ROTATING MACHINERY SERVICES, INC.

THE FINISH LINE

PHONE 908-859-8440 FAX 908-859-6088 WWW.ROTATINGMACHINERY.COM

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RMS Celebrates 5 Years

People say it's not good to look back, but look ahead. Others tell us we need to look back to see where we've been. Either way, to look back five years prompts us to remember many things that have changed our lives. Many of us have experienced marriages, divorces, births and deaths, graduations and many other moments that make our lives have meaning. For those of us at RMS five years ago was just the start of a new chapter in our lives.

RMS was formed to provide customers with a very experienced, highly focused team of engineers and technicians, capable of maximizing the output of existing machinery, and providing solutions to challenging reliability problems. Since we all come from the turbomachinery industry we specialize in getting broken machinery back on-line in the shortest possible time. More importantly, however, we felt customers really valued, and deserved, service that went above and beyond. "That level of care and attention, in our experience, was best provided by a moderate sized, independent company made up of highly experienced, dedicated people" says Robert Klova, President of RMS. It is around these principles in which RMS is built.

Standing (L-R): Jerry Hallman, VP of Operations; Sydney Gross, Senior Turbomachinery Engineer, and Robert Klova, President.
Seated (L-R): Neal Wikert, VP of Projects; and Barry Ruch, Manager CAD Design.

Be sure to check out what else happened in 1998 on page 3.

Inside this issue:

Steam Turbine Uprates, Preliminary Checks

By Sydney Gross

Whether you're horsepower limited or you're planning to uprate that compression train as part of a de-bottlenecking project, the question has presented itself. Is the steam turbine capable of being rerated? Before you call RMS or go back to the OEM, you can do a few quick hand calculations to determine whether your turbine may be a suitable candidate for uprating.

But first, how do you uprate a turbine? Easy, you put more steam through it. Power is roughly proportional to flow. What about efficiency improvements and modern technology? Unless the turbine is operating way off design, and we'll discuss that in more detail in a later issue, or you're willing to invest in gutting the machine, chances are that efficiency improvements alone will not get you where you want to go. So, if you want 15% more power, expect to use 15% more steam.

That raises the first two questions the turbine engineer is going to ask,

1. Are the turbine inlet and exhaust flanges large enough to pass the additional steam at a reasonable velocity?
2. Is the shaft suitable for the higher power?

These are important questions because they deal with the two largest and most expensive components of the turbine, the casing and the rotor. If it's necessary to replace either, your decision to keep the old turbine may change.

We'll look at question 1 now and visit question 2 in the next issue.

What is a reasonable steam velocity? The answer to that can be found in API 612 and NEMA SM23. Inlet flange velocities are limited to 175 ft/sec and exhaust flange velocities are limited to 250 ft/sec for non-condensing (back pressure) turbines or 450 ft/sec for condensing turbines. Extraction/induction flanges are also limited to 250 ft/sec. There are several reasons for limiting the steam velocity. Some of them are excessive noise, pressure drop, pressure shock, turbulence, and erosion.

We're interested in an average velocity for this consideration. In order to calculate the average steam velocities at the flanges you need to know the flange sizes, steam mass flow rate, the states of the steam at inlet and exhaust and the Prandtl-Meyer Supersonic Expansion Function.

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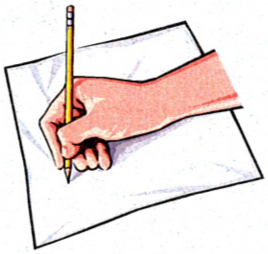
Special points of interest:

- Labyrinth Seals
- Steam Turbine Rerates
- Fogging Systems

Rules of Thumb

By Neal Wikert



Labyrinth Seals

Clearance is a strong factor in labyrinth seal performance. Most calculation techniques assume leakage is proportional to clearance cubed. That is, if you double your clearance your leakage will go up by a factor of 8!

A good rule of thumb for labyrinth seals is to set the **radial** seal clearance at .001" per inch of shaft diameter for spring-backed seals. Also, set a minimum radial clearance at 1 ½ times the bearing clearance to avoid rotor dynamic problems.

Labyrinth seals can be subjected to a pressure differential of 4 –6 times that of a carbon ring seal with no shaft speed limitations. Carbon ring seals are generally limited to a fifteen (15) pound drop across the seal and to a shaft speed of less than 200 feet per second.

A stepped labyrinth can reduce leakage by up to 30% over a straight labyrinth.

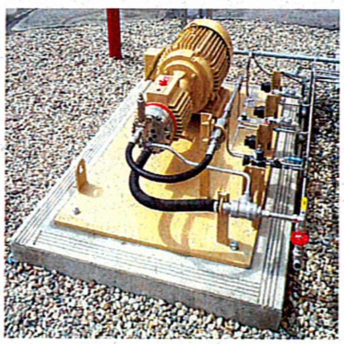
Labyrinth seals in steam turbines cannot be made from aluminum, as the steam will attack the aluminum. Labyrinth seals in the bearing housings are often made from aluminum.

Labyrinth seals in ammonia service cannot be made from bronze material.

RMS Gas Turbine Inlet Fog Cooling Systems for Critical Applications: High Reliability and Custom Engineering

"Customers value the extra horsepower provided by these packages, but don't want to add another complex and touchy system in this era of reduced maintenance budgets"

RMS supplies unique gas turbine inlet fog cooling systems, designed for applications where the highest levels of reliability are required. Our systems are also designed to keep maintenance to an absolute minimum. "Customers value the extra horsepower provided by these packages, but don't want to add another complex and touchy system in this era of reduced maintenance budgets" points out Bob Klova, RMS's president.



Single Variable Speed Pump and Staging Valves

Simple, Rugged Design

The biggest key to the reliability inherent in the RMS package is use of a single diaphragm pump. To introduce the correct amount of moisture under all combinations of humidity and temperature requires a broad range of water flow rates. Most fogging systems achieve this via the use of up to seven fixed-speed ceramic plunger pumps; staged to approximate the flow needed to approach wet-bulb temperature.

As shown in the picture on the left, the RMS design achieves the same range by using a single large, *variable speed*, diaphragm pump. Diaphragm pumps are inherently more reliable than plunger pumps and have the capability of running dry for short periods of time, which is the Achilles heel of the plunger pump in this application. Extremely high pressures (up to 2,500psi) are required to deliver a fine fogging mist. To maintain these pressures over the broad range of flows, typically three staging valves take the place of multiple pumps.

Power Maximized

Another advantage provided by the variable speed pump is that the system can fog right up to the wet bulb temperature, maximizing power under all conditions. Staged fixed-speed plunger pumps, on the other hand, introduce steps in the flow profile, preventing maximum flow from being reached at most times.

Other High Reliability Features

A number of reliability-enhancing features have been incorporated to insure nearly 100% availability in these systems:

⇒Triple Filtration: filter elements at the nozzle, and upstream and downstream of the pumps.

⇒Swirl-Atomizing Nozzles: inpaction pins, which can separate or creep from ideal alignment, are eliminated.

⇒Multiple Protection Systems: alarms on high and low pump pressure, water feed pressure and probe failure.

⇒Anti-Vibration Engineered Fogging Grid: each installation is designed to eliminate flow-induced resonance and features vibration damped mounting.

⇒Redundant Weather Stations: provide measurement averaging plus voting logic in case of probe failure.

Continued on Page 3

Steam Turbine

Continued from Page 1

You don't need the last one, I just wanted to see if you were still with me.

The equation for the average velocity is, $v = m \div (\rho * A)$ where

m = mass flow rate of steam in lbm/sec

ρ = steam density in lbm/ft^3

A = *flange cross sectional area in in^2*

The mass flow rate, m, should be obtainable from the performance data sheet in the original instruction book for the equipment. Or, it should be measured by an orifice flow meter upstream of the turbine. Remember that the power is approximately proportional to the flow so the new flow can be approximated by multiplying the current flow by a ratio of the new desired power to the power at the current flow.

The steam density, ρ, is obtained from the steam tables for the conditions at inlet and exhaust. The inlet is easy since the inlet pressure and temperature are always available. The exhaust may be a challenge especially for a condensing turbine because you need steam quality. Chances are, you'll have to make an assumption about the machine's efficiency, apply it to the isentropic enthalpy drop from inlet to exhaust pressure then go back to the steam tables and get the density from the exhaust pressure and assumed exhaust enthalpy. If you don't follow that, just give me a call and we'll figure it out together.

The flange area, *A*, is simply equal to $\pi * (d^2 \div 4)$ for a round flange with an ID of *d* or L * W for a rectangular flange.

Plug in the numbers and check it against the criteria above. Now, I'm not going to sit here and tell you that if the inlet velocity is 176 ft/sec you can't rerate your turbine. Velocities exceeding the criteria may be acceptable in cases. It takes a little judgment if your turbine is marginal. Things to consider are how far beyond the criteria the velocity is and how long the turbine will run there.

We'll talk about shaft capability in our next issue.

Flange Steam Velocity Limits

	Condensing	Non-Condensing
Inlet	175 ft/s	175 ft/s
Exhaust	450 ft/s	250 ft/s
Induction /Extraction	250 ft/s	250 ft/s

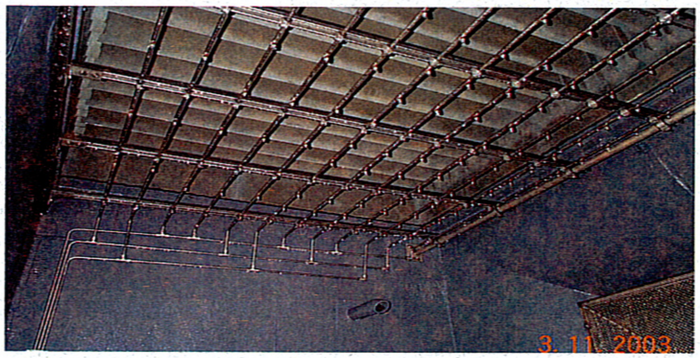
Fogging System

Continued from Page 2

Custom Engineering Insures Maximum Reliability at Your Site

Each RMS Fogging System is custom engineered to maximize reliability at given site conditions. Inlet plenums are reviewed for corrosion potential, with coatings or claddings offered where needed. Class I Division 2 ratings are available for hazardous areas.

RMS can even incorporate the system control logic into existing PLC-based gas turbine control systems to eliminate the reduction in reliability introduced by an additional PLC. Maintenance agreements are also offered to provide a true "set it and forget it" situation for the user.



Anti-Vibration Fogging Grid

A Look Back 5 Years
It Seems Like Only Yesterday When ...

*Mark McGwire breaks Roger Maris' home-run record.
*Chicago Bulls win their 6th Championship.
*Cal Ripkin sits out a game for the first time in 16 years, ending a 2632 consecutive game streak.
*U.S. Women's Hockey team brings home the Gold Medal after defeating their archrival Canada 3-1.
*The International Team beat the American Golfers in the 1998 President's Cup.
*Michael J. Fox reveals his battle with Parkinson's Disease.
*John Glenn returns to Space.
*Furby was the "must have" holiday gift.
*The decreasing size & cost of cell phones makes them a common accessory.
*FDA approved Viagra.
*Shows that premiered in 1998:
That 70's Show
Teletubbies
Whose Line is it Anyway?
Will & Grace
*President Bill Clinton became the 2nd president to be impeached.

*Deaths:
Linda McCartney
Buffalo Bill Smith
Phil Hartman
Clerow "Flip" Wilson
Florence Griffith Joyner
Alan Shepard
Sonny Bono
Dr. Benjamin Spock
Harry Caray

ROTATING MACHINERY SERVICES, INC.

50 Industrial Drive Bldg #4
Alpha Industrial Park
Phillipsburg, NJ 08865

Phone: 908-859-8440
Fax: 908-859-6088

"Quality Service from Start to *Finish*"

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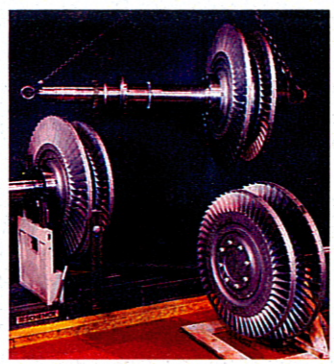
www.rotatingmachinery.com



Rotating Machinery Services provides a wide range of turbomachinery engineering, rerate, overhaul and field services to users of compressors, steam turbines, expanders and gas turbines. ***RMS*** serves the refining, chemical, gas transmission, power generation and steel industries. ***RMS***' experience, expertise and knowledge of a wide range of rotating equipment provides our customers with assurance that their work will be performed by recognized experts in their field who care deeply about their work. It is this dedication to our customers that allows us to provide "Quality Service from Start to *Finish*".

1998 - 2003

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YEARS OF EXCELLENCE

ROTATING MACHINERY SERVICES, INC.