

A Vision Built on Coming Together

"Superior performance is achieved through top-flight people. We have built—and will continue building—a dedicated and motivated team where everyone feels their contribution is valued."

- John Bartos, CEO

RMS News

RMS Vision
TPS 2019 Recap
Footprint Expansion Project
Meet the Flow Parts Team

Tech Talk

Allis-Chalmers Compressor Upgrade
Expander Blade Root Design
The Importance of Communication
Changing the Performance of Your Compressor

Spotlight On

New RMS Team Members
Career Opportunities

Turbo Toons



Rotating Machinery Services Vision

John Bartos, CEO

I would like to kick off this quarter's newsletter by sharing the guiding principles behind RMS. Our internal vision statement is presented below, and I will follow up with how that core philosophy translates into how RMS came to be what it is today.

Our vision is to reinvent the concept of an aftermarket turbomachinery business – to create a higher level of service aligned with employee satisfaction. *Based on a foundation of industry experience and long-standing relationships, we understand our customers' needs and we strive to ensure they are satisfied.*

Relationships, solid engineering, technical expertise, and skilled practitioners backed by responsiveness at competitive pricing and lead-times are the KEYs.

Superior performance is achieved through top-flight people. We have built—and will continue building—a dedicated and motivated team where everyone feels their contribution is valued.

Responsiveness is a culture, developed through people who are passionate in their work, backed by top-quality vendors and a network of expert resources.

We will be the preferred choice of our customers by staying focused, continuously improving, and leveraging our talents by recruiting and retaining top experts in the industry. We will assure the integrity, competitiveness, and continuity of our company by building strong relationships and maintaining open lines of communication with our employees, customers and suppliers.



The foundation for this vision came about not through a master plan, but through a series of events.

RMS' origins (and you really have to go back to the origins of our predecessor, CONMEC) arose from circumstances beyond the control of any of those businesses' founders. Dating back to the mid 1980's, corporate mergers and consolidations resulted in talented people being displaced from jobs that they enjoyed and from areas where they called home.

RMS, and CONMEC before it, represented a "coming together" of individuals who had a passion for turbomachinery and an affinity for the communities where they lived. If we fast-forward to today, those corporate mergers and consolidations continue to dominate the business headlines, and nowhere more so than in the turbomachinery business.

As RMS continues on its path of growth, we have been fortunate to bring aboard talented individuals who would have been otherwise negatively affected by those occurrences. RMS has become a career destination, a gravitational pull, a safe-space for people who love turbomachinery and want little more than an opportunity to service the industry by practicing their trade.

It is truly amazing to see what happens every day when a group of people work together by choice, practicing a trade that brings true enjoyment. The end result can only be superior performance for our customers and in the marketplace, and it is my true privilege to be a part of it.

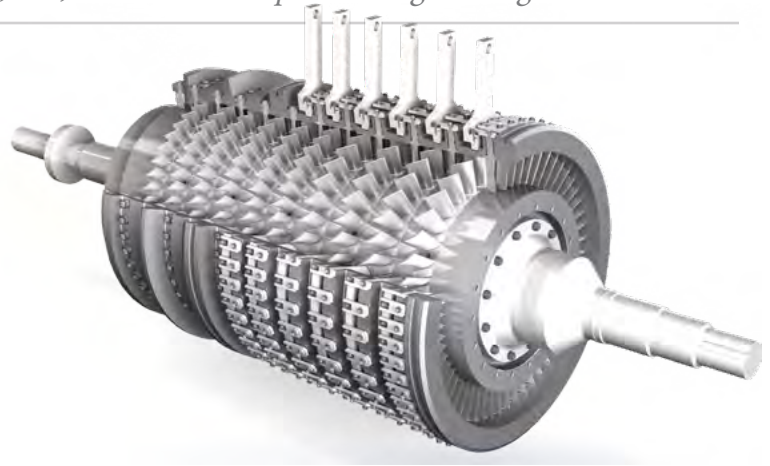


John Bartos, CEO

Upgrading an Allis-Chalmers Axial Compressor for Reliability and Maintainability

Behzad Abdollahi, Design Engineer II and Tony Rubino, P.E., Director—Compressor Engineering

Allis-Chalmers (A-C) axial compressors were mostly designed and manufactured in 60s and 70s. They are robust machines that still perform reasonably with many of the originals still in operation. However, many of the legacy design and manufacturing processes were limited to the technology of half a century ago and are presently antiquated. This article briefly summarizes some design limitations in the original design and RMS improvements for these machines.



Rotor

The original A-C rotor is comprised of two drums with conical holes intended for blades. The blades are inserted in the hole and held at a defined angle with a fixture, and second person (from inside the drum) has to tighten the nut. The limitations include:

- The blades are held by means of a large nut. Poor contact on the conical face or any loosening in the nut will 'unseat' the blade and change its natural frequency which could potentially cause catastrophic failures.
- To remove or replace a rotor blade, at least one stub shaft has to be removed, which is problematic with regarding to reassembling the rotor and maintaining journal, probe area and shaft end concentricity.
- There is no bare shaft balancing feature. Although the rotor may be balanced at the journals, there may be large coupled forces within the drums.
- Low accuracy of the blade angle setting and room for error such as assembling blades backwards.



RMS upgrades:

- RMS provides a rotor assembly that eliminates most of the above maintainability concerns by using a proven blade attachment (circumferential dovetail), while maintaining the cost and rotor stability advantages of a drum rotor construction.
- The blades are installed into the circumferential groove alternating with spacer pieces.
- The rotor is designed to include balance provisions by using blade balance weight grooves at each stage and sacrificial material at the drum ends. In addition, the blades and spacers can be drilled for weight normalization and balance corrections at each stage.
- The rotor does not need to be taken apart for a blade replacement overhaul.

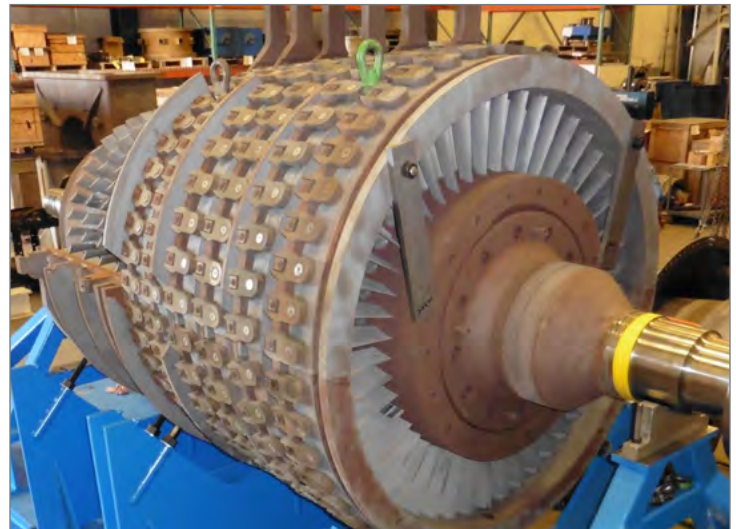
Stator

The original A-C rotor is comprised of two drums with conical holes intended for blades. The blades are inserted in the hole and held at a defined angle with a fixture, and second person (from inside the drum) has to tighten the nut. The limitations include:

- **Casing:** The original (internal) casings are made out of gray cast iron which is prone to cracking and thermal induced warping. Additionally, the cast iron material is not readily weld repairable. RMS manufactures new casings from high quality steel forged material that is more resistant to erosion and enables design and reliability upgrades. All the critical surfaces and fits are retained for interchangeability to the outer casing, so there is no need for re-piping and grouting, etc.
- **Variable stator vanes:** The existing design requires setting the vane angles and match drilling fork vane assembly during assembly which is inaccurate and laborious. RMS upgrades the variable vanes with a wrench drive assembly configuration to facilitate reassembly for overhauls. The wrench drive upgrade saves many labor hours to assemble, and the vane angles are set during design and manufacturing. Therefore, it significantly increases the precision and eliminates assembly mishaps.
- **Fixed stator vanes:** The fixed vanes have a conical seat attachment similar to rotor blades. For a new casing, RMS upgrade is a tangential entry blade attachment like the rotor. If the customer elects to reuse the casing, RMS has developed a proprietary method of pre-setting the tangential angle with precision.

Bearings

Most of the bearings for the A-C axial compressors were designed prior to advent of rotordynamic analysis as we know it today. Many include 'field-stabilizing' features that stabilizes the bearings, but to the expense of reducing reliability. There is a well-known history of journal scoring during operation for virtually all the above-mentioned bearings. Repairing journals or making specialized bearings can be very costly and confusing to keep track. RMS performs thorough rotordynamic analysis for each individual machine and designs appropriate modern day conventional bearings to suit.



Actuators

The variable stator vanes are rotated by means of archaic pneumatic cylinders that need to be custom-made and can be very expensive. Many of our customers experience hysteresis (swinging back and forth) due to poor controllability of these actuators. RMS replaces the old actuators with a closed-loop hydraulic system that includes internal control logics and has proven to be extremely accurate and reliable. The replacement actuators are 'drop-in' and do not require re-wiring or making changes to the Data Control System (DCS) signals.

Expander Blade Root Design to Prevent Fatigue and Creep Failures

Eric Dunlap, Senior Engineer

Hot gas expander blades are expected to provide long term, reliable operation in a very demanding service environment. The rotor blades are expected to survive operating campaigns of up to six years at inlet temperatures up to 1400° F. In this environment the design of the expander blade attachment root becomes a particularly challenging problem. The root geometry must be carefully designed to minimize operating stresses to avoid fatigue and creep rupture failures.

Fatigue is weakening of the metal caused by cyclic loading that results in crack initiation, growth, and rupture at stresses below the ultimate tensile strength of the metal. The concept of fatigue strength is necessary to predict and avoid this failure mechanism. The material fatigue strength is the magnitude of completely reversing alternating stress under which the material will not rupture below a certain high number of cyclic loadings, usually 10^7 cycles at a minimum. In hot gas expander applications, the primary cyclic loading is due to alternating gas bending loads as the rotor blades pass behind the upstream nosecone struts and stator vanes during rotation. However, there are also constant, steady loads applied to the blades due to gas bending forces as well as centrifugal loading as a result of rotor rotation.

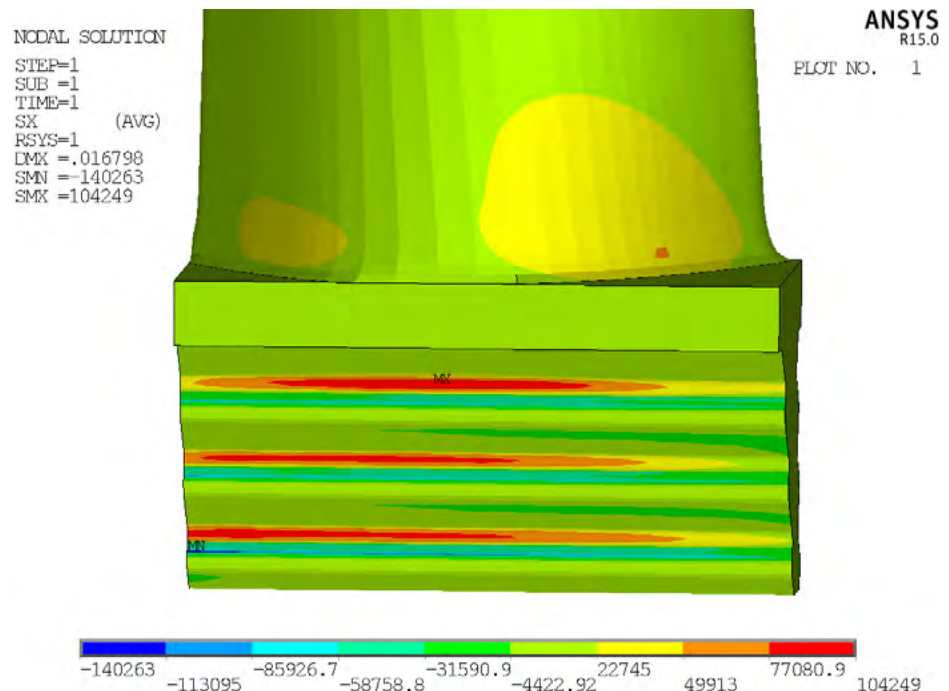
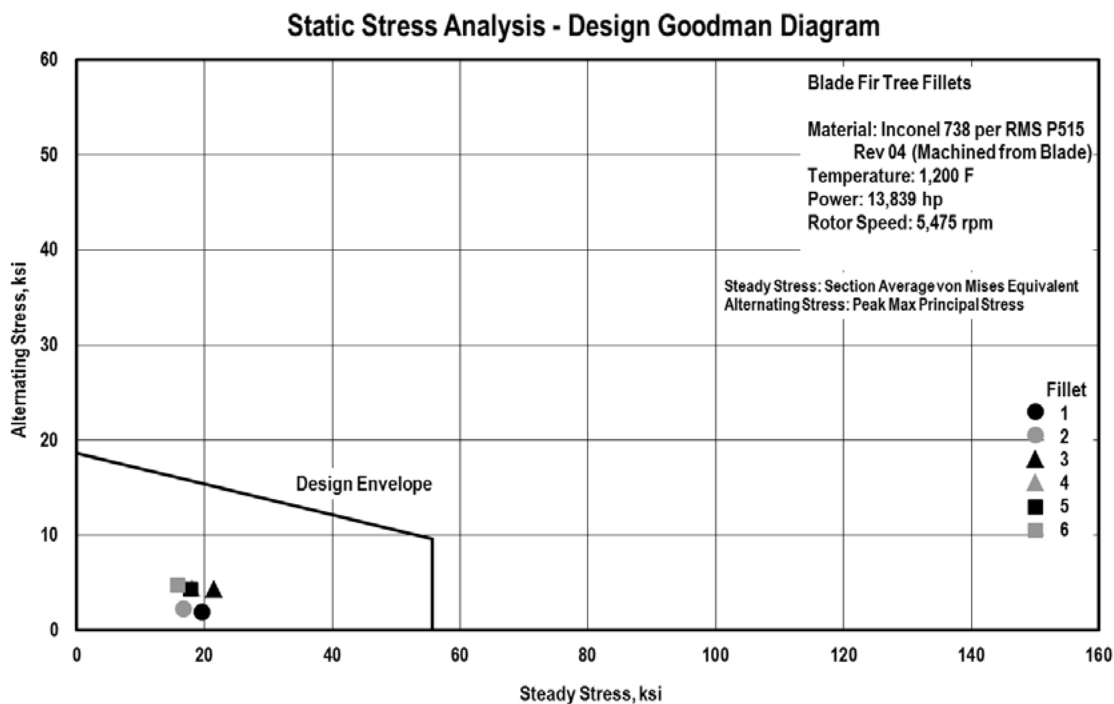


Figure 1 Example ANSYS Rotor Blade Attachment Stress Analysis. Peak stresses (red) must be minimized to avoid fatigue and creep failures

The material's resistance to fatigue decreases as the steady state stresses increase. A design tool called a Goodman Diagram is used to visualize this relation. On the Goodman Diagram, alternating stress is plotted on the vertical axis, and steady stress is plotted on the horizontal axis. A line is drawn connecting the material fatigue strength on the vertical axis to the material ultimate tensile strength on the horizontal axis. This line is known as the Goodman Line; high cycle fatigue failures are not expected for the combination of alternating and steady stresses beneath this line.

Typically, the area under the Goodman Line is further reduced to form a “design envelope” by applying a safety factor to the material fatigue strength and limiting the steady stress to the material yield strength. Blade stresses inside the design envelope are considered acceptable to prevent fatigue failure for the life of the rotor blades.



Example Goodman Diagram and Design Envelope

Rotor blade stresses must also be limited to prevent creep rupture. Creep is time dependent permanent deformation of a material under the influence of a persistent applied load, typically occurring at elevated temperature. Eventually the material will rupture if the deformation is allowed to continue for a long enough time. Critically, creep damage can occur at stresses well below material yield strength.

Creep damage accumulates in the material over time, and the rate of damage accumulation is dependent on both blade stress and operating temperature. Creep damage accumulates more quickly at higher stress levels and at higher temperatures. The challenge for the designer is to minimize blade stresses so as to maximize the expected blade lifetime before creep rupture is expected to occur. Experimentally determined creep rupture curves are used to predict blade life for a given stress level and operating temperature. Typically, hot gas expander blades are designed for at least a 100,000 hour operating lifetime, but can often have creep rupture lives much longer than that.

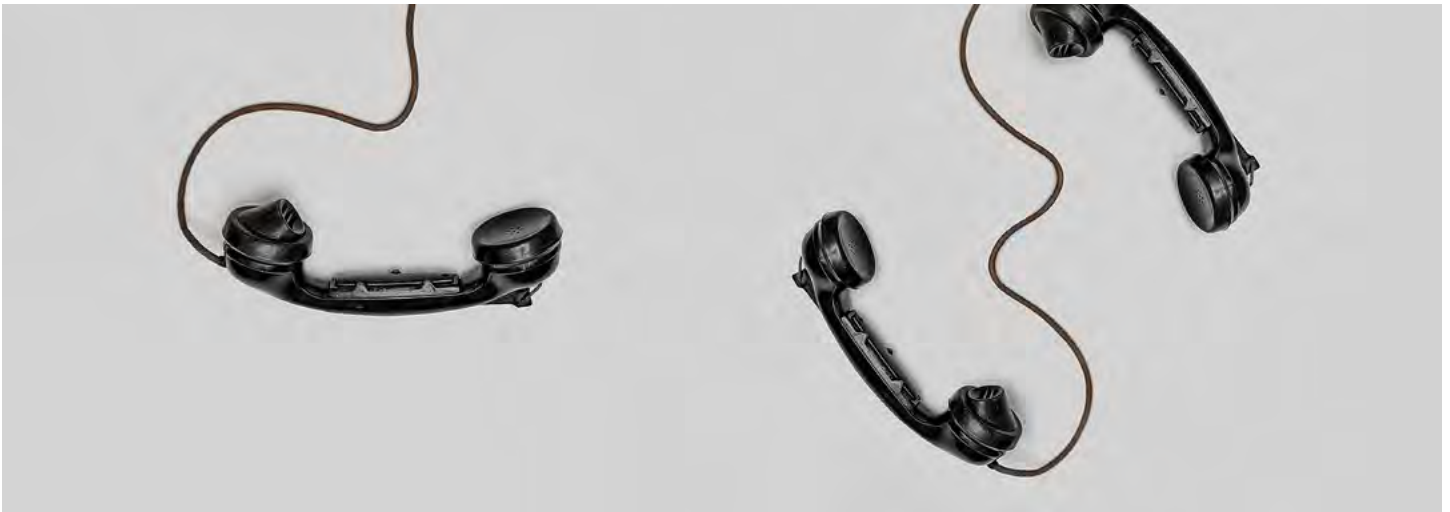
Successful blade attachment designs minimize operating stresses to prevent creep and stress rupture failures. The blades typically become life limited by other factors such as erosion, corrosion, or metallurgical degradation.

The Importance of Communication

Carol Hamm, Manager of Project Management

“Why is it important to communicate in business?” one might ask. As business professionals, do we have goals and tasks that are required? Of course we do. How do we achieve those goals and tasks, and achieve them effectively and efficiently? Answer: **Through effective communication.**

Communication is essential to convey those goals, tasks and replies. Communication is also an essential tool in all relationships we have, both in our personal and business lives. We cannot achieve anything without some type of communication. Communication, however, is a two-way street, both incoming to you and outgoing from you. Effective listening from the receiver is critical in communication.



Communication comes in various forms; verbal, written, visual as well as sign and body language. Everyone, in all cultures, utilize all the forms in our personal and business lives many times each day. If we are not, we are failing the whole purpose of our relationships and positions. Most people want to know what is happening in and around an organization. Even a simple email blast letting people know about new hires, or a new piece of equipment being installed, to fellow co-workers life events such as engagements, marriages and new additions to the family. Humans are social creatures so we like to stay informed on day-to-day happenings in our organizations.

Key elements to keep in mind when communicating are to whom are you communicating, the method of communication, timing and the topic. If your message is written and not directed to the right individuals, you may not receive any response. Always remember when formulating written communication to think about it from the perspective of who will be receiving your message. Be clear in the subject, the main message and if you are requesting a response. Be conscious of using words like, please and thank you to set the tone of professionalism. Make sure when communicating in person you are speaking to the person as you would like to be spoken to. Tone, inflection and facial expressions can give away your demeanor, especially if you are dealing with a person who is challenging and defensive in nature. Try to go into the conversation with an open mind and not past history.

Timeliness of this communication is also essential. In today's business world, communication can be in various forms such as emails, texts, phone calls and voice-mails, and now even Skype. (RMS is equipped with Skype for business so feel free to look your contacts up and add us to your favorites list.) It is a great way to communicate internally and externally in your organization quickly when there are miles between point A and B.

Sometimes our timeliness is delayed because we are very busy ensuring our customers equipment receives the attention that is required. There are many times when an individual requires answers within minutes and we are frantically trying to get hold of someone especially on cell phones. Please be mindful when dealing with your customers (internally and externally) and vendors that everyone is important, has specific jobs to do and we should be respectful with regard of everyone's time. If you receive a message, the sender is expecting an answer. It is the receiver's responsibility to acknowledge that you received their note or request. Be courteous and let the sender know when you will be able to respond by a specific time frame or within a specific length of time. Business etiquette is to respond within 24 hours if correspondence was directed to you.

If there is one point that should be stressed, always communicate to each other no matter the medium as if you were on the receiving end of the correspondence. Clarification between the sender and receiver is a critical part of the success of the direction. This should help you convey whatever your message, in a respectful manner that expresses your needs, subject and response time requested if necessary.

Communication is everything, without it we are islands.

Turbomachinery & Pump Symposium 2019

Dave Stewart, Vice President—Sales

The 2019 Turbomachinery & Pump Symposium was once again a huge success for our RMS Team. This show is always a great opportunity for RMS to showcase our highly engineered products and service capabilities. However, the most important opportunity the show provides RMS is an opportunity to personally engage our loyal customer base and future customers.

Typically, during a regular sales call, the customer does not have much time to discuss topics or products outside of what the meeting was scheduled for. This is where RMS shines at the Symposium. Customers have the opportunity to come in sit and relax, which gives us the opportunity to show them our complete offering and better develop a personal relationship. RMS had a record turnout for our customer dinner held on the Monday prior to the show at The Grove Restaurant. We want to extend our sincere appreciation to each and every one of you that joined us this year. Our customers are what make RMS successful. We look forward to developing deeper relationships with our existing customer base, and creating new opportunities with our new clients.

We look forward to seeing you all at the 2020 Turbomachinery & Pump Symposium!



Footprint Expansion Projects

Joe Gross, VP Operations



Anyone who has visited a RMS facility recently will agree that free space is in short supply. Dramatic business growth over the past several years has led to the hiring of many new people, more inventory, and more equipment in our shops. As a result, RMS has been working on several 'footprint expansion' initiatives that will provide more shop and office space and set the company up for the future.

The largest addition in space was the lease of a 60,000 ft² facility in Houston, TX. The building is initially being set up as a warehouse, but parts shipments will soon be executed from this location as well. High ceiling heights, overhead cranes, and ample outdoor storage provide the business with a lot of flexibility for future uses. The building is located minutes away from the existing Houston shop, making it easy to move material between locations.

The second expansion took place in Appleton, Wisconsin. The original office that was set up just a few years ago became woefully undersized due to a dramatic increase in headcount. Employees were sitting in conference rooms, doubled up in offices, and in some cases working out of their houses. The team recently moved into a new office location that offers more than twice as much square footage and the potential for future expansion.

Finally, RMS recently signed a lease in Bethlehem that provides 12,000 ft² of office and meeting space. Conveniently located next door to RMS's existing headquarters, the facility will be used by members of the executive team as well as finance and commercial staff.

Meet the Flow Parts Team

Mark Koerner, Vice President—AC Compressor Products

RMS prides itself on providing world-class technical expertise to meet our customer's most challenging turbomachinery needs, while remaining nimble and responsive to customer expectations. We have taken a unique approach to how we manage the spare parts business supporting our global compressor fleet.

RMS has created a Flow Parts Team within our commercial organization, solely focused on supporting quotation request for maintenance and consumable items where the design is established and minimal engineering is required to fulfill an order. These "Flow Parts" include bearings, seals, oil baffles, o-rings, gaskets, auxiliary parts, and generally anything that is not considered a capital part.

The team is divided into global regions of responsibility so that our customers get to know their commercial representative. With this structure, we are able to improve responsiveness and minimizing internal reviews, which could delay our response time.

Please consider using our customer inbox

RMS@RotatingMachinery.com

when submitting a request for quotation or for technical questions when unsure of where to turn.

The mailbox is continuously monitored, and we will be sure to acknowledge your request, letting you know who is addressing your need.



Evelyn Benitez

“Customer Service within RMS means everything! From the first contact, the customer becomes our priority. We work closely with our clients to provide the best customer service, gain their trust, earn their respect, and build a strong business relationship for years to come.”

Laura Assante

“Serving the customer means to be close to customers, understand their needs, offer the best service and be flexible to adjust based on their priorities. For Flow Parts, we take the initiative to know the fleet maintenance plans, offer parts lists to ensure that all necessary parts will be ready at site on time. With this, we build a strong relationship with the customers so they feel our company as a partner, not a supplier.”

Maria Frias

“Serving the customer is to Know Our Customer, providing personalized service and preventative care instead of reactive support. It means running with our customer in their tough situations. It is caring and treating them as our partner in business.”

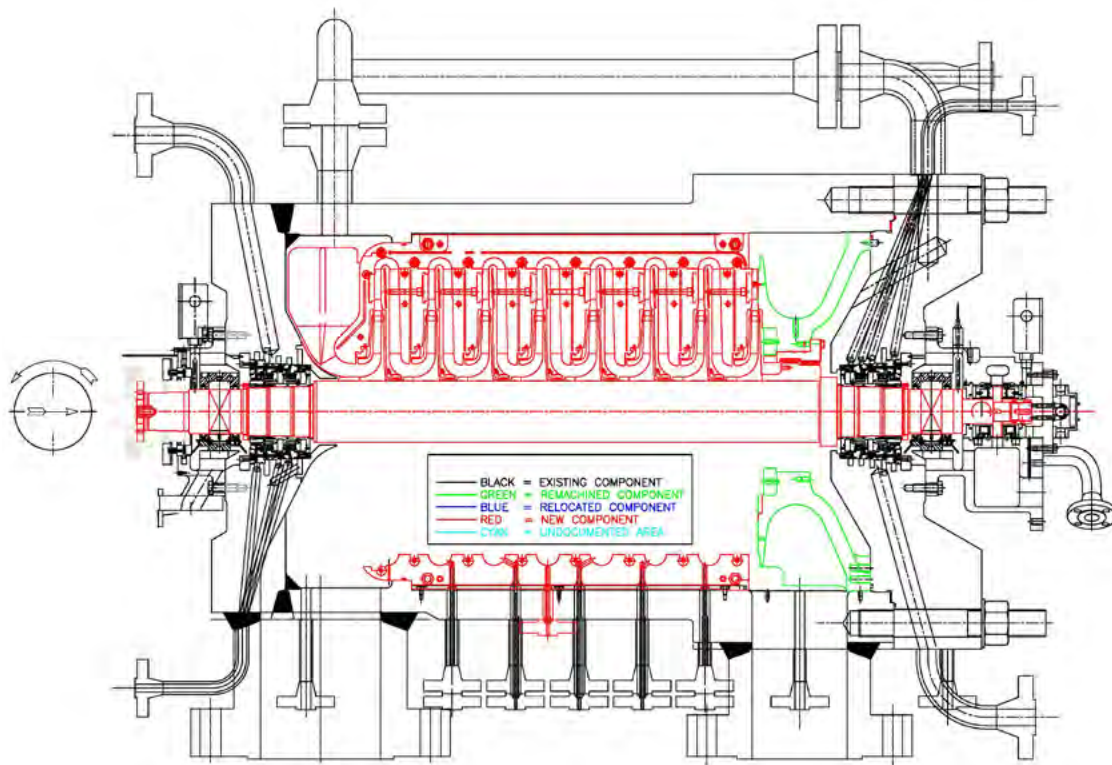
Alex Pierce

“For my part, serving the customer means understanding their needs so I can anticipate them and being attentive to those needs. My goal is to provide great service as quickly and smoothly as possible, while ensuring accuracy. I also think a component is trying to position ourselves to meet their future needs quickly and easily.”

The Basic Engineering Approach to Changing the Performance of Your Compressor

Steve Kaulius, Director/CC New Business Development and George Donald, Technical Director/CC Development

It all starts with the simple principle that **the only thing the compressor knows is flow (CFM) and Head**. Therefore, the first thing we do is determine if the new conditions require more or less flow or more or less head. Next, we look to see if the new conditions can be achieved in the present machine.



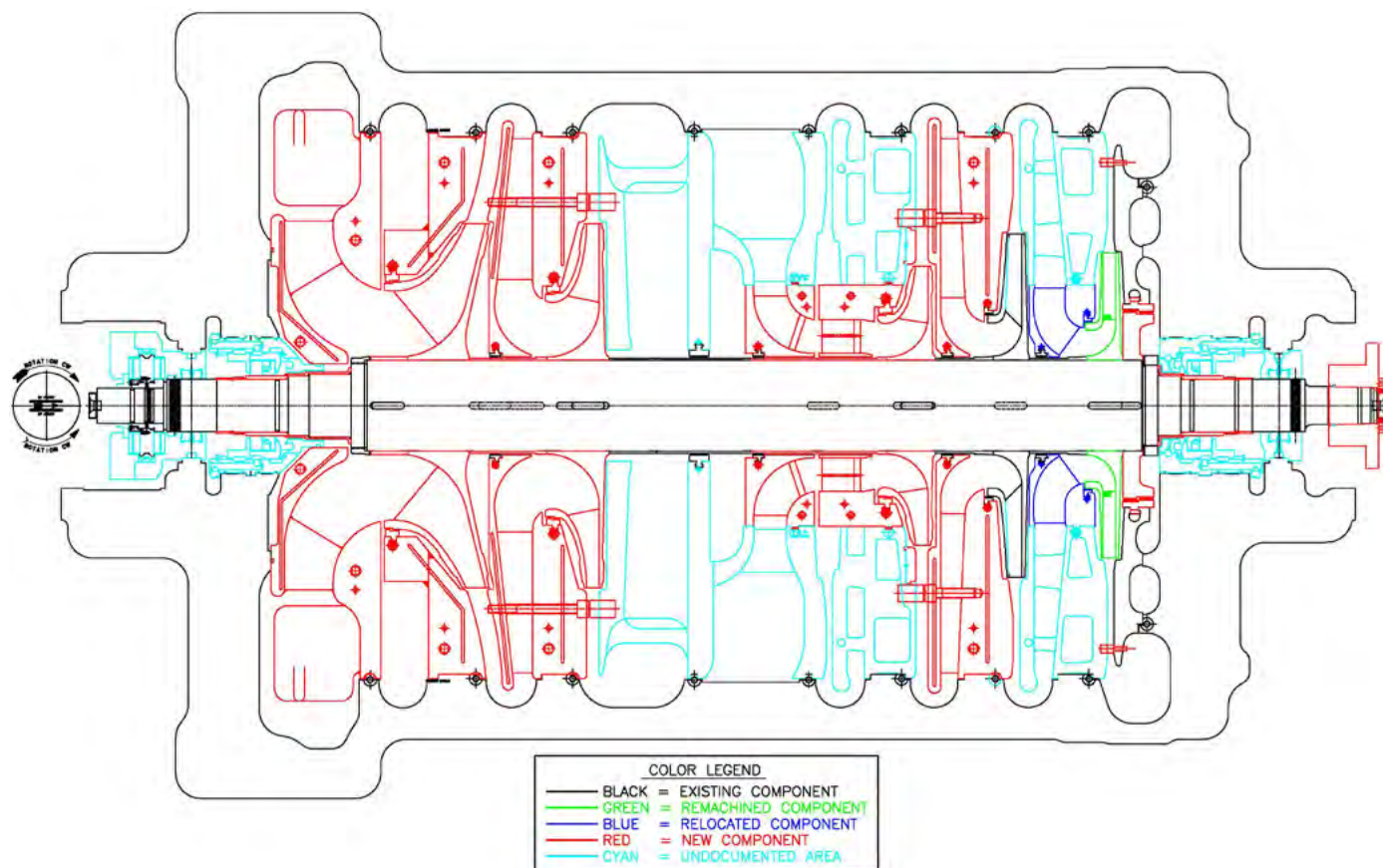
When looking at the impacts of flow changes, we consider the following areas:

- Impeller flow coefficients (Are they within the range for centrifugal compressors)
- Nozzle velocities
- Axial stage spacing of the impellers
- MACH number effects

When looking at the impacts of head changes, we consider the following areas:

- *Can the speed of the compressor be changed?*
- *Can the impeller diameters be changed?*
- *If impellers diameters are changed, what is the effect on the diffusers?*

At this point, we are ready to make a stage-by-stage performance model of the compressor. This model is compared to the performance curves of the existing compressor and modified to get a reasonable match with the existing machine. The individual stage performance data can then be moved around within the compressor to see if any of the existing stages can be used. This will significantly reduce the cost of any subsequent compressor rerate.



Once we are able to devise a solution that will accomplish the desired performance, we can do our final checks on stage spacing, performance compromises and required engineering analysis as-well-as choose the appropriate materials for the rerate.

If any of the flow considerations are outside of normal ranges, there may be adjustments needed to the stage performance in one or both of the below parameters:

- Pressure losses
- Efficiency reduction

Once adjustments are made we can calculate a new speed and HP for the compressor, we look at the driver and train components such as couplings. Consideration is made on the impact on the lube and or seal systems. A detailed plan on execution of the project is created and a proposal is made.

RMS Goes Global

Dave Stewart, Vice President—Sales



RMS has been providing quality repairs and upgrades on various manufactures' equipment for more than 20 years. The bulk of these projects were done in North America, with a couple performed internationally in places like Japan and Wales. With the acquisition of the AC Compressor / CONMEC business from Baker Hughes, a GE Company in May 2018, RMS now has the opportunity to showcase our technical expertise and service capabilities in a global market.

RMS has already established strong Agents/Distributors in several countries and regions around the world. These representatives have a strong local knowledge of the region and customer base. RMS' experienced team has already established a strong global flow parts business of OEM product lines under the direction of Mark Koerner (Vice President—AC Compressor Products). These global representatives will work closely with RMS to provide engineered solutions to customers on their non-OEM equipment.

Want to find your nearest RMS contact? Reach out to David Stewart at dstewart@rotatingmachinery.com.

The RMS Family Grows

Please join us in welcoming the newest RMS team members!

Drew Davis • Marketing Specialist

Drew has many years of marketing experience planning and executing trade shows globally, developing marketing strategies targeted to social media exposure and distributing marketing materials to customers. He's previously held positions with Jetstream and Edward Jones.

Juan Doblado • Sourcing Specialist

Juan joins RMS from Revak Keene Turbo Machinery Services with 5 years' experience in materials management and 4 years of experience in purchasing.

Bill Fogle • Network Administrator

Bill has more than 15 years of experience as a network administrator. He previously held positions as a network administrator in Service Tire Truck centers, Good Shepherd Rehabilitation Network, and other companies.

Stephanie Glasheen • Office Administrator

Previously, Stephanie was employed at Funset Boulevard in Appleton, WI for the past 13 years. She had worked several roles in the business up to and including management for the last 8 years.

Ciara Keeling • HR Support

Ciara has multiple years of HR experience mixed in onboarding, administration, recruiting, and employee relations. Ciara has previously worked for Menzies Aviation and Reconciled Mediations, LLC.

Jeffery (Jeff) King • NE US Account Manager

Jeff has many years' experience with rotating equipment sales, project management and field service. Jeff has previously held positions in Elliott Group, Dresser Rand, Ingersoll-Rand, and other companies.

John Korevec • Sr. Engineered Order Manager

A West Point graduate, John is also an alum of pre-GE AC Compressor and has had several roles during his career including: Application Engineer; Manager of Contract Administration & Scheduling teams; Senior Project Manager; Manager of PM & PE groups; and various other leadership positions.

Allan Mathis • Principal Engineer

Allan has many years of experience working with rotating equipment for companies such as Amoco, Rohm and Haas, and most recently DOW.

Christopher Okula • Project Management

Christopher comes to us with 5 years of Project Management experience in the medical and video industries.

David Owens • Project Management

David comes to us with 28 years of experience in various roles such as Application Engineer, Regional Sales Manager and Project Management for Ingersoll-Dresser Pumps, Patterson-Kelley, B-Tek and Flexicon.

Glen Smeal • Application Engineer

Glen comes to RMS with more than 10 years' experience working with rotating equipment, most recently with Forum Energy Technologies.

Tim Torrey • Manufacturing Engineer

Tim has 30+ years of experience in the rotating machinery business. He previously held positions at Siemens Demag Delaval Turbomachinery.

Brandon Welch • Gulf Coast RMS/Mepco Account Manager

Brandon has many years' of sales experience. He previously held the position of National Key Account Manager at Erik's.

Join the RMS Team!

We currently have the following positions open at RMS.

Bethlehem, PA; Houston, TX; or Appleton, WI

- Services Commercial Coordinator

Bethlehem, PA and Houston, TX

- Machinist
- Mechanic

Houston, TX

- Senior Oil-Free Screw (OFS) Engineer
- OFS or Centrifugal Compressor Mechanic
- Cost Estimator

Bethlehem, PA

- Senior Structural Analyst
- Design Engineer II (AC Compressor)
- Compensation and Payroll Specialist
- Quality Control Inspector

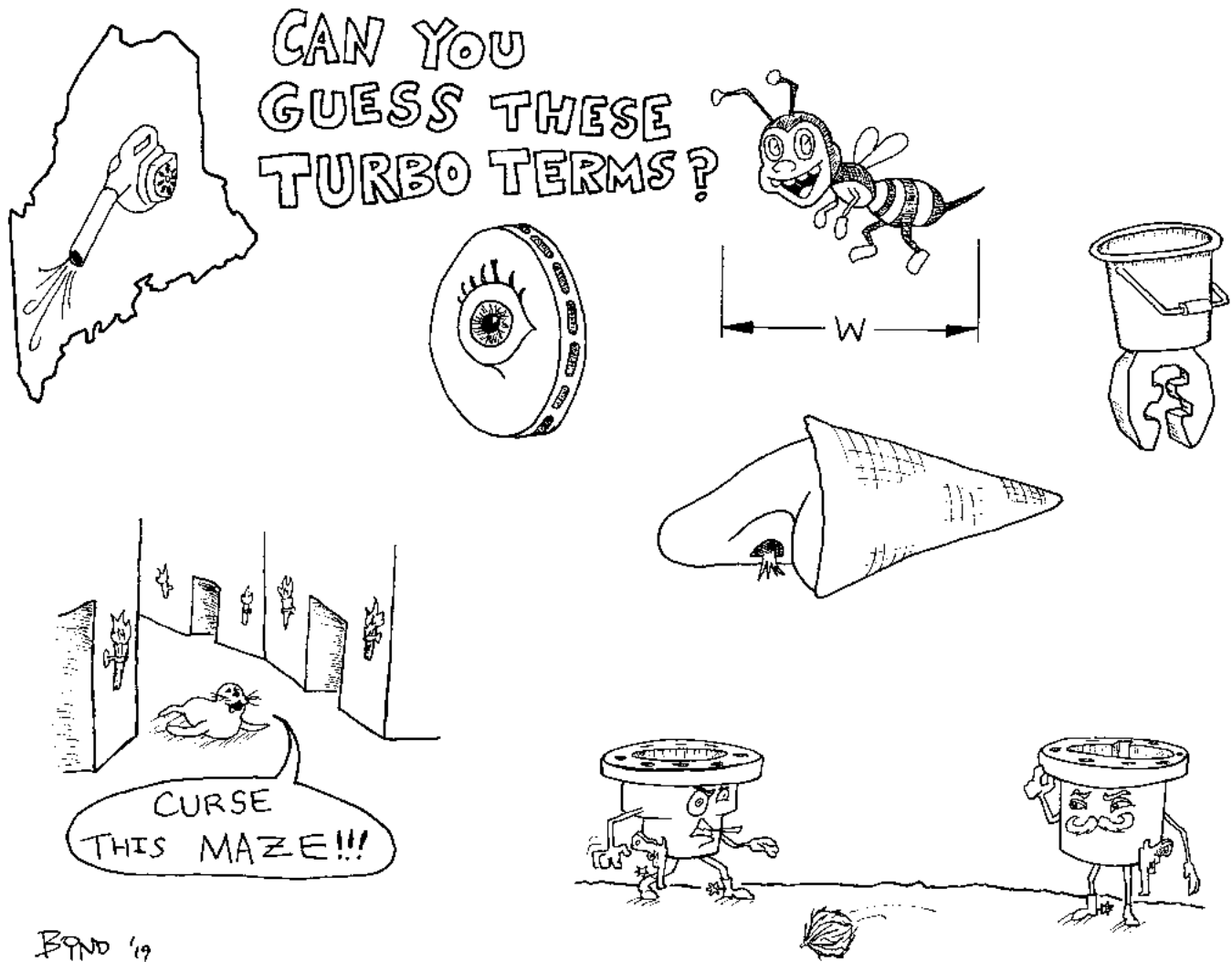
To apply, please send your resume (Attn: Human Resources) to:

recruiting@rotatingmachinery.com

or

2760 Baglyos Circle, Bethlehem, PA 18020

Turbo Toons by RMS's own Marc Rubino, Principal Engineer



ANSWERS From top-left clockwise: Main Air Blower, Impeller Eye, B-Width, Turbine Bucket, Nose Cone, Coupling Hub Stand-Off, Labyrinth Seal



Exclusive Source for Axial,
Centrifugal & Oil Free Screw
Compressors, Parts & Service

CONMEC

Our range of product and services includes:

**Axial Compressors • Centrifugal Compressors
Gas Turbines • Steam Turbines • Power Turbines
FCC Expanders • Nitric Acid Expanders • Oil Free Screws**

- Field Services
- Analytical Evaluations
- Dynamic Balancing
- Machinery Installation, Redesign,
Repair, Commissioning, Overhaul,
and Rerates
- Reverse Engineering
- Third-Party Inspection
- Consulting
- Orphan Equipment
- Labor and Labor Supervision
- Spare Assemblies and Components
- Remaining Life Assessments
- Design Engineering
- Surplus Equipment Rejuvenation

We provide the turbomachinery support and expertise you are looking for.

Corporate & Appleton Engineering Offices

484-821-0702

Parts Inquiries

RMS@rotatingmachinery.com

Tennessee Sales Office

Mike Spangler

484-896-8438

mspangler@rotatingmachinery.com

Florida Sales Office

Jonathan Calhoun

404-372-6936

jcalhoun@rotatingmachinery.com

Appleton, WI Sales Office

Andy Jansen

920-460-3811

ajansen@rotatingmachinery.com

Houston Sales Office

David Stewart

346-274-8590

dstewart@rotatingmachinery.com

Kurt Diekroeger

713-898-1015

kdiekroeger@rotatingmachinery.com

James Lucas

346-237-1850

jluca@rotatingmachinery.com

Nick Schneider

713-380-9605

nschneider@rotatingmachinery.com