Keynote Panel: MRO in the Light of Digitalization

Monday, June 11 | 10:15 am – 12:15 pm

Join the best and brightest experts from around the world at the 2018 must-attend event bringing together business leaders, technology experts and authorities in the field of turbomachinery. It is an ideal opportunity to network, learn about the latest trends and open new chapters in turbomachinery. Targeted Maintenance, Repair and Overhaul (MRO) at the right time is key to ensuring efficient, reliable and affordable operation of turbomachines throughout their lifetime. Digitalization thereby provides unprecedented opportunities to define targeted MRO measures, learn valuable lessons from digital twins and optimize processes. In other words, digitalization is about to revolutionize the way of designing, manufacturing, operating and servicing turbomachines. But which are the challenges and opportunities that OEMs are facing in this respect? And how do operators deal with these new trends? What are the views of insurers and certification institutes on this? To learn about these aspects, join your peers and attend the ASME Turbo Expo 2018 Keynote Session on Maintenance, Repair and Overhaul in the Light of Digitalization. Two prominent experts from OEMs, Mr. Paul Stein (RTO Rolls-Royce) and Dr. Zuo Zhi Zhao (CTO Power & Gas Siemens), will share their views on this thrilling subject and discuss it with a panel of specialists from the airline industry, oil & gas industry and insurance/certification industry. The Keynote is held in conjunction with the annual ASME IGTE Honors & Awards program honoring individuals who have made significant contributions to the advancement of the turbomachinery technology.

“Digitalization is about to revolutionize the way of designing, manufacturing, operating and servicing turbomachines”

Keynote Moderators

Pascal Decoussemaker, GE Power Services
Prof. Damian Vogt, Conference Chair, University of Stuttgart

Plenaries

Additive Manufacturing in MRO
Tuesday, June 12 | 10:15 – 11:10 am

Big Data in MRO
Wednesday, June 13 | 10:15 – 11:10 am

Keynote Panelists

Mr. Paul Stein is currently Research & Technology Director at Rolls-Royce. He joined the company in 2010 as Chief Scientific Officer. Previously he was Director General, Science and Technology at the UK Ministry of Defence, responsible for national investment in defence science and technology. Prior to that role, Paul was Managing Director of Roke Manor Research, at that time owned by Siemens and was a member of the Siemens UK executive management board, leading on technology and contributing to business strategy.

Dr. Zuo Zhi Zhao is currently Chief Technology Officer in the Power & Gas division at Siemens. He joined the company in 2009 at its Chinese hub in Shanghai as Program Manager of Gas Turbine Technology Development and held the positions of Engineering Manager of Gas Turbine Shanghai Engineering Hub, General Manager of Gas Turbine Business Operation and General Manager of Gas Turbine Business Unit. Previously he was a Project Leader on aircraft engine research and development at GE Global Research in Niskayuna, NY, USA.
Digitalization and MRO at ASME Turbo Expo 2018

Shawn J. Gregg, GM, Propulsion Engineering, Delta Air Lines

Inputs, outputs. Factors, responses. Correlations awaiting discovery. Whether applied to design, operation, or restoration such data can yield intelligence to reduce costs and increase performance in every phase of a product's lifecycle. The advent of data analytics and the concepts of digital thread and digital twin are giving Operators and Maintenance, Repair, and Overhaul (MRO) providers capabilities that once resided only with Original Equipment Manufacturers (OEMs). The digital revolution has arrived in the MRO world and now Digital and MRO are coming to ASME Turbo Expo 2018.

The Digital impact begins at the OEM where analytical experiments assess the impact of geometry and boundary conditions on part life/performance. Performance characteristics taken from operational data are integrated with physical characteristics taken from the MRO environment to model and predict new part performance in existing turbomachinery and applied to the design and development of new turbomachinery. Operational data is now incredibly valuable, but how is it obtained? As turbomachinery graduated from hydro-mechanical to digital-electronic based control philosophy, sensors became a necessity. These sensors were largely placed and monitored for control purposes with limited diagnostic intent. Today, OEMs and Operators are adding diagnostic sensors – with no intrinsic controls functions – to better model and forecast turbomachinery life and performance. As such, sensing technologies from other industries are infiltrating the power generation and aviation industries. Acoustic imaging is being used to identify issues with rotating turbomachinery components. Machine olfaction technologies are monitoring emissions and guiding smoke and fume troubleshooting. Wireless sensing technologies, with their simple and cost-effective implementations, are providing OEMs and Operators with previously inaccessible parameters on both new and legacy products. New technologies like these paired with traditional pressure and temperature sensors are providing a more complete turbomachinery picture.

The MRO environment also provides a wealth of data. The physical condition of the engine-run part is the tangible embodiment of all the part has experienced; and each part can tell its own story. The challenge has not been recognition of this data; rather, it is the data collection. Historically, collecting geometry or physical condition specific data (e.g. distress maps) was a labor intensive effort making it a challenging business case. Today, this can be accomplished with 3D scanning technologies. Paired either with design or measured-new-part geometry one can quickly determine how, and how much, a part has degraded. Part conditions combined with financial models and operational characteristics can produce trade studies that allow MRO providers to optimize maintenance costs, balancing engine run-times with part repair and replacement costs.

As Operators and MROs look to minimize maintenance costs, they are turning to data analytics to interrogate operational...Continued on pg. 56
As the Turbine Turns...

#33 March 2018

Lee S. Langston, Professor Emeritus
University of Connecticut
Mechanical Engineering Dept.

A Useful Equation for Gas Turbine Design

“The essence of mathematics is not to make simple things complicated, but to make complicated things simple.” [1]. Certainly we as engineers know this to be the case!

With this clear statement in mind, I would like to go over a simple mathematical equation that explains some gas turbine phenomena and design in a straightforward and elegant way. This equation is written in terms of the variables $X_1$, $X_2$, and $X_{12}$, where $0 \leq X \leq 1.0$ and $X_{12}$ is given by

$$X_{12} = X_1 + X_2 - X_1X_2$$

I have come to call (1) a nonlinear superposition expression, since it is composed of a sum of $X_1$ and $X_2$ (superpositioning) minus the nonlinear product $X_1X_2$. A plot of $X_{12}$ yields a segment of the surface of a hyperbolic paraboloid, bounded by $0 \leq X \leq 1.0$.

Combined Cycle Powerplant Efficiency

One practical use of Eq. (1) results in an expression for the efficiency of a combined cycle gas turbine/steam powerplant. The sketch in Fig. 1 shows a schematic of a combined cycle powerplant consisting of a Brayton cycle (gas turbine) whose exhaust provides energy to a Rankine cycle (steam turbine).

Using just the First Law of Thermodynamics and the definition of thermal efficiency (useful energy output/costly energy input), the combined cycle efficiency, $\eta_{cc}$, becomes (Horlock [2])

$$\eta_{cc} = \eta_B + \eta_R - \eta_B\eta_R$$

Where $\eta_B = W_B/Q_{in}$ and $\eta_R = W_R/Q_{BR}$ are the thermal efficiencies of the Brayton and Rankine cycles respectively. Thus $\eta_{cc}$ is directly analogous to the general nonlinear superposition equation given in (1).

Taking $\eta_B = 40\%$ and $\eta_R = 30\%$, the sum minus the product in Eq. (2) yields $\eta_{cc} = 58\%$, a value of combined cycle efficiency greater than either of the individual efficiencies -- which is the secret of success of this modern power plant.

Film Cooling Effectiveness

Since at least the 1960s, film cooling, the use of air films bled from the compressor and directed onto the external surfaces of superalloy turbine airfoils and combustion liners, have been utilized by gas turbine designers. This has allowed thermal efficiency enhancing turbine temperatures to be dramatically increased, far above superalloy melting points.

The non-dimensional heat transfer variable $e$, (where $0 \leq e \leq 1.0$) is called the film cooling effectiveness. It is used by gas turbine designers to define heat transfer coefficients for film cooling heat load calculations that are...
Engine Component Heat Transfer Estimates

Frequently, one can use simple but exact one-dimensional (1-D) heat conduction solutions to estimate the heat loss or gain of gas turbine components under transient conditions. These easy-to-use solutions are found in most undergraduate heat transfer texts.

As an example, consider the case of estimating the amount of heat transfer per unit span, $Q$, that occurs to a high pressure compressor blade during an engine surge, relative to its stored internal energy $Q_0$ (based on the surge gas temperature, $T_{\infty}$). (A surge is the sudden reversal of flow in the compressor, accompanied by a sudden rise in compressor gas path temperatures [4]).

We consider a low cambered high compressor blade to be modeled as a rectangular bar, with a chord of $2L_1$ and an average thickness of $2L_2$. The transient temperatures in this 2-D bar is then given by the product of the exact 1-D solutions [5] of transient conditions in two infinite plates of thickness $2L_1$ and $2L_2$.

It follows [5] that the per unit span heat transfer to the compressor blade, $Q$, is then given by

$$Q = Q_0 + Q_{\text{in}} - Q_{\text{out}}$$

where the subscripts 1 and 2 refer to the 1-D exact solutions for the two infinite plates. Again, (4) has the same form as (1).

Conclusion

In summary, we see that three widely different gas turbine phenomena and design cases given by Equs. (2), (3) and (4), all have the simple, nonlinear superposition form, given by Equ. (1). The reader might try to find other situations that are described by Equ. (1), assuredly making complicated things simple, by mathematics!

References

1. Gudder, Stanley, Mathematics Department, University of Denver, Colorado.
The energy industry is undergoing a rapid process of change.

In many regions, the infrastructure necessary for power supply is coming under pressure due to the constant growth in demand for electricity. By 2040, according to the International Energy Agency, global energy requirements could increase by 30 percent, while there are still more than a billion people without electrical power. At the same time, renewable energies are playing an important role but continue to require backup due to the fluctuating power supply. In this situation, mobile units that can provide fast, flexible, reliable electricity are growing in significance.

A range of economic, environmental, and technological factors have led to an expansion in decentralized, distributed electricity generation. These factors were based on economic growth in developing regions, as well as difficulties in financing, approval, and operation of large, central power stations. Power plants based on mobile gas turbine technology have benefited from these developments. They can be installed quickly and can thus be connected to the grid swiftly. Their growth was driven by the increase in the requirement for electrification in parts of the world experiencing rapid development. This is where mobile gas turbines offer an attractive solution thanks to their “plug-and-play” design that lets them start feeding electricity into the grid in just a few weeks. Mobile gas turbines therefore serve as a bridging technology that brings the set-up times needed for higher capacities into line with the high level of demand.

The market for mobile gas turbines is continuously growing. The bulk of this market is currently served by products in the 30 MW class based on technology from the aircraft industry. They offer a range of features that suit for the applications described above:

- **High power density**;
- Compact unit construction, minimal installation requirements;
- Operation using gas and liquid fuel;
- Particularly flexible operation;
- Suitability for 50 or 60-Hz frequencies with minimal adjustment to configuration;
- Ability to operate under tough conditions.

That’s why, since about 2010 more and more uses have been found for mobile gas turbines, whose ability to make electricity available as quickly as possible is a critical advantage.
In recent years, the market for mobile gas turbines in the 30 MW class using technology from the aircraft industry has averaged over $1 billion p.a. for new units alone. That represents around 40% of the total market for gas turbines in this capacity range.

Many factors behind increased demand for mobile gas turbines

Many factors are contributing to the urgent demand for electricity. These include economic growth; damaged or unreliable infrastructure; market changes through liberalization and the expansion of renewables; and short-term needs for additional electricity. A growing population, higher standards of living, and development of the industrial sector are drivers of increased demand for electricity. Mobile units are an ideal solution in cases like these, when large volumes of electricity have to be supplied in a short period.

An unplanned outage at a power station can significantly impact on the power supply, and in a worst-case scenario can lead to electricity outages. In these cases, too, establishing a replacement supply is an urgent necessity. The necessary corrective action must often be performed in locations that are quite difficult to access – and since mobile gas turbines can provide rapid grid support in multiple locations, they provide a solution here and can also help cover seasonal peaks.

The transformation towards renewables necessitates a greater level of flexibility in implementing the mobile design of gas turbines and their ability to adapt to aspects such as operating cycles, fuel supplies, and environmental conditions. Mobile units are also an ideal choice when it comes to making large power capacities available on a short-term basis, e.g. for major events, prolonged downtimes at other power stations, or power-intensive applications such as mining or shale gas extraction.

Underdeveloped infrastructure and economic growth drive the demand.

In view of the requirements described above, the market for mobile gas turbines has been concentrated mainly in regions with a less developed infrastructure or experiencing rapid economic growth. From 1999 to 2016, therefore, the Middle East and North Africa accounted for the largest market share for mobile gas turbines (35%), followed by Latin America (21%) and Asia-Pacific (18%). In the shorter term, regions like sub-Saharan Africa and additional parts of Asia-Pacific will follow this trend.

This is the situation in which Siemens has developed its new SGT-A45 mobile gas turbine unit, which provides a generating capacity of up to 44 MWel, is suited for 50 and 60-Hz networks, and can run on gas or liquid fuels. The turbine is based on Rolls-Royce Aero-Engine technology and achieves efficiency levels of up to 40.4%. It has a higher generating capacity than any other gas turbine in its class, while being highly efficient and flexible. It also has all the properties for swift delivery and installation in just two weeks or less. Its compact design makes it easier to transport quickly – whether to its first installation site or to a new location. The turbine and its auxiliary units are mounted on three trailers to ensure optimized mobility: dimensions, weight and the connections between the trailers are reduced to a minimum. Most of the commissioning work is done before the unit leaves the factory, which reduces the time and cost of installation on-site.

If the electricity requirements exceed the level that can normally be demanded of a mobile application, an SGT-A45 installation can be modified to form a combined-cycle power plant to further improve its efficiency. In remote locations, this can be achieved using an Organic Rankine Cycle (ORC), to eliminate the need for water and water treatment systems, and to optimize energy recovery from the SGT-A45 off-gas stream at a relatively low temperature. The use of a direct heat exchanger in which the ORC working fluid is evaporated by the off-gas stream from the gas turbine can boost the system’s output capacity by more than 20%.
In its fifth year, the ASME 2017 Gas Turbine India Conference succeeded in bringing together the gas turbine professionals from academia, industry, and government, including engineering students in India to the Sheraton Grand in Bangalore, India. Bengaluru is the Aerospace Capital of India with existence of important national and international gas turbine research, engineering & development organizations. The conference theme “Energy & Propulsion Technologies for a Digital Future” was chosen with an objective to provide the conference participants a glimpse of emerging digital trends in the modern gas turbine research and technology domain. Over 300 attendees from 14 countries shared knowledge, experience, and challenges in the field of turbomachinery. We would like to thank our platinum sponsors, GE and Rolls-Royce, our bronze sponsor, QUEST, and our lanyard sponsor, TURBOCAM, for supporting this conference. We also recognize the Gas Turbine India Conference Committee for the wholehearted and selfless volunteer hours that they collectively dedicated toward the successful technical program of the conference.

Gas Turbine India 2017

The technologies making all this possible are equally available to OEMs, Operators, and MRO providers. Data is the differentiator with each owning a different data stream: OEMs – design data, Operators – operational data, MRO providers – part condition data. OEMs and Operators with an MRO business have access to two of the three streams while independent MROs have only the part condition data. The challenge for unlocking Digital’s full potential is accessing and aggregating all three data streams.

ASME Turbo Expo 2018 will explore the application and impact of Digital technologies across the turbomachinery industry with a special focus on MRO.

It is an exciting time as technologies historically focused on turbomachinery design and analysis as well as other industries are brought to bear in the operational and MRO environments. Listen, interact, and learn how academia and industry are researching, developing, and maturing the systems and methods today that will fully leverage Digital technologies across the turbomachinery lifecycle tomorrow.

Register Today for Turbo Expo 2018!
http://www.asme.org/events/turbo-expo/register

ASME Gas Turbine Segment Leader for 2018

ASME Gas Turbine Segment is pleased to announce Jaroslaw Szwedowicz, as the Segment Leader for fiscal year 2018. He is the R&D Senior Key Expert at Siemens Power and Gas and has over 25 years of industry and academic experience in lifetime methodologies, friction- & piezo-damping technology, fluid-structure interaction, acoustics, blade dynamics, testing and digitalization for GT. Jaroslaw has authored over 50 publications and holds 5 patents with over 14 patent applications. His skills and experiences have a proven track record in innovation based projects, technology roadmaps, and successfully leading international teams for various products. Jaroslaw acted as an AE in the ASME Journal of Engineering for GT & Power. Now he is an AE in IMechE Journal of Mechanical Engineering Science. He currently chairs the ASME Swiss Section and is a Reader at ZHAW as an academic part-time job.