "normal" console testing, but substituting properly programmed controllers for the control system functions is beyond the "norm".

STEAM TURBINE FIRST STAGE PRESSURE

By Sydney Gross

Often times turbine manufacturers publish something called a First Stage Pressure Curve related to turbine performance. Many turbines have provisions for a casing pressure tap in the first stage vicinity. In this issue, we will consider what is meant by first stage pressure and its use as a diagnostic tool.

First stage pressure (FSP) is the static pressure following the first complete turbine stage. One might consider it the inlet pressure to the second stage. In the case of a Rateau stage, it follows the first row of rotating blades. For a Curtis stage, it follows the second row of rotating blades.

Monitoring this pressure tells us several things. The most basic is an indication of the stresses in the casing. Limits on FSP may be set to prevent casing damage. However, more frequently, it is used as an indicator of turbine performance and thrust loading. It gives an indication of flowpath area relative to steam flow rate.

To understand this more clearly, consider the turbine stages as orifices in series with a fixed discharge pressure. If we have a given flow rate through the series for a particular set of inlet conditions and we want to increase the flow rate, we need to increase the inlet pressure and reduce the specific volume of the steam. Likewise, if we want to decrease the flow, we have to decrease the inlet pressure to increase the specific volume. That is in essence how a turbine operates at different load points. If it is a single valve turbine, the governor valve throttles the steam to an intermediate pressure and specific volume that will satisfy the desired flow rate for the fixed orifice or stage areas. If it is a multi-valve turbine, the first stage nozzle area is varied to a greater extent to satisfy the rest of the stages.

One can see how the FSP can be an indicator of the turbine load for as-new conditions. However, we can take the converse of the above argument to consider adverse conditions that occur within the turbine flowpath to change its areas. Most often we are concerned with flowpath erosion which increases stage areas and flowpath deposits which decrease stage areas. A rise in the FSP for a given flow indicates erosion of the flowpath preceding the measuring point or a plugging with deposits of the downstream flowpath. The latter is a common occurrence where steam quality is poor. A drop in the FSP indicates erosion of the downstream flowpath or plugging upstream.

Apart from the condition of the flowpath, The FSP gives an indication of the thrust loading. Prior to bearing metal temperature measurement, the FSP was relied upon more heavily to predict a thrust overload condition.

As with many turbine parameters, a single data point is meaningless. In order to utilize FSP as a predictor of turbine health, it needs to be monitored along with other conditions such as flow, pressures and temperatures. With diligent monitoring, it can be a useful tool for scheduling turbine maintenance.

THE AXES OF 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). A typical interference diagram is shown in Figure 1. In our last two newsletters, we discussed aliasing and nodal diameters. In this newsletter, we will describe the axes.

The X-axis, (abscissa) contains the nodal diameter families. Nodal diameter families are modes where the blades have the same number of circumferential nodes. Figure 2 shows simplified representations of three bladed disks with continuous shrouds. The blades on the disk on the left are being excited in the first fixed-fixed tangential mode. The blades on the next two disks are being excited in the second fixed-fixed tangential mode. All of these modes belong to the three nodal diameter family. The nodal diameter families on an interference diagram refer to the number of circumferential nodes of the blades but not necessarily the disk. The number of nodal diameters of the disk may be different, particularly at higher nodal diameters, where there may be very little disk participation in the blade modes at all.

For bladed disks with blades grouped into shrouded packets, counting the circumferential nodes (or locations of maximum deflection) can be difficult. For modal analyses, performed with a finite element analysis program for example, the nodal diameter families typically are determined by conducting a Fourier analysis on the blade deflected shapes.

The Y-Axis (ordinate) contains the frequencies. There are at least three sets of frequencies required for an interference diagram. One is the natural frequency of all of the blades for all of the modes of interest. Another is the rotational frequency of the rotor. Since rotor speeds are generally given in revolutions per minute (rpm) and frequencies in cycles per second (cps or Hz), the rotor frequency on an interference diagram is:

$$f = \frac{N * ND}{60}$$

Where:

f = Frequency, Hz

N = Rotor Speed, rpm

ND = Nodal Diameters

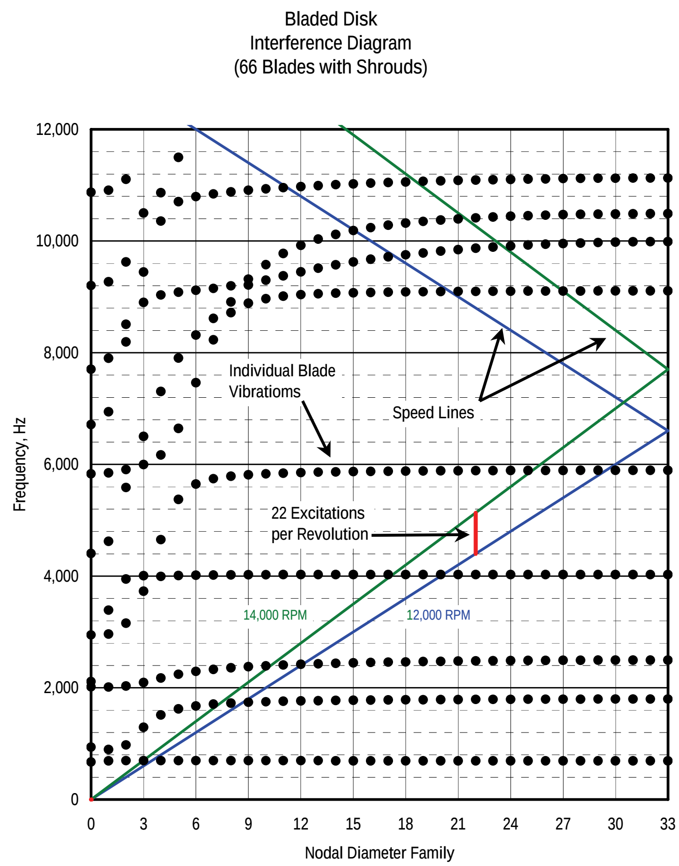


Figure 1

The third set of frequencies that must appear on the interference diagram is the frequencies related to the number of periodic excitations, which most typically are the upstream vanes (or nozzles). After all, without a source of excitation there is no interference and, therefore, no need for an interference diagram.

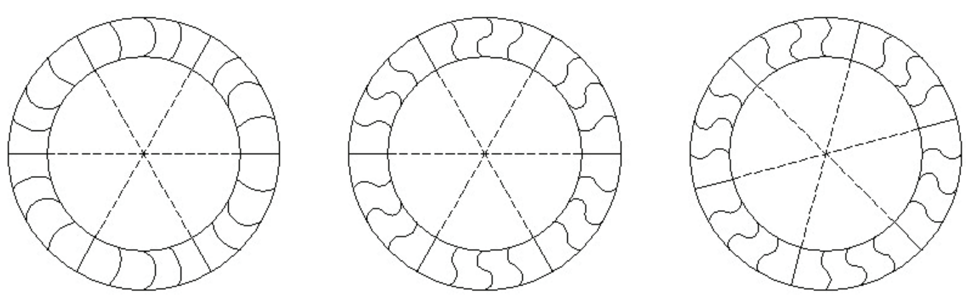


Figure 2

RMS WELCOMES NEW EMPLOYEES

Donna Schanzenbach
Controller

Over twenty years experience in the accounting field. Experience in general accounting, financial reporting and analysis, budgeting, auditing and accounting system implementations. Bachelor's degree in Accounting from Moravian College.

Formerly, Donna worked at Lutron Electronics and spent the past fifteen years leading her own accounting practice with a primary focus on non-profit organizations.

John Kurt Weinstein
3D/CAD Specialist

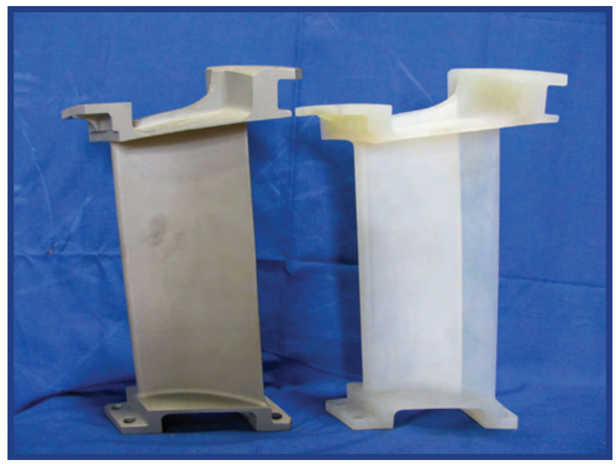
Kurt has over twenty years experience in the design/drafting field.

Most recently, Kurt worked in the cement industry, as a 3D mechanical designer of equipment. He was in the Product Development group which worked to bring new products to market.

ADVANCED DRAFTING COMES IN MANY SHAPES AND SIZES

By Richard Pittenger

In June 2009, RMS was awarded a contract by a major gas and electrical supplier for spare nozzle segments. Due to the complex shape of the part, several reverse engineering steps were taken to ensure the form, fit and function of the spare parts RMS would be providing.

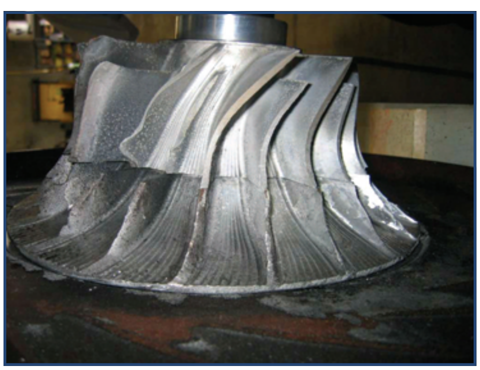


In addition to our traditional techniques of using height gage, micrometers, etc., RMS implements the newest methods whenever applicable. The existing nozzle was scanned using a high accuracy CMM mounted laser scanner accurate to 0.001". Next, the CMM scan data was used to create a Pro-Engineer 3D solid model. This model was then used to create a Sterolithography (SLA) prototype part made from a resin compound that is accurate to with 0.002" of original scanned part. In the photograph the original part is shown on the left, the SLA prototype is on the right.

High accuracy laser scanning, 3d modeling capabilities and prototype model creation, just a few of the ways RMS is dedicated to "Quality from start to finish"

DIESEL ENGINE TURBOCHARGER RCFA

by Tony Rubino



A domestic user of turbocharged, marine diesel engines has been experiencing unexplained turbocharger failures for the past eight years. Some of the failures were catastrophic and resulted in explosions. The lack of condition monitoring instrumentation continues to severely limit failure avoidance. RMS was contacted to perform root cause failure investigations on the more recent failures. Although most of the forensic evidence was damaged beyond any significant conclusive analysis, intermediate recommendations for remediation and earlier detection of impending failures were developed by RMS and the customer. Subsequently, several turbochargers were identified for removal (prior to failure) followed by forensic disassembly which proved highly informational.

The analysis is not complete at the time of this writing, but a highly plausible and somewhat complex failure scenario has evolved. During rapid throttle movement excursions, turbocharger compressor surge and rotor reverse thrust appears to affect the oil flow direction through the compressor end journal bearing eventually resulting in shaft kinking. Typical consequential damage includes bearing failure, seal failure, oil leaks, compressor tip rubs, compressor blade breakage and eventually afterburning in the exhaust casing. RMS is anticipating a multi-faceted solution including bearing redesign and possibly compressor surge avoidance protection.

FCC EXPANDER FLOW PATH EROSION

By David Linden

In our last newsletter, we discussed how significant amounts (400 ppm) of abrasive catalyst exit the FCC regenerator and would enter the power recovery expander. Experience has shown that to achieve an expander-operating period of 4 or more years, the catalyst levels must be reduced to levels less than 120 ppm. This equates to approximately 100 lbs of catalyst entering a typical 60,000 BPD expander (25,000 Hp). The catalyst removal is accomplished by use of a Third Stage Separator (TSS). The latest separation technology has shown that particle removal efficiencies have improved and can result in expander catalyst loadings of less than 50 ppm.

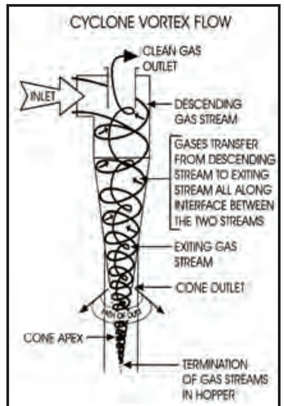


Figure #1 - Cyclone Separation Technology

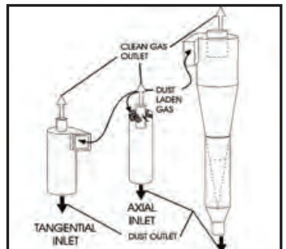


Figure #2 - Cyclonic Separation Technologies

The TSS utilizes cyclone technology that spins the catalyst-laden gas and causes the heavier catalyst particles to separate out of the gas. Figure #1 shows the operating principals of the cyclone separator.

Several different cyclone technologies have been utilized in Third Stage Separators, including tangential and scroll inlet cyclones and axial swirl vanes as can be seen in Figures #2 & 3. There has always been significant debates as to which technology is the most efficient. All of the designs are capable of removing 100% of the 10-micron and larger particles entering the TSS. There is some data that suggests that smaller size cyclones or swirl vane assembles (10 inches in diameter) provide the highest separation efficiency. Efficiency versus the propensity to plug up from catalyst deposits is a topic of debate.

Multiple cyclones or swirl vanes are needed to accommodate the high gas volume flow of the FCC Process. As few as five large diameter (>30" diameter) cyclones have been utilized in some applications, while more than 140 small size swirl vane assemblies have also been utilized.

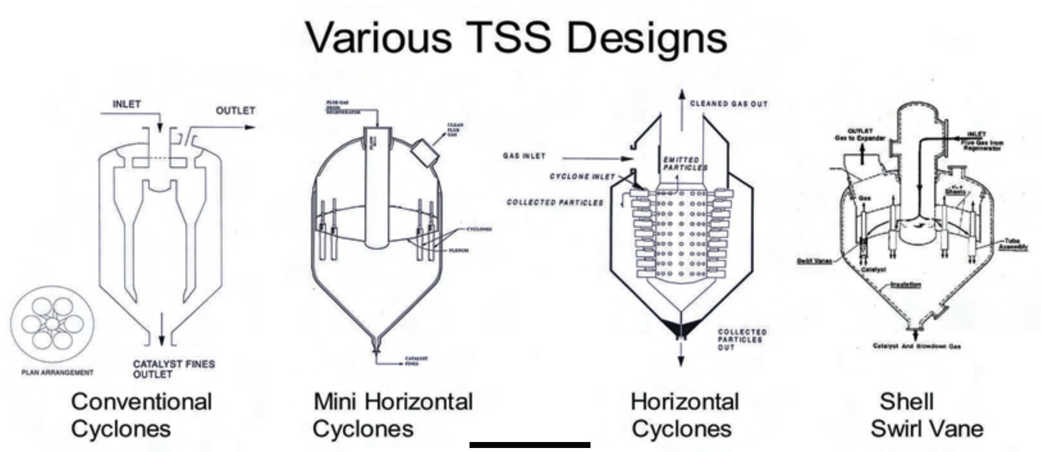


Figure #3

The merits and longevity of each design is often another area of lengthy and heated debate.

The cyclones/swirl vanes are almost always mounted in a vessel as can be seen in the typical installation shown in Figure #4. While cyclone assemblies have been mounted in both the horizontal or vertical directions. More recent technology favors a vertical mounting. The vertical mounting often reduces the size of the vessel that locates and holds the cyclones in place.

A small amount (1 to 4%) of flue gas is used to transport the separated catalyst from the bottom of the TSS. This underflow line conveys the catalyst to a 4th Stage Separator for collection or to other down stream environmental clean up devises such as an Electro-Static Precipitator or Wet Scrubber.

While there is little that an operator can do to affect the performance of the TSS under normal operation, continuous online performance monitoring is critical to assure proper system operation and to identify any deterioration.

Our future newsletters will discuss TSS performance evaluations and monitoring.

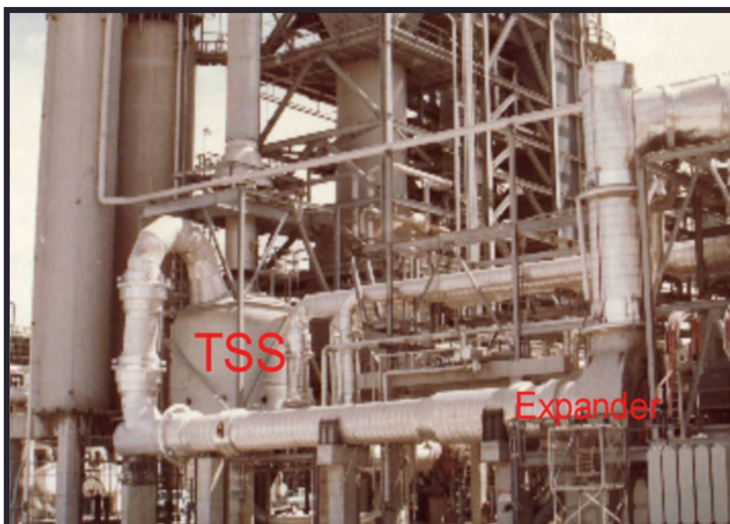


Figure #4—Typical TSS - PRT Installation

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All we have of freedom, all we use or know -

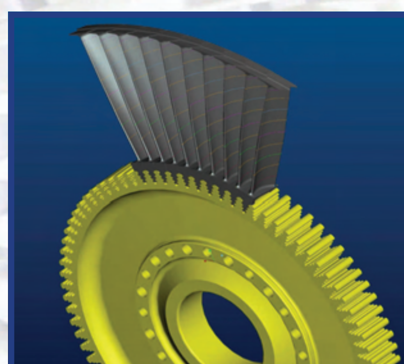
This our fathers brought for us long and long ago.

- Rudyard Kipling, The Old Issue, 1899

BOOTHS 741 & 743

PLEASE JOIN US AT THE 38TH TURBOMACHINERY SYMPOSIUM SEPTEMBER 15th - 17th, 2009

George R. Brown Convention Center
Houston, Texas



EXCITING THINGS ARE HAPPENING AT RMS!

STOP BY TO:

- RENEW OLD FRIENDSHIPS AND CREATE NEW ONES.
- LET US TELL YOU ABOUT OUR NEW CAPABILITIES!
- LEARN HOW WE CAN PROVIDE THE OPTIMUM SOLUTION FOR YOUR TURBOMACHINERY NEEDS

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