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VI + MFPT: Diagnostics, Prognostics and Failure Prevention

"Where Theory Meets Practice"

Machinery Failure Prevention remains one of the top technology use cases in our new digital world, yet the laws of physics continue to govern machinery behavior. By attending MFPT 2022, you will increase your knowledge in important concepts including Systems Engineering, Sensors, Signal Processing, Data Management and Analytics, Diagnostics and Prognostics, Failure Analysis, and Human Performance. Each of these disciplines work together to prevent machinery failure.

With in-depth training workshops, technical sessions on emerging industry applications, case studies on challenging problems, and the latest technologies featured in the Exhibit Hall, the combined VIATC and MFPT event is not-to-be missed for machine failure prevention professionals.

- PRECONFERENCE WORKSHOPS ON AUGUST 2
- TWO OUTSTANDING KEYNOTES ON AUGUST 3
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Savannah, GA, August 2nd – 5th, 2022

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Chairman's Letter

We at the Society of Machinery Failure Prevention Technologies (MFPT.org) hope this newsletter finds you and your family well and that 2022 thus far has also bid you well.

It is my pleasure to share that MFPT is hosting its annual conference this August 2-5 in Savannah, GA. The conference is again combined with the Vibration Institute's annual training conference. This joint meeting offers significant training and networking opportunities for those in the field of condition monitoring and equipment reliability.

The conference offers papers and presentations from each of MFPT's focus groups including Data Management and AI, Diagnostics and Prognostics, Failure Analysis, Human Performance, Sensors, Signal Analysis, and Systems Engineering. You will find the preliminary program here: <u>MFPT/VIATC Annual Conference</u>.

We begin our conference with a choice from 6 half-day pre-conference workshops on August 2nd. On August 3rd and 4th, each day begins with two exciting keynotes hand selected by the Vibration Institute and The Society for Machinery Failure Prevention Technology.

We do have a few remaining speaker slots in our conference: For a description of our presentation categories, and to submit your abstract, please visit: <u>MFPT Focus Group Topics</u>.

In the short term, please enjoy our newsletter and references to our online materials. You may also consider joining the Vibration Institute <u>here</u>, and benefit from discounted attendance at the conference, a subscription to Vibrations magazine, and access to a wealth of technical articles and videos in the member portal. When you do join, please edit your profile to include MFPT as one of your two-chapter choices.

We look forward to your participation in our Society, and our discussion forum on LinkedIn.

Best Regards,

Preston Tohnson

Preston Johnson Chairman, Society for Machinery Failure Prevention Technologies.



Articles

Reverse Rotation Protection for Centrifugal Pumps

Pumps may lead to mechanical damage. Normally a centrifugal pump (with standard check valve in discharge line) is used in solo / series / parallel operation in industries. When pump is operating, and a power failure occurs then pump may begin to rotate in reverse direction. In reverse rotation, the pump acts like a hydraulic turbine and spins in opposite direction. A discharge check valve stuck wide open may result in over speed with reverse rotation and may run at resonance region causing pump damage.

Consequences

Following are the consequences faced either individual or in combination -

- 1. Detaching of impeller from shaft.
- 2. Failure of mechanical seal (Single spring seals) are designed to run in one direction only
- 3. Resonance due to reverse flow with high head causing pump spinning faster than rated. This effect is more prominent in long shaft vertical turbine pumps.
- 4. Mechanical Failure due to reversal of axial thrust and torque reversal causing damage of keyway / damage in notch fillet radius areas.
- 5. Damage of hydrodynamic bearings due to inadequate lubrication particularly when the pads are offset design.

Actions to be taken

During evaluation phase, please ask explicitly from Pump Vendor-

- 1. Consult Process and advise vendor that pumps may be subject to reverse rotation owing to specific reasons attributed to the pumping and piping system.
- 2. Ask vendor how pump would be protected under these scenarios. Normal constructional features such as suitable lock nuts, bi-directional bearings and seals would suffice. However, this needs to be confirmed by vendor and the details recorded in Bid clarification and PO data sheets by suitable notes. This point might be raised in HAZOP, and vendor's response stated in data sheet can be referred to close the action.
- 3. For large / high energy pump explore the need to provide double check valves.

Based on criticality of consequences, a specification requirement may be mandated to vendor, however we should allow vendors to explain their standard features which we should evaluate and then record as pre order meeting notes.

Protection methods to prevent reverse rotation of pumps

Mechanical Device:

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To prevent detaching of impeller from shaft keyed impellers are used. Few designs by vendor ensure shaft impeller set as self-locking and reverse rotation safe

Pump reverse rotation can be prevented by ratchet & pawl mechanism as shown in figure 2. Simple ratchet and pawl arrangement require no lubrication and have no parts to wear during normal operation. This type of arrangement should be used on non-hazardous area only.

To prevent motor getting restarted while spinning backwards a tachometer and a protection logic in the MCC is required that will not allow the motor to start unless it detects zero RPM.

Few machinery protection System providers now have a feature of reverse rotation monitoring, commonly used on pumps, turbines, and compressors to alert operators to inadvertent machine rotation in the incorrect direction.

About the Author:

Mantosh Bhattacharya is a Subject Matter Expert in Turbomachinery located in UAE and certified CAT IV vibration analyst. As a Subject Matter Expert, Mantosh focuses on selection, review of technical features of mission critical turbomachinery. Mantosh is in advisory board member in ATPS (Asia Turbomachinery and Pump symposium - Texas A&M TEES) Mantosh is also the Chairperson Failure prevention focus group of the Society for Machinery Failure Prevention Technology (MFPT). Mantosh can be reached at <u>mantosh.b@petrofac.com</u>



You are ready for Digital Twin, Now What?

In my last article, (https://www.mfpt.org/wp-content/uploads/2021/10/1634156746 MFPT-News-Fall-

<u>2021.pdf</u>) I introduced some of the many business objectives we can optimize using a contextualized, holistic view of our plants. I shared several data sources, both engineering and real-time, that can help us create that 360-degree view of our equipment, systems, processes, and plants.

I also suggested many of these data sources exist, just in different information systems. We will have to find a way to connect to these data sources. Once connected, we will want to turn the data into information that can drive decisions and actions. So, let's start building.

Data Inventory:

By associating the engineering, control systems, Industrial IoT condition monitoring, and operational activity data with the equipment; we essentially are creating a form of digital twin. We define a digital twin broadly as a digital representation of a physical asset that is used to gain insight into its operational state, its performance, and its condition. We incorporate all the data needed to help drive human and computer decisions that work to optimize the plant's performance.





In addition to data mentioned in the above paragraph, we also want to track plant activity that is related to the asset. This activity includes maintenance activities, the cost of maintenance, safety and environmental, and so on. As a result, we can deliver a holistic picture of the assets health and performance to those who operate and maintain the equipment.

Data Connectivity:

From an Information Technology (IT) perspective, we can think of a data collection and analysis network, or data platform, that connects our field sensory data to streaming analytics and recording, and to the Asset Management application.

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Figure: Data Collection Platform for Field Data

Some of the data we collect may be high frequency data or images from cameras. These inspection data sets need preprocessing, breaking down the complex data into condition indicators.

For example, vibration, ultrasonic, and motor current dynamic time waveforms can be processed with Fast Fourier Transforms (FFT), digital filters, and other signal processing techniques that produce one or more



condition indicators related to the equipment. Thermal image processing can label temperatures at several points within the image. The results of the streaming analytics are trend-able equipment condition and performance indicators. Streaming analytics are core to managing complex or high frequency data.

Data Visibility:

Now that we have real-time data, both from the process and from our condition monitoring sensors, we make it visible. For example, the flow rate parameter pulled from the control system, coupled with the rotational speed of the pump as pulled from the motor drive, together are good indicators of whether the pump's operating state is ON or OFF. Later, we can use this to calculate run-time and schedule any preventative or usage-based maintenance accordingly.



Figure: Pumps Operational Trends

Our next step is to add in the condition indicators from our condition monitoring system. Now we can see the response of these indicators to different operating conditions. We will need these "data groupings" for our advanced analytics down the road.

Even with trending data, and threshold values from our engineering references, we can build some descriptive dashboards. These dashboards often represent individual equipment, or systems, or even the plant. Providing an equipment hierarchy style menu allows for navigation through-out the plant, complete with roll-up threshold violations.

The benefit to the responsible user is data from multiple sources is presented in a high-level dashboard. For example, control systems data including pressure, is displayed along with IoT vibration and temperature data.



Figure: Vertical Pump Dashboard with Status, Alert, and Pump Curve.

Our responsible users, our subject matter experts (SMEs), have a more holistic view of their equipment and processes. Better decisions are made with better and more complete data. Ideas for analytics and process automation begin to become clearer.

Build Your Team:

Putting all the pieces together takes a team. Modeling (thresholds, data relationships) takes engineering and SMEs, as well as information technologies to manage the underlying "digital twin" system. Monitoring requires <u>MFPT Website</u>
<u>Discussion</u>



a field network with security, connectivity, and bandwidth to support the controls network, the Industrial IoT condition monitoring network, and the connected worker network. Analytics takes additional experts to turn the analytical results into actionable information (business process automation). Work requests and improvement requests are then delivered to the planners, along with the expected benefit. Going further, the digital field worker can access dashboards, digital enabled workflows, and training.

To pull this story together, it takes a team to implement Industrial IoT and the associated Digital Twin. We need to work with operations, maintenance and reliability, leadership, information technology and integrate all the sensor and applications. A Mature IIoT environment is really a convergence of Engineering Technology (ET), Information Technology (IT) and Operational Technology (OT). There are many components in the process. In addition to coordinating all the team members, we are challenged with long term management, refresh, and evolution of the infrastructure.



Figure: Industrial IoT is a Team Sport

There is a lot to do, it takes a village. Yet, each plant and enterprise should be taking its first steps today. Fortunately, there are many integration teams, reliability consulting teams, process experts, and information technology teams available to assist in the journey.

Safe travels!

About the Author:

Preston Johnson is a Senior Solutions Manager with CB Technologies, Inc. (CBT). CBT is a domain expert systems integrator with deep knowledge in IT and OT systems and integration. As a solutions manager, Preston focuses on Monitoring and Analytics as he assists clients begin their digital journey. Preston is also the Chairman of the Society for Machinery Failure Prevention Technology (MFPT). Preston is MFPT chair of the Data Management and AI focus group, and a fellow of MFPT. Preston can be reached at <u>preston.johnson@cbtechinc.com</u>



MFPT – Fluid Systems Diagnostic Technology Focus Group

The Machinery Failure Prevention Technology Society is a Division of the Vibration Institute that specifically focuses on technology for the early detection, diagnosis and prognosis of machinery incipient failure with the goal of highlighting new technology for the elimination of the catastrophic effects of unanticipated machinery failure. Our regime of interest covers both industrial and military machinery with Focus Groups concentrating in the following areas:

- Signal Analysis
- Failure Analysis
- Data Management
- Sensors Technology
- Systems Engineering
- Diagnostics & Prognostics
- Human Systems Monitoring

At the 2022 Joint Meeting of the Vibration Institute and the MFPT in Savannah, GA on August 3-5, the MFPT will form a new Focus Group in Fluid Systems Diagnostic Technology to establish and maintain the information repository on current and emerging technology for fluid systems diagnostics technology solutions.

Our current focus is on:

- <u>Lubrication Systems</u> that provide operating friction control and cooling for load bearing parts that define operating life of machinery.
- <u>Hydraulic Systems</u> that provide motion control.
- <u>Coolant Systems</u> that maintain thermal conditions to allow machinery to perform as designed.

Conference attendees that sign up for participation in this Focus Group will also be invited to add any fluid systems that will make the Focus group more relevant to their area of expertise.

It is our goal to include:

- <u>Fluid System Users</u> familiar with the design, operation and failure problem areas of current fluid systems technology.
- <u>Fluid System Diagnostic SME's</u> and technology providers to provide definition of the fluid diagnostic technology field state of the art.
- <u>Fluid Systems Diagnostic Technology Developers</u> in the S&T, academic, commercial, and Government communities.

Please see the Invitation to the Fluid System Diagnostic Technology Focus Group in the email that this newsletter came in. And let us know if you plan to attend the Formation Meeting.



Things to do in Savannah while at the Conference

We are just months away from the 2022 VI + MFPT Annual Conference. It should be a busy conference with lots of great workshops, exhibitors, and presentations. But we do not a want you to miss out on all the Savannah has to offer.

So, we thought we would highlight some of Savannah key attraction so you can make the best of your trip.

Visit the Cathedral of St. John the Baptist

While in Savannah, a must-see is the breathtaking <u>Cathedral of St. John the Baptist</u>. The cathedral dates back to 1878 and the architecture resembles what you'd see in Rome.

Explore Forsyth Park

If you're looking for one of the best places to visit in Savannah, you won't want to miss <u>Forsyth Park</u>. Not only is it 30 acres of gorgeous landscape, but also full of history and culture.

Tour the Mercer Williams House

If you're an architecture enthusiast, one of the <u>best places to visit in Savannah</u> is the Mercer Williams House. This home started construction in 1860, was interrupted by the Civil War, and then completed in 1868.

Take a Ghost Tour

This list would not be complete without a few recommendations to see some paranormal activity. One of the most well-known things to do in Savannah is to take a ghost tour since it's known as America's most haunted city.

Discover Bonaventure Cemetery

The Bonaventure Cemetery is over 100 acres. It features famous gravesites including Gracie Watson, Johnny Mercer, and 500 confederate soldiers.

Explore Old Fort Jackson

See history in an exciting way at Old Fort Jackson! If you're looking for engaging things to do in Savannah with kids, this is an incredible option to add to your list.

Take a Boat Cruise Down Savannah River

One of the most exciting things to do in Savannah is to take a riverboat cruise. It's a great way to see several sights along the river as well as enjoy an experience with many cruise options including dinner cruises, lunch or brunch cruises, sunset cruises, and gospel cruises.

Take a Food Tour

If you love a good southern meal, a Savannah food tour is a must! There's a variety of food tours to choose from including historic district walking food tours, dessert tours, pub crawls, and hop-on-hop-off trolly tours.

The Historic Savannah Theatre



The Historic Savannah Theatre is one of the best things to do in Savannah when you're ready to relax and take a load off. There's nothing quite as magical as a live theater performance, especially in a historic theater dating all the way back to 1818. Nearly 200 years of talent has taken place on its stage!

Eat and Shop on Broughton Street

This eating and shopping strip features quaint shops like the Paris Market with treasures and decor from around the world and Civvies which features high-quality second-hand clothes with fun features from all different eras.

Visit the Forest Gump filming locations

While in the area for the Historic Savannah Theatre, make sure to stop by Chippewa Square, best known for its bus bench scenes in the film, Forest Gump. If you're into movies, this is one of the best things to do in Savannah.

Explore E. Jones Street and Gaston Street

East Jones Street is known as the "prettiest street in Savannah"! A few blocks south, and running parallel to East Jones Street, is Gaston Street which is also full of pastel-colored houses.

Old Savannah Trolly Tour

Learn about Savannah's history in the most fun way with an Old Savannah Trolly tour. Not only does your tour show you the incredible sites and share the stories of the history there, but they also bring it to life too!

Visit Plant Riverside

Though much newer than the historic district, visiting the <u>Plant Riverside District</u> is another of the best things to do in Savannah. Once a power plant, the area has been developed into an entertainment district, full of fun things to do!



MFPT Focus Group Areas: https://www.mfpt.org/focus-groups/

The Society's mission (of providing an interchange of technical information for the benefit of owners and operators of mechanical machinery) is facilitated within our focus groups. The focus groups include:



All the focus area disciplines interact with each other. For example, systems engineering identifies functional requirements of equipment and their likely failure modes in the application. This engineering work drives human inspection tasks as well as automated inspections. Sensors give us quantifiable data about the physical world, and signal analysis transforms that data into condition and performance indicators about our equipment. Exploring and interpreting these indicators are diagnostic, prognostic, multivariate data analytics, and analysis of failures. In each of these areas, the performance of the human is always an element of success and efficiency.

Thru discussions in our focus groups, participants gain knowledge that helps drive towards failure prevention within the participant's organization. Our discussion forum (see link above) makes it easy to post a question, comment, article, etc., for all the MFPT community to see.

Each year, we host sessions in each of these areas at our annual conference and our webinars. Join our <u>mailing</u> <u>list</u> to stay informed.



Systems Engineering

FG Chair: John Lucero, NASA, Glenn Research Center

The Systems Engineering Focus Group (SEFG) provides a forum to foster the development and application of a systems approach to complex technical problems. Due to the interdisciplinary technical structure of MFPT, technical processes representing System Design, Technical Management and Product Realization are instrumental in the development and integration of new technologies into mainstream applications. The SEFG will encourage the application of these Systems Engineering tools to problems posed by the MFPT community.

Sensors

FG Chair: Ed Spence, Machine Instrumentation Group

The Sensors Focus Group (SFG) facilitates the discussion of sensors for Machinery Failure Prevention. Discussions include new sensor technologies and the means to connect them, data driven approaches to data analysis, and developments under the Industrial IoT umbrella.

Ed Spence, our Sensors Focus Group Chair, hosted a tutorial:

• Accelerometers for Machine Health Monitoring and Diagnostics

And we hosted several sessions with sensors as the focus:

- Complimenting acceleration measurements with advanced strain gauge technology
- Miniature Solid-State Batteries for High Temperature Industrial Sensors
- Combining Wear Debris and Vibration for a More Complete Understanding of Machinery Health

Signal Analysis

FG Chair: Suri Ganeriwala, SpectraQuest

The Signal Analysis Focus Group (SAFG) facilitates the discussion of data acquisition, signal analysis, diagnostics, artificial intelligence, logicians, etc. A core focus is signal processing (of all sensor type data) to assess the condition of components, subsystems, systems accurately and reliably in enough time to maximize reliability and minimize costs.

Data Management and AI

FG Chair: Preston Johnson, CBT

The Data Management and AI Focus Group (DM&AIFG) supports the discussion of data management tools, capabilities and standards that facilitate the detection and measurement of failure modes; that facilitate monitoring machinery and structural health; and that facilitate maintenance decision making. Participate in discussion of best practices and options for collection, advanced analysis, and dissemination of technical information for all sensed parameters.

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Diagnostics and Prognostics

FG Chair: Hoffy Hoffmeister, Ridge Top Group

The Diagnostics and Prognostics Focus Group (D&PFG) provides a forum to foster professional collaboration in the practice and technology of Prognostics and Health Management (PHM). The D&PFG provides and entry point for members new to the field of PHM and a forum for experienced professionals to collaborate on the most pressing problems. D&PFG encourages the use of standards and the application of PHM techniques across multiple domains.

The MFPT D&PFG is a group of professionals working to advance the field of PHM by collaborating on technical issues and sharing relevant industry information. Sample discussion areas include, Mechanical and electronic PHM, Prognostic methods and technology, PHM Standards, PHM case studies.

Failure Analysis

FG Chair: Mantosh Bhattacharya, Petrofac

The Failure Analysis Focus Group (FAFG) fosters the development, utilization, and enhancement of failure analysis techniques and methodologies. Lessons learned are conveyed to the MFPT Community, to prevent recurrence of failures, saving precious resources. The FAFG engages with other MFPT Focus Groups to show why failure analysis is an integral part of the product life cycle.

Human Systems Monitoring

FG Chair: Mark Derriso, US Airforce

The mission of the Human Systems Monitoring Focus Group (HSMFG) is to create an international forum where academia, industry and government agencies can discuss the state of the art in the area of human monitoring systems technologies. Topics of interest include but are not limited to wearable sensor technologies, data acquisition and management architectures, data analytics and assessment methodologies and health, fitness, and human performance monitoring techniques for industrial and military applications.

The MFPT HSMFG is a group of professionals working to advance the field of human systems monitoring by collaborating on technical issues and sharing relevant methodologies and approaches from academia, industry, and government to advance the state of the art.



Publications:

MFPT members have published several books on failure prevention technology subjects. These include:

• "Prognostics and Health Management: A Practical Approach to Improving System Reliability Using Conditioned-Based Data", co-authored by James P. Hofmeister

Prognostics and Health Management provides an authoritative guide for an understanding of the rationale and methodologies of a practical approach for improving system reliability using conditioned-based data (CBD) to the monitoring and management of health of systems. This proven approach uses electronic signatures extracted from conditioned-based electrical signals, including those representing physical components, and employs processing methods that include data fusion and transformation, domain transformation, and normalization, canonicalization and signal-level translation to support the determination of predictive diagnostics and prognostics. Written by noted experts in the field, Prognostics and Health Management clearly describes how to extract signatures from conditioned-based data using conditioning methods such as data fusion and transformation, domain transformation, data type transformation and indirect and differential comparison.

• "<u>Condition Monitoring Algorithms in MATLAB®</u>": Offering the first comprehensive and practice-oriented guide to condition monitoring algorithms in MATLAB®, by Adam Jablonski. This book is available from Springer at the above link.

This book offers the first comprehensive and practice-oriented guide to condition monitoring algorithms in MATLAB[®]. After a concise introduction to vibration theory and signal processing techniques, the attention is moved to the algorithms. Each signal processing algorithms is presented in depth, from their basics to the applications, including extensive explanations on how to use the corresponding toolbox in MATLAB[®]. In turn, the book describes several techniques for synthetic signals generation, as well as vibration-based analysis techniques of large data sets. Finally, it shows readers how to directly access data from industrial condition monitoring systems (CMS) using MATLAB[®] .NET Libraries. Bridging between research and practice, this book offers an extensive guide on condition monitoring algorithms to both scholars and professionals.

Other Publications

You will find many of our conference publications at <u>MFPT Publications</u> We are working to improve the listing and indexing, yet feel free to search today for your key words.



Webinar Link: Current issues in rotating equipment maintenance

Rotating equipment is typically among the most critical for process and maintenance productivity. Application areas include equipment used in chemical, oil and gas, pharmaceutical, mining, and other asset intensive industries.

Hosted by Plant Engineering, this recording of the hour-long Webinar is available to those who want to view it.

View Webinar

Going Forward

The Society for Machinery Failure Prevention Technology (MFPT) continues its mission of providing a technical interchange of MFPT topics. We look forward to our conversations, and our in person meeting the week of August 2nd to August 15th, 2022, in Savanah, Georgia at "Live at Loews".

Please also follow MFPT

at <u>MFPT</u>

and on our LinkedIn discussion forum at MFPT: Society for Machinery Failure Prevention Technology

MFPT Discussion Forum

and on Twitter

MFPT on Twitter

join our mailing list at

Mailing List

become a formal member of MFPT by selecting MFPT as your VI-Institute chapter

MFPT Membership