ROTATING MACHINERY SERVICES,INC.

VOLUME 3, ISSUE 1

January-June 2006

THE FINISH LINE

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RMS Newest Additions

William E. Sullivan, P.E.
Manager of
Analytical Engineering

Bill joined our staff in early 2006. He brings with him over 30 years experience in the design, analysis and testing of turbomachinery components and assemblies. His primary responsibility at RMS is to provide analytical support for the product groups, mostly in the areas of rotor blade structural design and dynamic stress analysis. Other duties include general structural analyses associated with rotating machinery and related hardware. Before joining RMS, Bill specialized in the stress and vibration analysis of impellers, rotor blades and bladed disk assemblies for the turbomachinery aftermarket. You can contact him at our Phillipsburg Office at 908-859-8440 ext 305. Email address – wsullivan@rotatingmachinery.com.

Bo Schaller
Marketing Specialist
Centrifugal Compressors

Bo joined our staff in early 2006. He brings with him 6 years of Turbomachinery applications experience. He also has over 4 years of information technology experience. Bo's specific areas of expertise include sizing and quoting centrifugal compressor rerates. He will be responsible for centrifugal compressor sales support and application engineering, as well as other product line application activities. You can contact him at our Phillipsburg office at 908-859-8440 ext 316. Email address – bschaller@rotatingmachinery.com.

Matt Konek
Associate Engineer

Matt Konek joined our staff in early 2006. He recently graduated Lehigh University with a Bachelor of Science in Mechanical Engineering, where he concentrated in design and fluid dynamics. His role at RMS is to provide project and design support. You can contact him at our Phillipsburg Office at 908-859-8440 ext 315. Email address—mkonek@rotatingmachinery.com.

Can Your Centrifugal Compressor Meet Your Future Needs?

By Bo Schaller

Whether due to market fluctuations, environmental restrictions, or many other reasons, process requirements change. It does not matter in which industry you work. Times change. New processes are created. Old processes are made better. But where does that leave your existing equipment? Is it simply metal for the scrap yard? Or is it something much more than that.

In this multipart series, we are going to take a look at this issue. We will set forth some rules of thumb that you can use to determine if the centrifugal compressor you already own can meet your needs far into the future. First let's look at the definition of rerate. In the turbomachinery industry, a rerate is simply a change in the original equipment to meet a new condition or process. This can range from a small change like trimming impellers to a large change like all new internals. In either case, however, time and money are saved in comparison to purchasing new equipment.

There are limitations to any rerate. Each compressor is designed for a certain range of conditions. What we need to determine is if your new conditions or process is within that range. There are four main aspects that must be considered when looking at rerating your compressor: flow, pressure or head, horsepower, and speed. Each of these plays an important role in determining the feasibility of a rerate. These are the questions that we will help you answer:

Are the nozzles large enough to handle the new flow rate/gas density? Is the compressor casing capable of the new pressure? Can the compressor deliver the new head (pressure rise)? *(Con't pg. 2)*

What's Inside

2006 Tradeshows

RMS thanks all who stopped by to visit us at the following conferences.

We had a great time spending quality time with old friends and meeting new ones!

Industrial Gas Turbine Symposium
April 19

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Kinder Morgan Supplier Showcase
Apr 25 - 27

****

Reliability & Maintenance Conference and Exhibition
May 23 - 26

Can Your Centrifugal Compressor Meet Your Future Needs? *(Continued)*

Can the driving equipment (motor/gear or turbine) meet the new power requirements? Can the compressor train components accommodate a speed change?

Let's start by looking at Flow Capacity. Many times a change in process requires more flow to pass into a compressor. The inlet nozzle may be a limiting factor as to how much flow the compressor can handle. Maximum acceptable nozzle velocity is dictated by gas density and nozzle size. A good rule of thumb for inlet nozzles is:

$$MaximumVelocity_{Nozzle}\,(ft/s) = \sqrt{\frac{0.02 \times 32.17 \times 1545 \times z_1 \times T_1}{MW}}$$

To compute the inlet velocity based upon the new inlet volume flow:

$$Velocity_{Nozzle}\,(ft/s) = \frac{Q_{ICFM}}{D^2_{Nozzle}\,(inches)} \times \frac{144\ in^2}{ft^2} \times \frac{\min}{60\ s}$$

There are other factors related to flow capacity, such as impeller sizing and axial space, which may limit a rerate, however looking at the nozzle capability is an easy first pass to determine the flow capabilities of a compressor.

RMS would be more then happy to assist you with all your centrifugal compressor questions and needs.

Steam Turbine Uprates, Steam Issues

By Sydney Gross

I warned you in the last issue that we would be talking about steam this time but I didn't come right out and say "Thermodynamics". So, let's pretend it's not thermo and just talk about what happens with steam in the turbine.

Before you get to the turbine, you have water, just plain water. Put the water in a pot and heat it on the stove, no lid. You've added energy. All the heat energy added to the water will result in raising the water's temperature. When the water reaches boiling temperature, it won't get any hotter whether you keep heating it or not. The heat energy you add to the water from this point on will go into changing the water from liquid to gas (or vapor). The steam is called "Saturated" because a reduction in energy will cause it to start condensing. For simplicity, we will be talking about the properties of steam per unit mass and we will use the English system. In our case mass is pound-mass or lbm.

We can't do anything else with the vapor because it flew off into the surrounding air. However, if we contained the water in a closed system such as a plant steam system, we could continue to heat it after it turned into a vapor. It would then be Superheated steam. If we limit the volume of the system, or pressurize it, some of the heat energy added to the vapor goes into raising the pressure of the steam. We can identify the amount of energy in the steam at any time as a combination of its internal energy, kinetic energy and potential energy. The kinetic energy is associated with the steam velocity which we will assume for the time is zero. The potential energy is associated with the height (altitude) of the steam and the energy that could be recovered if it fell from that height such as in a hydro-electric turbine. Again we will assume this is zero. The internal energy is a property associated with temperature pressure and volume of the steam. Although not entirely correct, we will use the term *Enthalpy* to identify the amount of internal energy. *Enthalpy* has the units BTU/(lbm).

Before we put the steam into the turbine, we need to understand one more property of steam called *Entropy*. *Entropy* is a measure of chaos or randomness in a system and has the units BTU/(lbm*F). We use it in a process that goes from point A to point B to measure efficiency. For instance, we have a back-pressure (non-condensing) turbine and steam enters with a certain temperature and pressure. Those two properties are enough to define the state of the steam as well as all the other properties we are interested in such as *Enthalpy* and *Entropy*. We'll call that point A. The steam leaves the turbine with a lower temperature and pressure again defining a steam state we will call point B. If the *Entropys* at points A and B are the same, then the process is ideal or 100% efficient. But we know it's not because there is no 100% efficient machine. The *Entropy* will increase (it always goes toward more chaos). However, if we forget for a moment the temperature at B and assume the steam leaving the turbine has the correct final pressure and the same *Entropy* as the steam at point A, we have the basis for calculating the turbine efficiency. Here's how we do it.

First find the steam *Enthalpy* at point A for the pressure and temperature. Call it H_A. (You need steam tables or a Mollier chart to find steam properties for a specific state. You can find steam table calculators on the internet.) While you're looking for the *Enthalpy* at point A, find the *Entropy* too and write it down. Now find the *Enthalpy* of the steam at point B using the steam tables and the pressure and temperature at point B. Call it H_B. The difference, H_A - H_B, is the *Actual Enthalpy Drop* across the turbine. We will call it $\Delta H_{A\text{-}B}$. This quantity, together with the mass flow can be used to calculate the actual turbine power. Now, using the pressure of point B and the *Entropy* of point A, go back to the steam tables and find the *Enthalpy* for this hypothetical state. Call it H_{Bis}. What you have done is found the *Enthalpy* at the end of a 100% efficient process. Calculate the *Isentropic Enthalpy Drop* across the turbine as H_A - H_{Bis} and call it $\Delta H_{A\text{-}Bis}$. The *Efficiency*, η, of the turbine is the ratio $\Delta H_{A\text{-}B}/\Delta H_{A\text{-}Bis}$.

Here's an example:

Steam enters a turbine at 650 psi and 700°F. It exits at 150 psi and 450°F. What is the turbine efficiency?

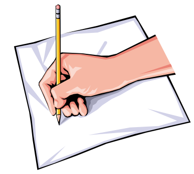
1. Find the inlet properties from the steam tables:
   - T_A = 700°F
   - P_A = 650 psi
   - H_A = 1347.9 BTU /lbm
   - E_A = 1.5768 BTU /lbm*F
2. Find the exit properties from the steam tables:
   - T_B = 450°F
   - P_B = 150 psi
   - H_B = 1247.6 BTU /lbm
   - E_B = 1.6317 BTU /lbm*F
3. Find the enthalpy at the exit pressure and inlet entropy:
   - H_{Bis} = 1200.1 BTU /lbm
4. Calculate the efficiency:

$\eta = \Delta H_{A\text{-}B}/\Delta H_{A\text{-}Bis} = (H_A - H_B)/(H_A - H_{Bis}) = (1347.9 - 1247.6)/(1347.9 - 1200.1)$ η = 67.8%

Next time we will calculate the ideal number of stages for a turbine based on inlet and exit steam conditions, speed and wheel diameter.

Rule of Thumb - Steam Turbine Generator Package

By Neal Wikert



Maintenance Program

The steam turbine is a rugged machine that will provide years of trouble free operation. However, trouble free operation cannot be expected if proper maintenance is postponed or neglected. Follow instructions given in the steam turbine instruction manual. Again, make sure personnel review, understand and follow these procedures during periodic maintenance inspections. Below is a typical maintenance checklist, which should be performed regularly.

Checklist

1. Check over-speed protection devices.
2. Follow manufacturers recommendation for checks on the Trip & Throttle Valve.
3. Grease valve rack fittings to insure smooth operation.
4. Verify that the lube oil console is kept clean and fully supplied with proper type and viscosity of oil. A reliable lube oil system is essential.
5. Maintain, test and regularly service all protective devices at manufacturers specified intervals.
6. Verify that all bearing temperatures are within established limits.
7. Verify that all vibration readings and axial positions are within established limits.
8. Verify no unusual noise exists.
9. Check alignment.
10. Check for proper lubrication.
11. Replace Filters in lube oil.

The following spare parts should be available at all times to assure availability when needed: Recommended Maintenance Spares

- Active thrust pads
- Inactive thrust pads
- Inter-stage seals
- HP & LP end seals
- Plain end bearing cartridge
- Thrust end bearing cartridge

Generator

The generator is designed to give many years of reliable service with a minimum of attention. Trouble-free operation cannot be expected if proper maintenance is postponed or neglected. Provide proper maintenance on the equipment. Follow instructions given in the generator instruction manual. Be certain personnel review, understand and follow these procedures during periodic maintenance inspections. Below is a typical maintenance checklist, which should be performed regularly.

Checklist

1. Verify that the generator is clean and verify that stator and rotor ventilation passages are unobstructed.
2. Check for excessive loading or service factor.
3. Verify winding temperature rise is not in excess of rated value.
4. Verify insulation resistance is above recommended minimum.
5, Verify voltage and frequency variation.
6. Check air gap
7. Verify that bearing temperatures are within limits and lubricant is clean and proper level maintained.
8. Verify no unusual vibration or noise exists.
9. Check alignment.
10. Check for proper lubrication.

The following spare parts should be available at all times to assure availability when needed:

Recommended Maintenance Spares

- Spare split sleeve bearings for each end
- Several sets of galvanized steel filters

RMS Praise's ESCO Turbine Technologies, Inc.

RMS praises ESCO Turbine Technologies as one of their valued Suppliers. In May of 2005, RMS presented ESCO with a challenge.

An oil refinery customer asked RMS to replace and upgrade a set of blades in a hot gas expander for the fluidized catalytic cracking process. The blades encountered a catalyst that has the consistency and erosive quality of sand. RMS engineers came up with an unique blade redesign that would alter the flow path, decrease the impact of the catalyst particles and extend the service life of the blades. Time was of the essence. RMS placed an order with ESCO for two 63-blade set. ESCO used rapid protyping and other Speed to Market techniques to move the project along very quickly. After the tooling was made, the castings were poured at ESCO Cleveland in Inconel 738LC alloy. The parts were shot peened, machined and coated before being shipped to the customer for installation. At every stage, the parts were carefully inspected for metallurgical and dimensional integrity. Because of the blades' improved design, RMS engineers expect them to last significantly longer than the original parts. Jerry Hallman, RMS VP of Operations said, *"Twenty-one weeks from launch to installation-that's about half the time it normally takes to get parts made. Even though they were busy with other projects, the folks at Eastlake (TT Cleveland were absolutely great to work with. It went smooth, and I think we built a relationship that we all can be proud of. We look forward to working together with ESCO in the future."*

With ESCO's help, RMS was able to redesign, tool, cast machine, coat and deliver parts to an oil refinery in only 21 weeks-a great example of speed to market. **Job Well Done, ESCO!!**

A full version of the above article was published in the ***EDGE Magazine, Solutions from ESCO****, December 2005 issue. (Article Authored by John Howard—Skyline Communications)*

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"Quality Service from Start to *Finish*"

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www.rotatingmachinery.com

If you would like to receive our newsletter via email, please contact Kathy Ehasz at 908-859-8440 or kehasz@rotatingmachinery.com.

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PLEASE JOIN US!

RMS invites you

to come join us at the

35th ANNUAL TURBOMACHINERY SYMPOSIUM

Sept. 26 - 28, 2006

> See some of our latest work
> Let us show you how we can enhance your business

EXCITING THINGS

ARE HAPPENING AT RMS !

Booths 754 & 756