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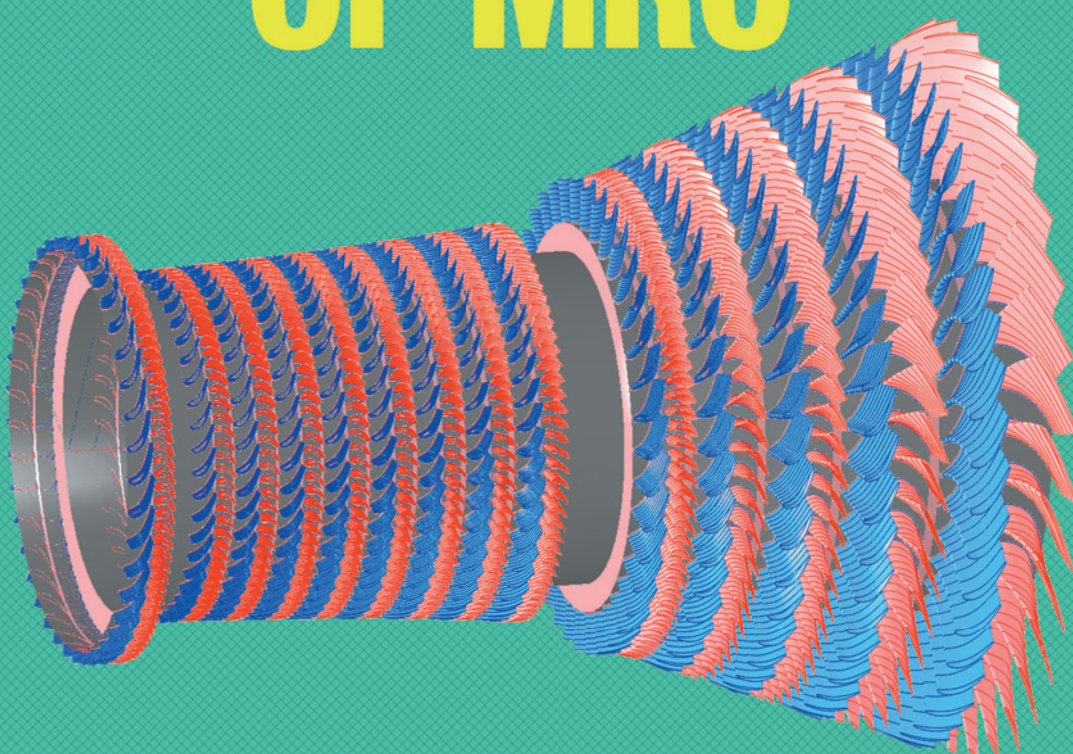
UBM

THE DIGITAL TRANSFORMATION OF MRO



Also in this issue:

LNG • Mechanical Drive • HRSG Duct Firing • Inlet Air Filtration
Regenerative Cycle • Centrifugal Compressors • Surge Control


HIGH-EFFICIENCY DESIGN WITH CUSTOM BACK-END WASTE HEAT RECOVERY.
HIGH-PERFORMANCE EMISSION CONTROLS – FOR THE LOWEST LEVELS OF CO AND NOX AS LOW AS 2PPM.
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Drew.Robb@UBM.com

COVER STORY

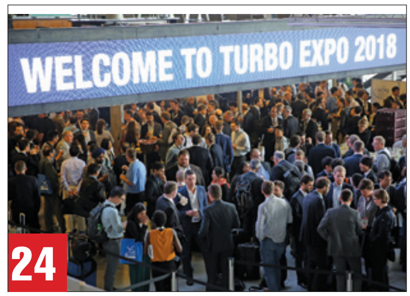
14 TRANSFORMING MAINTENANCE, REPAIR AND OVERHAUL

The annual International Gas Turbine Institute Turbo Expo often has a dominant theme. For 2018, the focus turned to additive manufacturing (AM or 3D printing), digitization and analytics. Each day's keynotes and an entire track looked at every aspect of the digital revolution.

The overriding message: there is value in adopting digital technologies, insight to be gained by investing in analytics, and better performance to be found by adopting AM. However, attendees were cautioned to avoid over-generalized digitization efforts. They were advised to find high-potential value targets to showcase the benefits.

Drew Robb

Cover photo: Multi-module 10MW steam turbine designed in AxSTREAM; control stage includes sets of prismatic blades on the high-intermediate pressure zones and 3D geometries on the low-pressure end. Courtesy of SoftInWay.



COVER STORY

24 TURBO EXPO 2018

The annual Turbo Expo covers a lot of ground. More than 3,000 participants came to hear over 1,000 technical papers presented in over 400 technical sessions. Tracks include heat transfer, electric power, aircraft engines, ceramics, fuel types, combustion, emissions, controls, cycle innovation, fans & blowers, cogeneration, manufacturing, marine, oil & gas, steam turbines, and lots more.

Within that packed program, some of the standout sessions were about duct firing, inlet air filtration and using aeroderivatives in LNG applications.

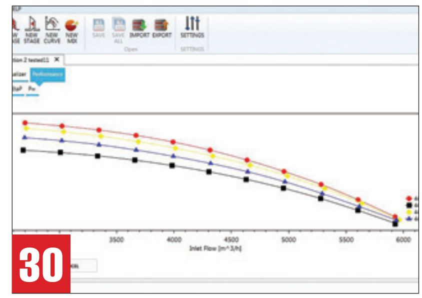
Drew Robb

OPERATIONS & MAINTENANCE

27 STRESS CORROSION CRACKING

Best practices for lubrication maintenance can help to prevent the catastrophic failure of aeroderivative gas turbines An example is provided of a Rolls-Royce Avon GT used as a prime mover for process gas compressors in an offshore oil gas platform off the coast of India. There are over 90 Avons operating in the Mumbai High offshore oil gas field.

Sarma Krishnamoorthy



COMPRESSORS

28 RAISING PERFORMANCE

Raising the availability of centrifugal compressors is one of the primary tasks for maintenance teams. Quantitatively evaluating machine performance plays a key role in understanding if a compressor is working as expected. Software tools, such as Cmap, allow the user to predict compressor performance and obtain a quantitative indication of deviating parameters.

Massimiliano Di Febo & Pasquale Paganini

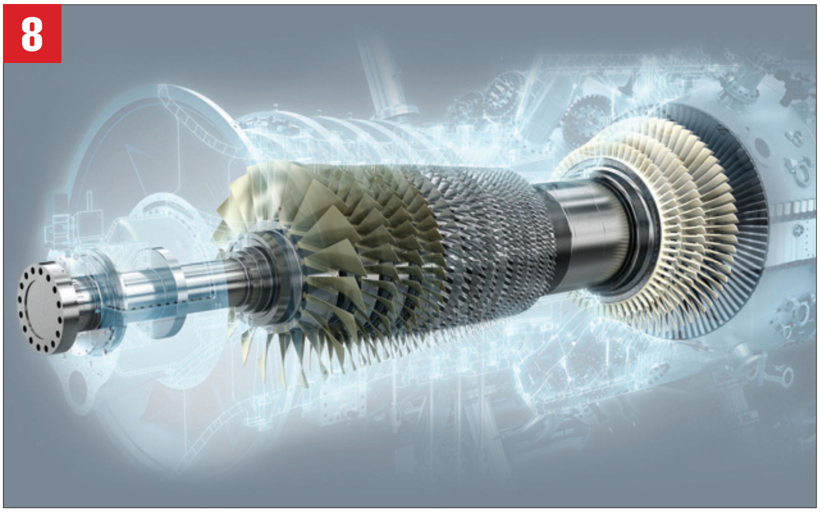
GAS TURBINES

30 REGENERATIVE CYCLE

A regenerative cycle provides the heating of the boiler feed water via steam extracted from the turbine. This variation of the Rankine cycle reduces boiler fuel consumption and the work of the turbine. It has the objective of increasing overall plant efficiency.

This regenerative cycle has been applied in many power plants. Boilers, heat exchangers and steam turbines have been redesigned with this cycle in mind to achieve higher performance, greater efficiency, and more flexibility and reliability with the potential to realize low cost and clean generation.

Departments



COLUMNS

TURBO SPEAK

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R. Tom Sawyer (June 20, 1901 to January 19, 1986) was one of the founders of *Turbomachinery International* in 1959. His credits include being the inventor of the first successful gas turbine locomotive, assisting in the development of the diesel locomotive, the founding of IGTI and the author of books on GTs, locomotives and atomic power.

Drew Robb

TURBO TIPS

15 FUTURE PUMPS

This column addresses the challenges of submerged pumps. For many services and for pumped liquids, the best approach is to submerge the pump and motor. The pump train is isolated from oxygen. Motor gaps and voids are filled with liquid. Seals or couplings are eliminated.

Amin Almasi

Q & A

31 NEW DIRECTOR AT THE TURBO LAB

Dr. Eric Petersen, the new director of the Turbomachinery Laboratory, discusses the purpose of the lab, his immediate plans and developing trends in the industry.

MYTH BUSTERS

36 TEENAGERS AND COMPRESSORS CAN'T STAY OUT OF TROUBLE

After years of running and testing centrifugal compressors, compressors behave like teenagers in many ways. The authors compare surge conditions to some of the problems teenagers encounter.

Rainer Kurz & Klaus Brun


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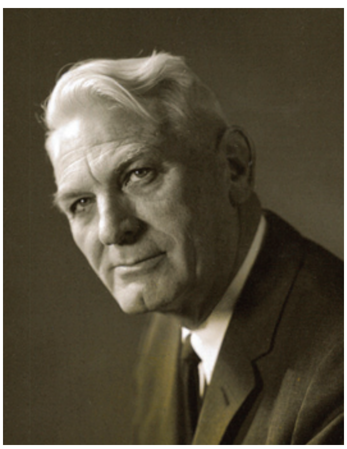
THE ADVENTURES OF R. TOM SAWYER

The Adventures of Tom Sawyer by Mark Twain is an 1876 novel about a young boy growing up along the Mississippi River. But it's the adventures of R. Tom Sawyer we will be discussing in this column.

I was reminded of him when I attended the Turbo Expo last month. The American Society of Mechanical Engineers (ASME) honors worthy members with an annual R. Tom Sawyer Award. Why are we talking about him? R. Tom Sawyer (June 20, 1901 to January 19, 1986) was one of the founders of *Turbomachinery International* in 1959. His credits include being the inventor of the first successful gas turbine locomotive, assisting in the development of the diesel locomotive, the founding of the International Gas Turbine Institute (IGTI) and the author of several books on gas turbines, locomotives and atomic power. He was the first recipient of the ASME IGTI award in 1972. His impact on the industry was so major that the award was thereafter named after him.



R. Tom Sawyer

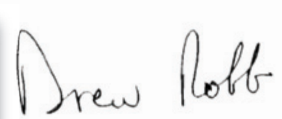
Sawyer used this magazine as a vehicle to promote what was at the time a novel machine, the gas turbine. He showcased the value of the GT to the power, marine, oil & gas and other sectors. He achieved tremendous success in popularizing the machine and pushing forward its development. His tireless efforts earned him the moniker, "Mr. Gas Turbine."

Why bring this up? Apart from the fact that it's a slice of history that most attendees at the Turbo Expo under 50 won't be aware of, the industry needs more R. Tom Sawyers. Faced with competition on many fronts, we need more pioneers like him pushing the bounds of the gas turbine. We need more people promoting the gas turbine to new markets.

During his time, no one used the gas turbine for power generation. No one considered it a viable option for marine propulsion or oil & gas duty. That didn't deter him. He pushed on the technical side and on the marketing side to widen the appeal of the technology.

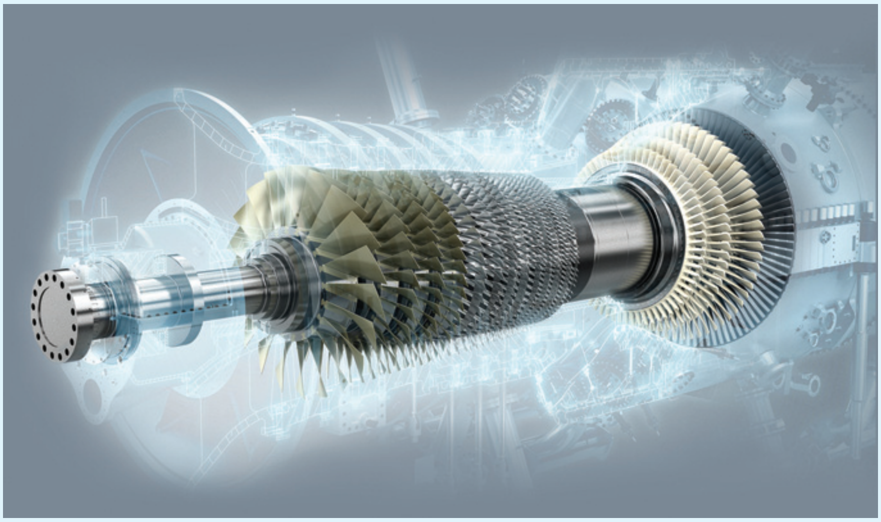
There is an important lesson here for today. Yes, times are tough, sales are low and environmental regulations are challenging. Yet these pale in comparison to what Sawyer faced at a time when no one used gas turbines. It is time for more of us to follow his lead, grit our teeth and figure out a way once again to assert the value of the gas turbine.

Dr. Wadia



DREW ROBB
Editor-in-Chief

Siemens digest



Siemens cuts back on its Power Generation division while investing heavily in its MindSphere software and other digital technologies

Siemens shut down for seven days its Power & Gas (PG) division operations worldwide to cut costs. "The shutdowns are part of a comprehensive package of measures, which also includes issues, such as travel costs, sponsoring, participation in trade fairs and investments," said the company.

This news came on the heels of a November announcement that Siemens would cut almost 7,000 jobs (mostly in its PG division), and that it planned to permanently shut down some PG manufacturing locations in Europe.

Despite these actions Siemens PG and Siemens Power Services have announced a series of new orders which stand in sharp contrast to the cutbacks.

Siemens has signed an agreement with WorleyParsons to explore greater collaboration on energy and power infrastructure projects, grid optimization, integration of renewable technologies, and energy efficiency and storage technologies in North East South America and the Caribbean (NESAC) region. It focuses on offshore oil and gas opportunities, as well as onshore electrification and industrialization projects.

The Siemens SGT-700 GT has entered the Chinese distributed generation market for the first time. The company will work with Aero Engine Corporation of China to supply two units of SGT-700 to a distributed energy station project run by Guangzhou Development Group in Taiping Industrial Park, Guangzhou.

This project is expected to go into operation in the second half of 2019. When the combined cycle unit begins operation, it will meet the industrial park's electricity and heat demand and cut energy consumption and emissions.

Siemens has received an order from Inter Pipeline to provide long-term service for two SGT-800 GT generator sets in Canada. The units are scheduled for operation at the Central Utilities Block (CUB), part of the company's Heartland Petrochemical Complex currently under construction in Alberta's Industrial Heartland near Fort Saskatchewan.

The 25-year agreement includes scheduled maintenance for the two SGT-800s and associated auxiliaries. Siemens' remote diagnostics services are included. The GTs will be supplying power and steam to the propane dehydrogenation and polypropylene facilities. This facility will use propane to produce polypropylene.

Bayat Power of Afghanistan has received approval for the construction of Bayat Power-1. This Gas-to-Electricity Power Plant will be located in Sheberghan, Jowzjan Province. The 40 MW will use Siemens SGT-45 mobile turbines designed and manufactured in Houston, Texas.

Siemens and the Scottish energy company SSE have announced they will collaborate to build the gas-fired power station Keadby 2 in Lincolnshire, UK. Siemens will provide a full turnkey solution for the power plant, which will include the world's first deployment of the 50 Hertz version of its SGT-9000HL gas turbine. It will have capacity of 840 MW and 63% efficiency.

The collaboration also included a 15-year long-term service contract. Siemens will use digital service solutions including remote monitoring and diagnostics, to help maintain the availability, reliability and optimal performance of the plant. Construction at the site will begin this summer. Commercial operation is scheduled for 2022.

Siemens has received its first order from Panama for six SGT-800 GTs. Along with an ST, they will provide 440 MW of power as part of CCPP. Siemens' customer is the Chinese general contractor Shanghai Electric Group, which is responsible for building the plant.

Commissioning for the power block is scheduled for the fall of 2020. The scope of supply includes a power block in a multi-shaft configuration, consisting of six SGT-800 GTs of single lift package design, six gas turbine generators, one SST-600 ST, an SGen6-100A-2P ST generator, six VOTSG HRSGs, as well as Simatic PCS7 control system for the GTs and a SPPA-T3000 control system for the ST. The new plant will be built near the seaport of Colón on the Caribbean coast and be operated with liquefied natural gas (LNG).

Siemens is expanding its digital efforts and development work on its MindSphere platform. Its new MindSphere Application Center in Barcelona is where the company's digital solutions of tomorrow will be developed. The company already operates several other Mindsphere Application Centers around the world.

Microturbine orders

Capstone Turbine has secured a nine-year service contract at a new 650,000 sq. ft. warehouse and shipping center for a food retailer in the New York area. RSP Systems, Capstone's distributor for the region, secured the agreement for the center in the Bronx. The C1000 Signature Series microturbine is installed at the facility using five Capstone hot water heat recovery modules. The microturbine provides and 700 kW of backup power in the event of an outage.

Faster simulation

Italian oil and gas exploration company, Eni, has reduced the simulation speed of oil reservoir modeling by 20 times using 3200 Nvidia Tesla Graphical Processing Units, and Stone Ridge Technology's Echelon simulation software. It processed 100,000 reservoir models in 15.5 hours. It took 10 days using older hardware and software. Each model simulated 15 years of production in an average of 28 minutes.

(Continued on p. 10)

GE digest

Citing "ongoing challenges in the power industry," GE has announced plans to close its manufacturing facility in Salem, Virginia. The plant designs and produces control systems and integrated circuit boards for gas and steam generators, pitch systems for wind turbine blade controls, starters for GTS and down-tower assembly for wind power conversion systems. The letter of intent to close the plant noted "a significant decline in orders at this facility."

In December, GE Power announced plans to reduce employee numbers by some 12,000. The OEM cited challenges in power markets, claiming fewer gas turbine orders owing largely to overcapacity and renewables.

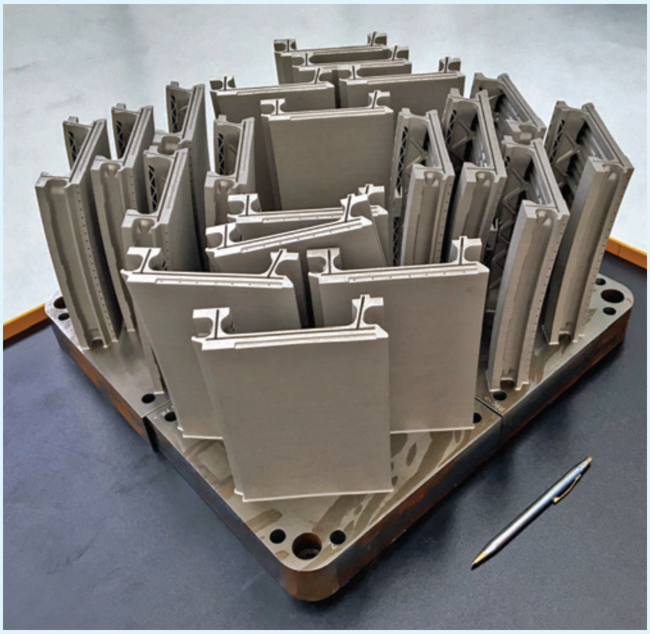
Meanwhile, business media have been reporting that Wartsila is a serious contender for acquiring GE's Jenbacher division of reciprocating engines. Jenbacher has been successful in power ranges below the ones Wartsila has been operating in, making the acquisition a good fit. Further, Jenbacher is focused on commercial and industrial customers whereas Wartsila has been serving primarily utilities. Jenbacher is a successor to the Austrian Jenbacher Werke. GE acquired the company in 2003.

GE's Power Services has unveiled a range of products and services targeting GTs of other OEMs, including Siemens' and Mitsubishi's SGT-800 and 501F units. GE also announced more than $200 million in a gas turbine cross-fleet orders backlog.

GE is benefitting from ST, generator and HRSG capabilities acquired from Alstom. The company says it has completed several outages at 501F power plants, spanning inspection services on all major plant components and systems. Its claimed 501F capabilities include: Increased intervals of up to 32,000 hours/1,250 starts (for fewer combustion inspections); more output and better efficiency in both simple-cycle and combined-cycle operations; and improved emissions with lower turndown and fuel flexibility.

GE has also signed several long-term agreements to provide maintenance and performance upgrades for Siemens SGT-800 turbines. Its capabilities in this fleet include: Significantly extended maintenance intervals up to 40,000 hours/900 starts; and increased output by up to 6% and efficiency up to 1.5%. A 1,230 MW combined cycle power plant (CCPP) has finished all its commissioning activities in Pakistan. The Haveli Bahadur Shah features GE 9HA.01 heavy-duty GTs, one 400 MW GE steam turbine (ST) and two HRSGs.

GE Power announced several new facilities using its HA GTs. The CPV Towantic Energy Center in Oxford, CT has achieved commercial operation using two GE 7HA.01 GTs and associated engineered equipment package. The 805 MW CCPP can take advantage of HA's dual-fuel capability that allows the turbines to run on a variety of fuels.



GE's MXL2 with additive manufactured performance upgrade for its GT13E2 gas turbine

PSEG Power achieved commercial operation at its Sewaren 7 CCPP in NJ, powered by a 7HA.02 GT. The facility generates up to 540 MWs. The TVA's Thomas H. Allen plant in Memphis, TN recently achieved commercial operation.

In addition, work at the Porto de Sergipe power plant, in Barra dos Coqueiros, Brazil, is progressing with three 7HA.02 GTs and three generators now arrived in the country. GE will supply the entire power island engineered package as well as the remaining balance of plant such as cooling towers, foundations roads and buildings. When complete, the plant will be capable of generating 1,516 MWs.

GE Power and Vattenfall Wärme Berlin announced the new MXL2 with additive manufactured performance. This is an upgrade for GE's GT13E2 GTs that uses key components manufactured using additive technology.

Because these components are made with a lightweight configuration and can be engineered to include advanced cooling channels, they help the gas turbine run more efficiently. This upgrade reduces component cooling requirements by up to 25%, increases output up to 21 MW in a combined cycle configuration and boosts efficiency by 1.6%.

Solar Turbines order

Solar Turbines has been contracted to provide turbomachinery for the Chervonodonetska and Khrestyschenska booster compressor stations in Ukraine. The stations have been commissioned for the development of the Shevelynka gas condensate field. Three turbocompressor units with tandem compressors C61 and GT Mars100, turbocharger unit with compressors of C61 and C51 types and a Titan130 GT, as well as a Taurus70 GT will be supplied. The equipment is likely to be delivered towards the second half of 2018.

New umbrella company

Cook Compression, Inpro/Seal, Waukesha Bearings and Bearings Plus have formed the newly named Dover Precision Components operating company. As the umbrella for these brands, Dover Precision Components is an integrated provider of performance-critical solutions for rotating and reciprocating machinery and features a diverse portfolio of products and services. Its brands include:

- Cook Compression delivers custom-engineered valves, sealing technologies, pistons and rods, as well as repair and reconditioning for reciprocating compressors
- Inpro/Seal, the inventor of the Bearing Isolator, designs and manufactures bearing protection and shaft seals to increase the reliability of rotating equipment
- Waukesha Bearings deals with engineered hydrodynamic fluid film bearings and brush seals for turbomachinery. It also produces active magnetic bearing systems
- Bearings Plus specializes in the repair, replacement and upgrade of fluid film bearings and seals.

Headquartered in Houston, Dover Precision Components maintains facilities in North America, Europe, Asia and the Middle East. It has more than 1,400 employees worldwide.

Microturbine solar hybrid

A successful demonstration of microturbine solar power system technology has been completed at the facilities of ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) in Casaccia, Rome, according to the European Turbine Network (ETN). Concentrated solar power (CSP) is part of Europe's low carbon energy goals. But problems include predictability and dispatchability of CSP plants.

This project is aimed at making CSP more robust, reliable, cost effective and more suitable for hybridization. The system was designed with a modular approach, capable of producing electricity up to 30 kW per unit for domestic and small commercial applications. For larger energy needs, the units can be stacked. The market study showed that the market for this technology is wide due to the adaptability of the system, which produces heat and power assisted by biofuel or conventional fuels if needed.

Nicholas Dorsch

New Elliot VP

Elliott Group announces that Nicholas Dorsch is now Vice President of Industrial Products. Dorsch will lead the company's industrial ST line and its power generation group. Dorsch brings 30 years of experience, including global operations, business strategy, process improvement, and change management. Most recently he was Senior Director of Operations for Gardner Denver's Nash Division.

Marine GTs

Rolls-Royce's MT30 GTs will power a fleet of 30 CCM-class frigates of the Japan Maritime Self Defense Force. Construction work on the first of the 30 planned frigates is slated to commence next year and the vessel is expected to enter service around 2022.

The MT30 is the world's most power-dense marine GT in service today. It has nearly 50% fewer parts than other aeroderivative GTs of the same class. The equipment features a twin-spool, high-pressure-ratio gas generator with a free power turbine. It maintains operating efficiency down to power levels of 25 MW. It can be configured in either mechanical, electrical or hybrid drive configurations.

Supercritical CO_2 project

NET Power has achieved first fire of its supercritical carbon dioxide (CO_2) demonstration power plant and test facility located in La Porte, TX. It includes a 50 MW Toshiba combustor integrated into the NET Power process. NET Power is targeting the global deployment of 300 MW-class commercial-scale plants beginning as early as 2021.

The system is designed to produce low-cost electricity from natural gas while generating near-zero atmospheric emissions, including full CO_2 capture. Several 50MW combustors will be utilized together in NET Power's commercial facilities. NET Power is a collaboration between Exelon Generation, McDermott, and 8 Rivers Capital.

The plant is designed to demonstrate NET Power's Allam Cycle technology, which uses a new turbine and combustor with CO_2 as a working fluid to drive a combustion turbine. The Allam Cycle eliminates virtually all emissions from natural gas power generation without requiring expensive, efficiency-reducing carbon capture equipment.

(Continued on p. 12)

MHPS digest

Mitsubishi Hitachi Power Systems (MHPS) has received more than half of all global orders for gas-fueled turbines in the first quarter of 2018, according to a report from London-based investment bank Barclays. This is MHPS's best-ever performance in the market. The report said Siemens had 26% of global orders in 1Q2018, with GE's share dropping to 14%.

While MHPS has steadily been increasing its North American manufacturing and sales capabilities, its Asian focus may further extend its advantage. Global technology research and advisory company Technavio reports that the Asia-Pacific region for GTs "is expected to become the largest revenue contributing region in the market by 2020 and is projected to occupy more than 49% of the overall market share.

"The high demand for power generation is attributed to the rising economic developments in the region. Factors such as the surge in carbon emission concerns due to prominence of coal-based power generation fueled the demand for gas turbines in the market. The growing need to replace coal-fired plants with natural gas-based gas turbine plants influence the market's growth."

Suncor Energy has agreed to purchase MHPS JAC gas turbine (GT) technology to power a more cost-effective and carbon-efficient process for bitumen production and power production in the Canadian oil sands. Two JAC GTs will be installed with two heat recovery steam generators (HRSGs) in a co-generation facility at the company's base plant oil sands mine near Fort McMurray, Alberta.

MHPS continues to win orders around the world including this J-class unit being shipped to Mexico

A proprietary process uses natural gas to generate up to 800 MW of electricity using JAC. Waste heat will heat the oil sands to separate the sand from the bitumen. This process will improve the efficiency of the existing production of about 350,000 barrels of bitumen per day. In addition, MHPS will provide digital power technology to monitor the equipment and provide predictive analytics, machine learning and adaptive controls.

MHPS Americas and NTE Energy opened the Middletown Energy Center. Powered by MHPS M501GAC GTs, the CCPP will generate 525 MW. The facility will be constructed, owned, and operated by NTE.

MHPS has received an order for two H-25 GTs for a thermal power station being built by China Resources Power Group in Taixing City, Jiangsu Province. The units will form the core equipment of a double-train 80 MW CCPP fired by natural gas. It is scheduled to go into operation in 2019. The plant will supply power, steam for manufacturing processes, and cooled air for air-conditioning.

Cryogenic nitrogen removal

BCCK Engineering, Inc. will provide its Nitech cryogenic nitrogen removal process as part of a complete, high-BTU gas cleaning system for a landfill gas-to-energy plant. Klickitat Public Utility District (PUD) selected Nitech to transform landfill gas into nearly 100% pure natural gas at the H.W. Hill Landfill Gas to Energy plant, located at the Roosevelt Regional Landfill in Klickitat County, WA. The Nitech Nitrogen Removal Unit (NRU) will be used to remove nitrogen from methane gas collected from the landfill. BCCK will provide a dehydration system in front of the Nitech NRU to dehydrate from the upstream solvent process. It will process 7.2 MMSCFD of gas and will recover 99.5% of the methane.

Biogas plant

In April 2018, the energy plant constructor ETW Energietechnik installed its first biogas processing plant in Scherwiller, France. The plant has been in continuous operation since mid-April. This is a compact model of the biogas treatment system ETW SmarCycle PSA developed by ETW.

With a processing capacity of 230 to 385

Nitech nitrogen removal


New ETW biogas plant

standard cubic meters of biogas per hour, this plant model has been specially developed for the French market. Plant manufacturer Rytec from Baden-Baden is responsible for the entire project development and the installed fermentation line. The smart process control reacts automatically to large volume flow fluctuations and changing raw gas qualities. This means that there is no loss in yield or quality of the biomethane produced.

PTC Rockwell partnership

PTC and Rockwell Automation have entered into an agreement for a strategic partnership to accelerate growth for both companies and enable them to be the partner of choice for customers around the world who want to transform their physical operations with digital technology.

Rockwell Automation will make a $1 billion equity investment in PTC. PTC and Rockwell Automation have agreed to align their respective smart factory technologies and combine PTC's ThingWorx IoT, Kepware industrial connectivity, and Vuforia augmented reality (AR) platforms with Rockwell Automation's FactoryTalk Manufacturing Execution System FactoryTalk Analytics, and Industrial Automation platforms. The result will be an integrated information solution that will enable customers to achieve increased productivity, heightened plant efficiency, reduced operational risk, and better system interoperability.

Turbomachinery Lab meeting

Representatives from 36 industrial firms attended the Turbomachinery Research Consortium (TRC) annual meeting. They selected the next round of student-led research projects based on 44 proposals. Results will be announced shortly, and those projects selected will begin in September.

The TRC is a members-only group of companies who have united with the Turbo Lab, a center of the Texas A&M Engineering Experiment Station, to find answers to important questions about turbomachinery performance and reliability through research. TRC member companies provide annual payments of $25,000 to support a broad range of member-selected projects. TRC member companies have exclusive access to a continuing series of reports and computer programs on all TRC research activities dating back to the foundation of TRC in 1981.

At any given time, 15 to 20 graduate students in Texas A&M's Department of Mechanical Engineering are supported by the TRC. Students conduct research on TRC projects at the Turbomachinery Laboratory research facility, adjacent to Texas A&M's main campus. The 37,000 square foot high-bay facility is equipped with 12 vibration damped test cells. The lab also boasts a variety of compressors that provide air for test rigs with capacities ranging from 4,000 standard cubic feet per minute (scfm) at 120 pounds per square inch gauge (psig) to 1,350 scfm at 300 psig.

ORC system

Italian firm Exergy, a manufacturer of ORC systems with Radial Outflow Turbine technology, in partnership with Baker Hughes, has been awarded a contract for the engineering, design and construction of a 5 MW ORC unit for waste heat recovery from GTs in an LNG plant in Thailand.

The customer, Samsung Engineering, acts as EPC contractor for the final customer and user, PPT LNG, in its regasification terminal located in Rayong. This ORC solution recovers the exhaust heat downstream generated from two Solar Mars 100 GTs installed in the LNG plant for regasification.

The cooling system employs cold water coming from the LNG regasification cycle as heat sink, in a temperature range between 5-38 °C, with no water consumption. The heat recovery plant exploits a large amount of the residual heat, otherwise discharged by the GT into atmosphere, increasing the efficiency of power production and reducing the environmental footprint of the power plant. The ORC will start commercial operation in the first half of 2019.

Ethos digest

EthosEnergy has been awarded an optimization and upgrades contract for work with a customer in the upper Mid-West. The contract is for an icon controls upgrade on two Pratt and Whitney FT4 TwinPac's (gas fuel only) with turnkey installation and commissioning. Over 70 Pratt and Whitney FT4 units (TwinPacs, MobilePacs, and PowerPacs) have been retrofitted with icon controls.

EthosEnergy has been awarded an eight-year major inspection contract, providing field services, parts replacement, and component repair to a major power plant in Texas. The contract provides maintenance coverage, extending for one full major inspection cycle for a GE 7EA GT.

The Pratt & Whitney MobilePac can be transported by airplane

LNG order

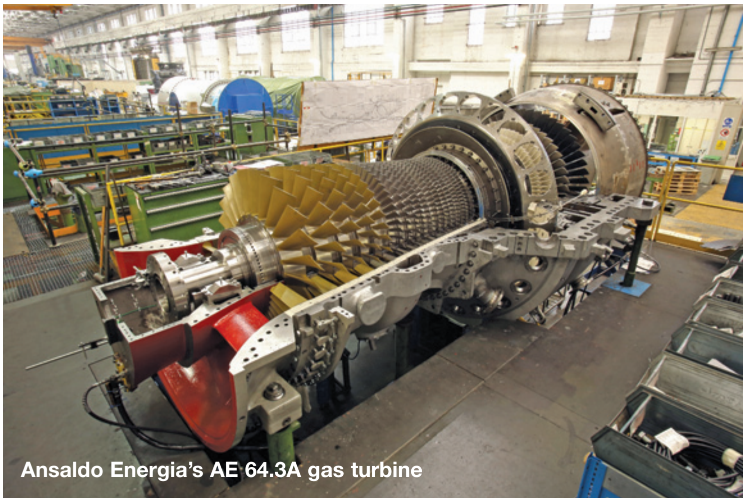
Baker Hughes, a GE company (BHGE) will supply turbomachinery equipment for the expansion of Cheniere's LNG facility in Corpus Christi, TX. Cheniere announced a plan to continue construction on the third liquefaction train at Cheniere's Corpus Christi liquefaction project (CCL Project).

When all three trains are completed, the production capacity is expected to be 13.5 MTPA of LNG. Cheniere appointed Bechtel as its EPC partner. BHGE will provide turbomachinery equipment for the third train consisting of six PGT25+G4 DLE GTs driving various compressors. BHGE has provided the same equipment for two other trains already under construction at Corpus Christi, and similar technology for five trains at Cheniere's Sabine Pass plant.

Ansaldo in Africa

Ansaldo Energia has signed an Engineering, Procurement and Construction (EPC) contract with Société Tunisienne de l'Électricité et du Gaz (STEG) to build a gas-fired open cycle thermoelectric power station. It will have an installed power of 625 MW and be situated in Mornaguia, south-west of Tunis.

A Long-Term Service Agreement (LTSA) contract covers maintenance and assistance work for the plant. The plant will be equipped with two AE94.3A GTs, plus generators and auxiliaries. Work will take 22 months.


Ansaldo Energia's AE 64.3A gas turbine

New compressor center

Global Compressor, a one-stop-shop quality compression parts and service, has opened a service repair center in Houston, TX. With an inventory of more than 28,000 compressor parts, Global Compressor's repair center is equipped to inspect and evaluate all compressor components to offer new, machine-repaired and exchange units. The center is capable of refurbishing, manufacturing and shipping parts to customers the same day.

Baker Hughes divests

Rotating Machinery Services has acquired the AC Compressor business from Baker Hughes, a GE Company. This acquisition brings the personnel, intellectual property and associated tooling of AC Compressor under the RMS umbrella. RMS will also receive the drawings and designs for the centrifugal and axial compressors offering, developed under the business known as CONMEC.

In 2017, RMS acquired the Mepco business in Houston. Prior to the acquisition, RMS had a portfolio that consisted of engineered solutions for compressors, expanders, and steam turbines. AC Compressor has a history dating back to 1931 under the former Allis-Chalmers nameplate. AC Compressor acquired CONMEC in 1997. In 2001, GE acquired both businesses. The AC Compressor business services and repairs industrial compressors in the refining & petrochemical, industrial, onshore and offshore production and pipeline & gas processing industries. The product line consists of axial, centrifugal and oil-free-screw compressors, with a worldwide installed base of over 1,200 machines.

Coal plant closure

An electric cooperative that provides wholesale power and services to customers in western Kentucky has told state regulators it intends to end an operating agreement at a 312-MW coal-fired plant in Henderson, which could lead to the plant's retirement. Big Rivers Electric told the state Public Service Commission (PSC) and Henderson Municipal Power & Light (HMP&L), which owns the Station Two plant that it wants approval to end its contract.

HMP&L's options for the plant include retirement, perhaps as early as 2019. The agency also could look for another operator or begin buying wholesale power from the market. HMP&L at present reserves 115 MW of the plant's generation; Big River sells the rest on the open market.

Small modular reactor

GE Hitachi Nuclear Energy (GEH) will receive funding from Dominion Energy for the BWRX-300, a 300 MWe small modular reactor (SMR). This provides seed money towards commercializing this technology. GEH projects the BWRX-300 will require up to 60% less capital cost per MW when compared to other water-cooled SMRs or existing large nuclear designs. ■

FUTURE PUMPS

ADDRESSING THE CHALLENGES OF SUBMERGED MOTOR PUMPS

AMIN ALMASI

Old-fashioned pumps using external electric motors, mechanical seals and conventional lubrication oil have presented many problems to modern facilities. They introduced reliability, safety and operational issues. That is why they are usually employed in a one operating and one standby configuration (known as 1+1). Fortunately, advanced designs now exist as alternatives to conventional pumps.

Conventional centrifugal pumps couple a pump casing to an external electric motor. They need a shaft seal to allow the shaft to extend outside of the pump casing. They also need a coupling and a relatively long shaft connected to an electric motor. However, the seals are susceptible to failure. Unscheduled shutdowns and serious safety issues have resulted due to factors such as the need for piping to an external pump, failed pump seals and leakage of the pumped liquid.

A submerged motor pump can avoid most of these problems. The pump and electric motor are mounted on a common shaft and submerged in the pumped liquid. At first glance, it may seem unwise to submerge the electric motor in hydrocarbons or flammable liquids. However, this is safe and reliable.

For many services and for pumped liquids, the best approach is to submerge the pump and motor. The pump train is isolated from oxygen. Motor gaps and voids are filled with liquid. Seals or couplings are eliminated.

Concerns about heat dissipation or electric motor temperature rise are best considered on a case by case basis. For relatively hot liquids (10°C to 40°C), special designs are needed. Submerged motor designs, though, are not suitable for very hot liquids. But they are reliable in low temperature and cryogenic services.

Each submerged motor pump system has unique characteristics. This depends on the processes being applied, the size and location of the pump, the source and details of the pumped liquid.

Submerged motor pumps are usually mated with variable speed drives. VSDs enhance flexibility and optimize pump performance by varying pump speed. As VSD regulates the rotating speed, greater variation in discharge pressure can be achieved for a given pumping capacity.

In addition, a VFD allows a compact variable speed pump to be started at a reduced frequency. This soft start decreases the starting current level and lowers the required current. This is important for motors larger than 0.7 MW.

"Submerged motor pumps are safe and reliable."

In-tank submerged pumps

In-tank submerged pumps eliminate conventional side nozzles on tanks, external pumps, suction-feed lines from tanks to pumps, and all associated risks. These in-tank designs typically draw the tank liquid down to extremely low levels. Pump manufacturers and operators are happy to reduce any undesirable remnant liquid in the tank.

Many in-tank submerged pumps are removable. When it is lifted from above, the suction valve closes and it is sealed. This allows purging. The pump can be safely removed for inspection and maintenance. Tanks can be located below ground level, if desired.

Further configurations of submerged motor pumps are available. A vessel-mounted submerged pump, for example, is offers high head pumping services with flow ratings as high as 5000 m^3/h. Discharge pressures can be as high as 250 Barg or more. These pumps are contained in a pressure vessel built to the appropriate vessel codes. As these pumps often operate 24/7 for prolonged periods, reliability is essential. By closing the suction, and discharge valves and applying an inert gas purge to the suction vessel, the suction vessel mounted pump can be removed for maintenance.

Conventional materials used in traditional pumps might not be suitable for submerged pumps. Special materials and designs may be required. For some submerged pumps, aluminium alloys are needed for housings and rotating components. They can be cast in the complex geometries required. They are particularly important for specific applications. In some cases, the alloy's yield strength increases as the temperature decreases without becoming brittle. They are commonly used for low temperature and cryogenic services. They are also corrosion resistant. Their thermal expansion properties maintain an exact fit and clearances over a wide temperatures range.

Hydride ceramic rolling-element bearings, for example, are needed for these pumps. Many of these new materials have not been used before for pumps applications. That's why they are not listed or referred to in pump codes such as API Standard 610. ■

Amin Almasi is a Chartered Professional Engineer in Australia and U.K. (M.Sc. and B.Sc. in mechanical engineering). He is a senior consultant specializing in rotating equipment, condition monitoring and reliability.

3D printers at a Siemens facility in Sweden

TRANSFORMING MAINTENANCE, REPAIR AND OVERHAUL (MRO)

DIGITIZATION, ADDITIVE MANUFACTURING AND ANALYTICS ARE REVOLUTIONIZING THE INDUSTRY

BY DREW ROBB

The annual International Gas Turbine Institute (IGTI) Turbomachinery Expo often has a dominant theme. For 2018, the focus turned to digitization, additive manufacturing (AM or 3D printing) and analytics. Each day's keynotes and an entire track looked at every aspect of the digital revolution.

The overriding message: there is value in adopting digital technologies, insight to be gained by investing in analytics, and better performance to be found by adopting additive manufacturing. However, attendees were cautioned to avoid over-generalized digitization efforts. They were advised to find high-potential value targets to showcase the benefits.

Experts from companies, such as Delta Airlines, Lufthansa, GE, Siemens, Mitsubishi Hitachi Power Systems, Bechtel, Strategic Power Systems, Ansaldo Energia, PSM, Equinor (formerly Statoil), Air France, MTU Aero Engines and Pratt & Whitney were front and center in the digital push.

Digital keynote

The opening keynote set the tone for the week. Jaroslav Szwedowicz, ASME's Gas Turbine Segment Leader, introduced the concept of Maintenance, Repair and Overhaul (MRO) in the Light of Digitization. He noted trends impacting the gas turbine (GT), such as the fluctuating power output of renewable generation.

As a result, GTs need to be more flexible, being able to operate in peaking and partial load modes, as well as base load. "IGTI is involving more stakeholders in

The digitization and MRO keynotes at the Turbo Expo were the show's most well-attended events

MRO and digitalization," said Szwedowicz. "We have also added an AM track for the first time."

Before introducing the guest speakers, he offered a history lesson, and part of the reason Lillestrom in Norway hosted this year's show. Some 115 years ago, inventor Jens Elling built the first ever GT in Lillestrom.

This 1903 model could provide 8 kW of power operating at 12,000 rpm. It comprised a six-stage radial compressor, intercooling, variable diffuser vanes, steam injection, and a single stage centripetal turbine with a turbine inlet temperature of 400°C.

"All these years later, the GT industry continues to innovate," said Szwedowicz.

Dr. Zuozhi Zhao, CTO of Siemens Power and Gas, began with a more recent historical reference. Over the past five years, he has observed a radical shift in the industry. Renewables and the introduction of batteries are bringing about challenges and opportunities in MRO.

Digitization is being looked upon as an answer to changing industry dynamics. However, it is a broad term that encompasses big data, cloud computing, edge computing, analytics, automation and more.

As such, there are many different interpretations of digitization. Zhao said it is important to define clearly what you are talking about to know how to harness digitization properly.

He was positive about the future. Yes, automation, robotics and artificial intelligence (AI) will take over many functions performed by people today, he said. But world electricity demand is going to double by 2045. That will generate plenty of new work opportunities.

"Digitalization is required to address the complexity of modern energy systems," said Zhao.

Billions in investment

Siemens has spent over 10 billion euros over the past decade in acquiring and developing software for digitization and automation. In the past year, the company has spent 1.2 billion in digital R&D. Siemens, a company known for its hardware prowess, now boasts 25,000 software engineers.

One result of increasing emphasis on software is Siemens MindSphere. It is a cloud operating system that connects plant systems with digital, Internet of Things (IoT) and analytics applications.

"High-quality sensors are so cheap that you can deploy as many as you want," said Zhao. "When you combine them with modern compute power, a cloud infrastructure and digital twins, you can enable a lot of things."

AM, he added, makes the digital twin a reality. He believes the digital twin is the answer to how to run plants and GTs with so many starts, stops and cycling while maintaining reliability.

A digital twin is an organized collection of physics-based methods and advanced analytics that is used to model the present state of every asset in a digital power plant. It can help perfect designs, improve plant operations and determine the best way to build power plants.

This is achieved by model-based simulation of various scenarios to isolate the ideal approach. They can also be used by taking feedback from the operational side and looping back to model the reason for problems. This can lead to much better designs.

For example, Siemens has been using this technology to create 3D printed turbine blades that can run at 1,000 mph and temperatures at 1,250°C. These blades have a greatly improved internal cooling geometry designed by AM. The company is also using AM to provide spare parts on demand.

Siemens has been active in 3D printing since 1989. It has integrated 3D printing

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3D printed burner fronts from Siemens

with computer-aided design (CAD) software, controls technology, automation, and turbomachinery systems to be able to digitally model all processes. It is deploying the technology to manufacture tailor-made products and create structures that cannot be achieved with conventional methods.

Components currently manufactured in solid form can be produced in an additive manufacturing process with the required cavities already integrated and as strong as their current counterparts. They are also lighter and require less material.

The benefits of AM are said to be the ability to bring products to market, reducing R&D and prototyping loops by 75%, and repairs being performed in a tenth of the usual time. Further, metal powder from the process can be recycled and used again, which leads to a reduction in scrapped material.

3D printed burner nozzles have already been made available for SGT-700 and SGT-800 GTs. They allow co-firing at higher combustion temperatures thanks to an improved burner tip design. Burner fronts were traditionally manufactured with 13 components and 18 welds. The AM versions consist of one component and two welds. They are also ten times faster to produce.

Zhao expressed enthusiasm about the way analytics capabilities are developing. Instead of merely describing past events or providing data-based proactive decision support, they have evolved to the point where analytics can explain why events happened, help to mitigate risk and predict what is likely to happen next with components, equipment, plants and entire fleets.

"Informing plant managers, fleet managers and top management about how to operate in the future is the real value of analytics," said Zhao. "Digitalization can assist in rapidly changing operating profiles based on price fluctuations, keep fleet availability high, lower risk and help managers make better decisions."

GE software

GE's digital transformation began a few years ago to enhance physical assets with digital technologies. The company's software business now augments how it services hardware around the world.

"It can be difficult to make change happen due to the traditional way of operating," said Russell Irving, Digital Twin General Manager and Chief Engineer, GE Global Research. "The digital side must never forget who we work for: we are the enabler, but the MRO network is the owner we serve."

As such, it is up to those dealing with digitization initiatives to find out what customers want. This is typically maximum uptime at lowest cost, or greater profitability. The goal is to facilitate this through software and analytics.

But a cultural shift is required. Irving said this is harder to achieve than technology development. But the rewards can be significant. He cited the example of the gas turbine development cycle. It used to take 10 to 13 years to develop a new GT. Digitization has shortened that to three years for certain models, using GE Fastworks.

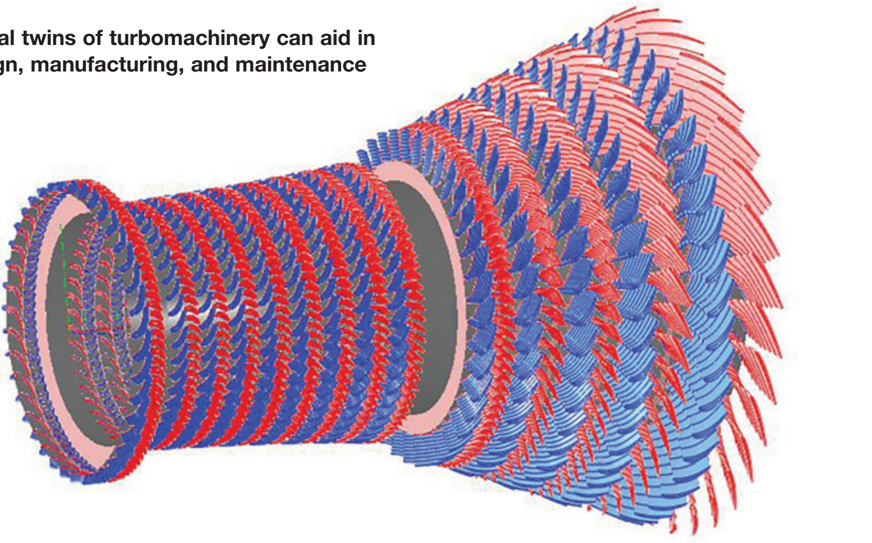
Irving also talked about using digital twins for each asset. This, he said, increases productivity and attains better business outcomes. But it is better to begin on a small scale rather than trying to model everything.

"Focus on outcomes, see what needs to change and make a twin of one module or one component that is the key to achieving that objective," said Irving.

Gains include being able to determine if an asset can be run hotter, when inspections should be done and when to replace components. According to Irving, this can save tens of millions in unnecessary service overhauls per customer.

"As we know more about the asset, we can have higher confidence on when and how to act with speed," said Irving. "We can really change the face of MRO if all assets are connected and we attain system-level consciousness."

Digital twins of turbomachinery can aid in design, manufacturing, and maintenance



He ended by comparing how you buy a pair of sneakers online compared to the industrial purchasing process. In the consumer world, you can track your order all the way from packaging to final delivery.

The current service capabilities of the industry cannot do that. It rarely is possible to tell the customer where their parts are, and even when they will arrive. Digitization is the way to change that.

Digital panel

A panel on digitization showcased digital challenges and opportunities. Frode Abotnes, Vice President of the Technical Multifield Center at Equinor (formerly Statoil, the Norwegian state-run oil and gas agency), said digitization has been an enabler of his company's high-value and low-carbon strategy.

One problem he faces, though, is having a lot of data but no real way to harness and analyze all of it. The information sits in information siloes that do not communicate. Another issue his company is addressing is how to find graduates with experience in both rotating equipment and software programming.

He envisions the MRO field shifting in a similar way as the lift-sharing phenomenon that turned the taxi system on its head. "We can learn from the consumer world how to give better service and develop smoother digital work processes," said Abotnes.

Pascal Decoussemaeker, Senior Product Manager at GE Power in Switzerland, and the European Turbine Network's Asset Management Chair talked about root cause analysis. Sometimes there is a need to look back many years. That is why it is vital to have enough data available, yet you do not know exactly what data you might need.

Root Cause analysis

This means you must stockpile a lot of information from multiple sources. New computing platforms and the cloud make it possible to retain sufficient information to be able to perform insightful root cause analyses.

He believes that any cultural conflicts that may exist will resolve gradually as more digital natives enter the workforce. They will expect companies to operate like the consumer sector, and drive change.

Gone are the days, he added, when you simply followed the GT OEM manual. Now you must optimize and adjust using digital asset management to reduce cost. The downside is an increase in risk. This is giving rise to outcome-based MRO where a specific amount of availability, reliability and performance is paid for as part

(Continued on p. 20)

A panel on additive manufacturing featured Winter, Verhoeven, Kataoka and Navrotsky (left to right)

of the contract.

"Machine learning lets us perform analytics rapidly and harness pattern recognition techniques to observe trends," said Decoussemaeker. "Instead of needing to refer data to experts for interpretation, we can use algorithms to reach conclusions faster to assist operators."

How about the cost of digitization? He accepted that it required investment. But he considers that such initiatives should be effective enough to bring the overall cost down so there will be no need to pass on any costs to customers.

Shawn Gregg, General Manager Propulsion Engineering at Delta Air Lines, emphasized that domain expertise is the foundation. Digital technology lays on top of that and adds value. But it cannot be done without deep understanding of the turbomachinery and MRO domain.

That is why Delta takes newly recruited graduates and puts them on the shop floor for a few weeks to tear apart and rebuild engines. They need to understand the physical reality of what they are dealing with if they are going to create workable models and productive applications.

Analysis & optimization

Sal DellaVilla, Founder and CEO of Strategic Power Systems (SPS), presented on data capture and analytics in a competitive power generation market. "We are in a new world of big data and analytics," he said. "Owner operators demand efficiency, flexibility, durability, environmental friendliness and reliability from OEMs."

He observed that each OEM has a different standard on how to test and validate machines. And the standard is changing in the face of digitization and new modes of plant operation. In the past, perhaps 100,000 hours were needed for a turbine design to be fully validated in the field. Some now promote 8,000 as being enough.

He stressed that digitization is nothing new. Data and analytical tools have always been in use. But now the pace is accelerating. We can look at assets in near real time in detail to see what is really going on.

SPS offers the Operational Reliability Analysis Program (ORAP). It captures data from globally operating power plants. This provides a picture of the performance of the entire fleet of turbines. Individual plants can see how their numbers compare to the fleet.

He gave the example of a plant in Southern California running aeroderivative GTs, which experienced "an event." The OEM's remote monitoring and diagnostics facility then called to notify the plant that an event had occurred.

They also wanted to know the cause and what action was taken. In this case, digital data failed to add any value. What is really required is predictive analysis. The plant operations and maintenance team addressed the event and returned the unit to service.

"Operators these days are being fed enormous amounts of data," said DellaVilla. "We need analytics to summarize, trend and provide tentative conclusions to help operators act rapidly."

Unless action can be taken at the plant, he said, monitoring and diagnostics are of limited value. It is all about how quickly a fault may develop and what can be done about it in enough time to prevent problems.

With the need for GTs to be available to start at short notice, ORAP numbers favor aeroderivatives which have average start times of 6.2 minutes compared to heavy duty GTs, which range from 17 to 30 minutes, depending on which class. Further, ORAP numbers indicate that recent changes to operating duty are exerting an impact on part replacement and maintenance patterns.

Michael Winter, Pratt & Whitney's Chief Engineer for Technology, called for higher precision in manufacturing. He views AM as a tool to realize that.

"If we can improve quality within 3D printed microstructures, we can achieve greater precision without incurring exorbitant costs," he stated. "The form and fit of 3D printed parts is easy; it is not so easy to obtain the right function. We have to better understand the microstructure to handle the standard of AM parts."

His company is already putting AM parts into production aircraft engines. He listed benefits such as low-cost manufacturing of complex components, rapid prototyping, easier tooling and faster repairs.

Christian Verhoeven, Technology Executive New Product Introduction & Additive Manufacturing, GE Power Services, extended the list of AM advantages to include higher performance and efficiency, advanced cooling, lower part counts, weight reduction, faster time to market, lower lead times and the elimination of defects in assembly.

The CT7 jet engine, for example, has modules that have had the number of their parts reduced from 300 to 1. In another engine, 855 parts were consolidated to 12, with a 5% weight reduction.

"Power turbines are benefitting from revolutionary cooling designs," said Verhoeven. "We are now putting more 3D printed components into the hot gas path of the turbine."

The GE H-class, for instance, has been upgraded with AM parts. This brought about a 5 MW boost and an efficiency gain of 0.2% in simple cycle. In combined cycle, this rose to 8 MW and 0.4%, respectively.

Blades with complex channel cores

Mitsubishi Hitachi Power Systems (MHPS) is another company investing heavily in 3D printing and digitization. Masahito Kataoka, MHPS General Manager for Large Gas Turbine Engines, said the latest parts it has developed include ring segments with channels, vanes with closed cooling, blades with complex channel cores and a new blade configuration, as well as combustor, compressor and seal parts.

"We are applying AM to our gas turbines to create performance and manufacturing improvements," said Kataoka.

This evolution, though, is being inhibited by size restrictions in 3D printers. The industry needs bigger machines, which are now under development. Another challenge is materials. Traditional casting materials and alloys are not useful for AM. A search is on for the best metal powders to produce consistent 3D printed parts.

"These technologies are critical in boosting performance and achieving 65%

Panelists included DellaVilla, Pariso, Kohli, Kappel and moderator Gregg

combined cycle efficiency," said Kataoka.

Vladimir Navrotsky, CTO of Power Generation Services at Siemens, said AM parts have improved the life expectancy of the combustion system in the SGT-9000 HL series, while reducing NOx levels and achieving more rapid design validation and reduced NOx levels.

"Our development time for prototyping has been reduced by 75%," he said. "We are now working on stator parts for gas turbines, which will lengthen the time between overhauls."

GT lifecycle

Another panel delved into the gas turbine life cycle through a data analytics lens. DellaVilla spoke again, this time zeroing in on data ownership. He made it clear that the data generated from power plants is owned by the plant.

OEMs and companies, such as SPS, share data. But it is essential to protect the rights of the data on behalf of the owner.

"We need to develop a data-sharing community of GT owners to look at blades' health, temperature, conditions, repair cycles and predict life," said DellaVilla. "If you have a big problem, it is useful to know who else is having that issue."

But a communication gap often exists between operations & maintenance personnel and plant owners. Those on the ground floor may wish to extend the scope of an overhaul. Owners want to get the facility running again and make money.

They hope to avoid spending more money and adding time. This disconnect can lead to inefficiency. Digitization and analytics can assist in resolving such conflicts. But only if they are carried out with a full understanding of the mission of the plant, the physics of machine operation and the necessities of maintenance.

"You can't do AI or predictive analytics without that domain knowledge," said DellaVilla. "On the other side of the coin, if you don't develop a sound business case, digital technologies might end up a bad investment."

Perspective on how this applies to airlines came from Rudolf Pariso, Chief Digital Officer for Air France Industries Maintenance. He saw many facets to digitization. In the consumer space, he said, companies need a very good B-to-C portal. He believes the B-to-B side must follow that example to enable seamless interaction across the supply chain and make it easy to do business.

He expressed reservations about the way airlines currently interact with OEMs on engine matters. This entails sending in forms with observations from borescopes and other inspection data.

If a crack is spotted, its specifics are communicated to the OEM to see whether that engine can continue in service or not. It can be a slow process to obtain a decision. Meanwhile, an engine sits on the ground idle.

"We need to be faster between stakeholders," said Pariso. "Another issue can be part availability: the unavailability of a small part, such as a cheap bracket may result in a $20 million engine being grounded."

He considers that digitization can improve supply chain operations, reduce inventory where desired and improve profitability. But the industry is not used to investing heavily in this direction. It is more oriented to building facilities and adding physical assets.

"We need to develop these new skills and combine data science with the engineering disciplines," said Pariso. "Work scoping in ten years will be very different due to digitization and will bring a lower cost of ownership."

But challenges remain. In the past, the requirements for in-flight data collection were modest: only a few snapshots of flight parameters during the journey. Today, constant data collection is the order of the day. That equates to five orders of magnitude more of data collection, said Pariso.

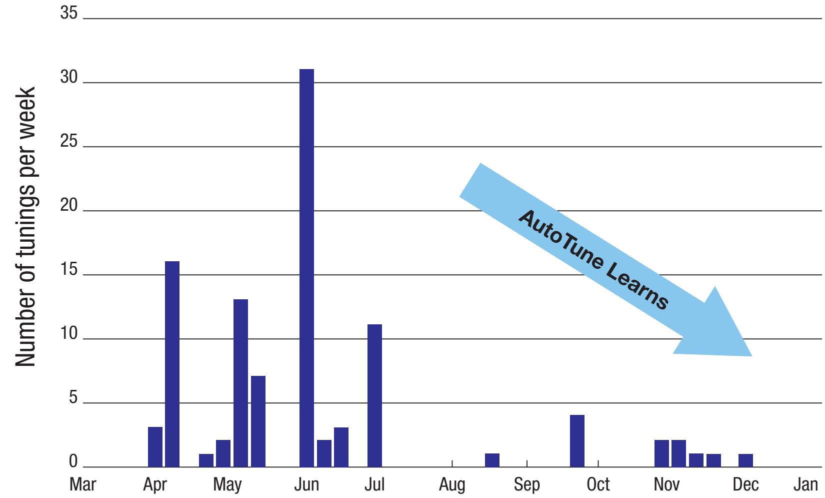
But the rewards are substantial. Air France has decreased the number of operational interruptions by 50% and has lowered its component inventory by 10%. It is now experimenting with AI, using 10 years of historical supply chain data to streamline part delivery and smooth engine repairs.

Doctor Atul Kohli, Senior Fellow for Heat Transfer, Analytical Methods at Pratt & Whitney surprised the audience by citing a figure of $9 billion. That, he said, was the amount his parent company was investing over a five-year period on digitization.

But complexity had to be understood, such as how engine conditions vary due to ambient conditions, air quality, temperature, pressure, particulate and other factors. It is no small matter to capture all that data accurately, let alone harness it effectively in analytics.

"Engineers should not be waiting for numbers or struggling to compile data," said Kohli. "They should be spending their time deriving insight from numbers assembled through digitization."

MTU Aero Engines has already integrated design and maintenance data to bring about greater cooperation between both disciplines.



PSM's AutoTune algorithm learns from successful and unsuccessful tunes. This reduces the number of tunes required

"We have established a database for operational and part data that is available to our designers," said Friedhelm Kappel, MTU Aero Engines. "When we inspect parts, we feed that data back into the design phase."

Easier said than done. Teething troubles include finding a way to connect a mountain of data with specific cases and findings. That, he added, is where AI comes in to analyze data automatically.

Digital transformation

The digital theme was continued on the final day of the show. Jeffrey Benoit, Vice President of Product Management & Marketing for PSM Ansaldo Energia Power Services explained that Ansaldo Energia digitally monitors over 300 GT's, ST's and generators from various OEMs around the world in support of long term service agreements.

The company has developed a digital solution that autonomously tunes the combustion system of industrial frame gas turbines. Manual tuning is time consuming, can create a lean blow out situation, emissions can go too high and that can result in fines.


Jeffrey Benoit

PSM's autonomous tuning system, on the other hand, is said to increase reliability and reduce cost. It captures information from successful and unsuccessful tunes to optimize tuning. Under this system, the number of tunes per week is higher initially, but falls sharply over time as the system learns the right way to tune that machine.

"Digitization is the way to manage complexity, transform data and maximize asset performance," said Benoit. "In the case of AutoTune, it allows you to move to the margins, safely, and gain more operational flexibility while maintaining emissions and stay within the limits of combustion dynamics."

Google is an example of smart digitization, said Bernhard Kruger-Sprengel, Lufthansa Technik. Google gathers massive amounts of data from vehicles and cell phones but has learned to only use relevant data for its traffic analysis.

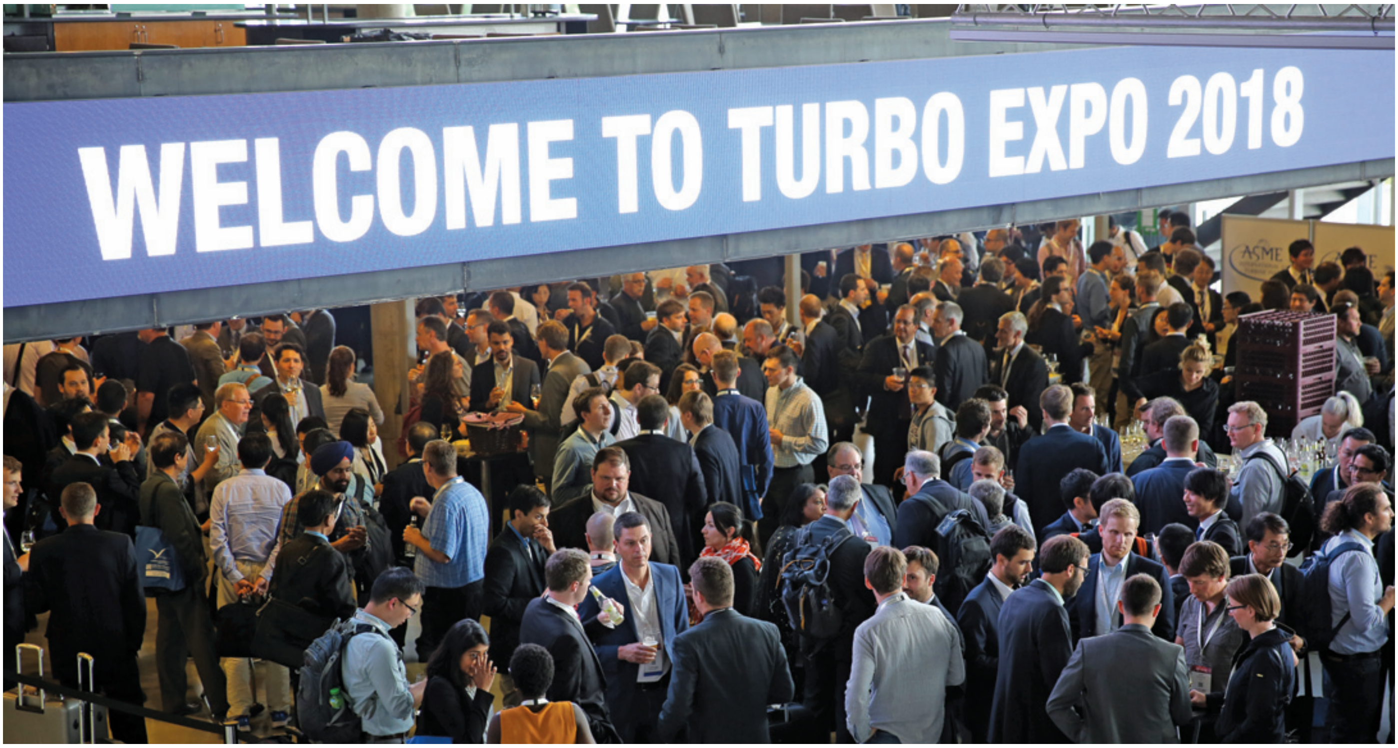
It simplifies the process by focusing only on where a vehicle is and whether it is moving. It ignores everything else: type of car, fuel type, number of passengers, the color of car, temperature readings and thousands of other parameters to provide valuable traffic service.

In aviation, however, things are a little different. You cannot rely only on one or


Bernard Kruger-Sprengel

two parameters. Data analysis alone does not answer all MRO questions. There are too many related data. It is a multi-dimensional problem.

"The big challenge is the relationships that exist between data, which means you cannot easily generate conclusions or predictions with AI," said Kruger-Sprengel. "You have to reconcile these models with the physical world." ■



TURBO EXPO 2018

SESSIONS AT IGTI SHOW SHOWCASE INLET AIR FILTRATION, LNG TURBOMACHINERY, AERODERIVATIVES AND DUCT FIRING

BY DREW ROBB

The annual Turbomachinery Exposition, organized by ASME's International Gas Turbine Institute (IGTI), covers a lot of ground. More than 3,000 participants came to hear over 1,000 technical papers presented in over 400 technical sessions.

Tracks include heat transfer, electric power, aircraft engines, ceramics, fuel types, combustion, emissions, controls, cycle innovation, fans & blowers, cogeneration, manufacturing, marine, oil & gas, steam turbines, and lots more.

Within that packed program, some of the standouts sessions were about duct firing, inlet air filtration and using aeroderivatives in LNG applications. They were delivered by speakers from Watson Cogeneration, Bechtel and EPRI. They provided tangible advice to plant operators and maintenance personnel about how to improve operations, boost power output, save money and select equipment.

Inlet air filtration

Inlet air filtration and cooling was the subject of several sessions. Steve Ingistov, Principal Engineer at the Watson Cogeneration Plant in Carson, CA, covered site and laboratory tests of inlet air filters from four different manufacturers.

A total of 720 12¾ inch diameter, 40-inch long filtration elements are placed inside each inlet air intake of four GE Frame 7EAs at the plant. The right choice of filter can reduce costs on many fronts. With so many filters per gas turbine (GT), the need for regular replacement mounts up. But more importantly, loss of power can hurt profitability. The wrong filters will let particulate through and that can lead to the deposition of tiny particles inside the compressor.

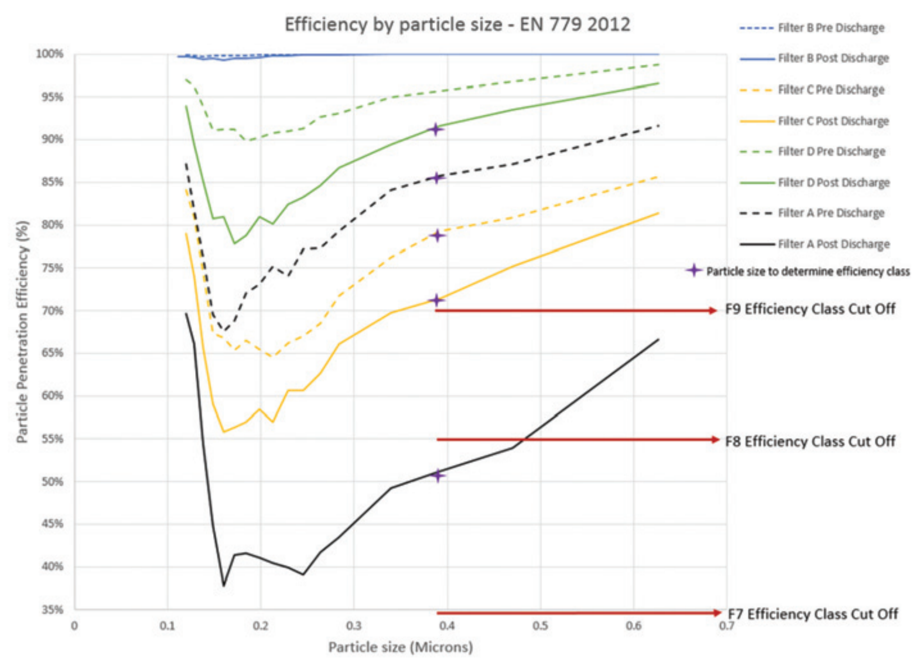
"Fouling of the compressor due to poor filtration can lose a lot of power," said Ingistov. "If you try to save money on filters, it can cost you a lot more in the long run."

Offline water washing may solve most fouling issues. However, a machine might be down for up to 16 hours while it is being done. As plants, such as Watson Cogen, provide steam and power to a refinery, downtime is expensive.

Another factor to consider in filter selection is location. Watson Cogeneration is situated by the coast in an area subject to fog. The presence of fog and rain swells the pleats in some filters. This causes a sharp rise in intake air pressure as there is less area for the air to pass through.

Both lab testing and field testing must be done, said Ingistov, to see which filters are best. Filter selection based on one parameter, such as filter efficiency or pressure could easily lead to an incorrect choice. It requires a look at all parameters to fully understand which filters to choose.

For example, statically pre-charged filters may initially operate well. But tests showed their efficiency drops rapidly after



Efficiency lines for the pre- and post-charge conditions in different air filters for various particle sizes in microns. Thorough testing of various types must be done to determine the ideal filter for a specific environment

An inlet air filter with buckled pleats after three months due to the impact of water.

a few months of operation. Buying pre-charged filters without testing their effectiveness once the charge diminishes could lead to an expensive mistake, he said.

Ingistov went to great lengths to test four types of filters to see which would be best for his facility. He conducted a series of tests, including dry and wet tests as well as lab and field tests.

A test on one parameter might show Filter A to be best, and another test on a different test might show Filter B as tops. However, deluge testing for one-hour and three-hour increments demonstrated that filters doing well based on one parameter often performed poorly under wet or foggy conditions.

"Within 30 minutes, pressure soared on two of the filters due to the presence of water," said Ingistov. "Only one filter performed well on the 3-hour deluge test."

As a result of these tests, Watson Cogen changed filters. The results are tangible. From having to shut down to clean a compressor every month, the plant now only needs to conduce offline water washing once per year.

Filtration economics

The filtration theme continued with a look at economic optimization of inlet air filtration for GTs. Dale Grace, Principal Technical leaders at the Electric Power Research Institute (EPRI), said that selecting the appropriate level of filtration for a GT helps to minimize overall costs and maximize revenue.

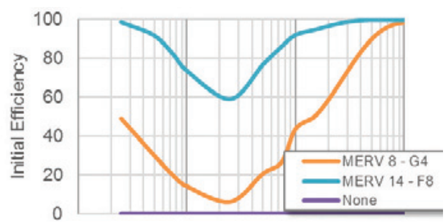
"Even a minimum level of filtration protects against erosion and corrosion of the compressor blading," said Grace. "Increasing filtration efficiency levels to High Efficiency Particulate Air (HEPA) improves compressor performance and power output."

Air filtration efficiency is a non-linear function of particle size. Minimum Efficiency Reporting Value (MERV) ratings are used to rate the ability of an air cleaner filter to remove dust from the air as it passes through the filter. The higher the MERV number, the higher the rating. F8 is a HEPA filter.

The bottom axis of the chart shows particulate matter (PM) size measured in microns. PM10 equates to cumulative concentration of small particles under 10 microns in size, and PM2.5 is under 2.5 microns. Particle sizes under 2 microns are most likely to cause fouling of the compressor.

Looking at efficiency against particle size highlights the tremendous variation that exists, especially in lower efficiency filters. Grace urged attendees to conduct a thorough analysis that looks at multiple factors. As well as raw numbers, he said to consider initial costs, operational costs and ongoing maintenance costs for the filter.

EPRI recommended a complex methodology to account for all aspects of the life cycle. EPRI's Air Filter Life-Cycle Optimizer (AFLCO) software is a tool that attempts to account for the influence of the specific GT, operating conditions, ambient conditions, load profile, filtration choices, and wash type and frequency. It also attempts to quantify revenue and cost considerations over many years.



Example of initial filter efficiency versus filter rating

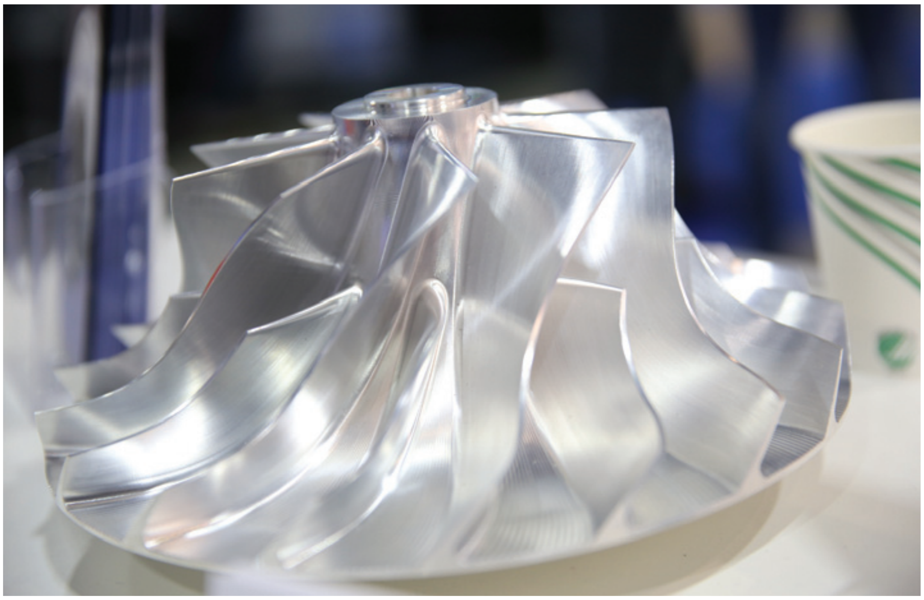
LNG and aeroderivatives

Aeroderivative engines in mechanical drive applications for LNG liquefaction was the topic addressed by Matt Taher, Principal Rotating Equipment Engineer at Bechtel Corp.

In early LNG liquefaction plants, steam turbines were utilized for compressor drives. The first GTs in LNG liquefaction were deployed in 1969. In an LNG liquefaction plant, the GT drivers and refrigeration compressors strongly influence overall plant performance and efficiency.

After the first aeroderivative was applied at Darwin LNG in 2006, there has been a continuing growth in the use of these engines for LNG mechanical drive. Natural gas accounts for a quarter of global energy demand of which 9.8% is supplied as LNG. LNG volume in 2016 was 258 MTPA (million tonnes per annum), a 13.1 MTPA increase over 2015.

(Continued on p. 26)



The exhibit at the Turbo Expo featured vendors showcasing turbomachinery component manufacturers as well as designers and software specialists

LNG production is predicted to jump at least 50% by 2035.

The energy intensive LNG liquefaction process consumes 6% to 8% of the gas being converted. Bringing that number down raises plant efficiency. High efficiency GTs help in reducing fuel draw.

Some of the desirable GT characteristics for mechanical drive LNG duty are high fuel efficiency, multiple shafts for easier startup and turndown, a large power output to produce more LNG and shaft speeds to match refrigeration compressor requirements. Aeroderivatives satisfy all four characteristics and are also easily swapped out for maintenance purposes, which aids plant availability.

The thermal efficiency of aeroderivatives is higher than traditional used heavy duty GTs. That's why aeroderivatives such as the LM6000, LM2500, Trent 60 and the LMS100 are being used or considered for mechanical drive LNG duty. According to Taher there are 94 aeroderivatives used in LNG mechanical drive around the world. Most of these are in Australia and the US.

The weight of aeroderivatives is another factor that leads to their selection. Taher compared two models with similar output. The Frame 5D has an output of 32.5 MW, an efficiency of 29.5% and weighs 65 tonnes (flange to flange). The LM2500+G4, on the other hand, has an output of 34 MW, efficiency of 41% and weighs 7 tonnes.

LNG mechanical drive turbines normally operate at high power and many are sited in hot areas or places with warm summers. Therefore, inlet air cooling is often utilized.

Taher pointed out that aeroderivatives are more sensitive to hot ambient conditions than heavy duty GTs. Aeroderivatives can lose as much of 1% power per 1°C rise in temperature compared to 0.7% for a traditional heavy duty GT.

Taher mentioned that the importance and growth of aeroderivatives in industry has resulted in the API 616 standard now being updated to cover the use of aeroderivative engines.

Duct firing

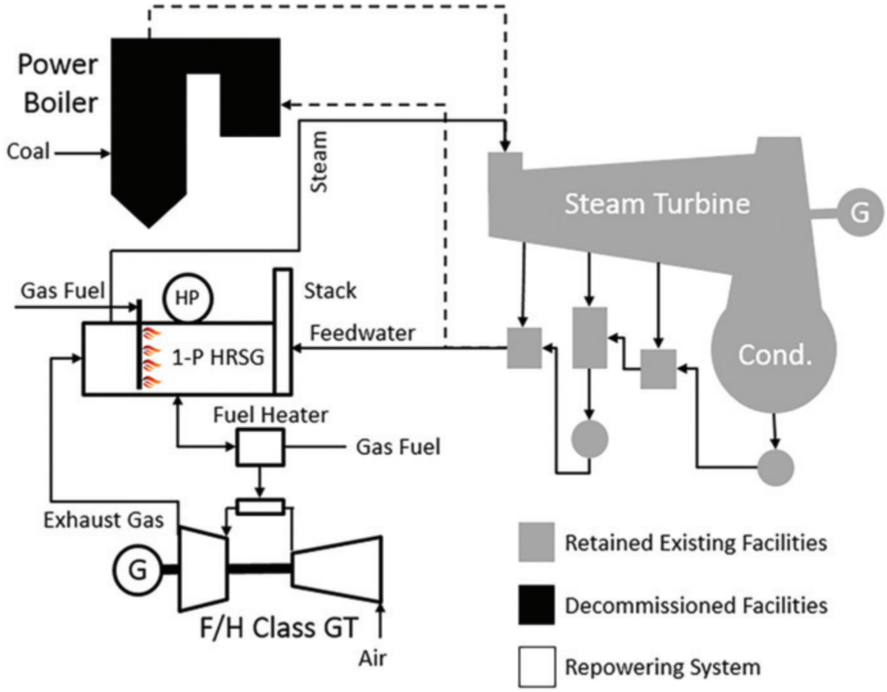
John Gulen, Principal Engineer at Bechtel Infrastructure & Power, provided a session on Heat Recovery Steam Generator (HRSG) duct firing, which is typically used to increase output on hot summer days when GT airflow and power output lapse.

The aim is to generate the maximum amount of power when it is most needed. However, this is achieved at the expense of heat rate.

Duct firing entails burning additional fuel in the transition duct between the GT exhaust and the HRSG inlet. In many cases, though, the burners are located behind the first superheater and between the re-heater tube banks. That is why duct firing could be more accurately referred to as supplementary firing.

"Under certain boundary conditions, duct firing in the HRSG can be a facilitator of efficiency improvement," said Gulen. "When combined with aeroderivative GTs with high-cycle pressure ratios and low exhaust temperatures, duct firing can be used for small but efficient combined cycle power plant designs as well as more efficient hot-day power augmentation."

This is a possible way for natural gas plants to better support variable renewable generation. In addition, repowering an obsolete coal-fired power plant slated for retirement with a highly fired, single-pressure HRSG and an advanced GT can be a cost-effective method to add capacity. The GT generates additional power while boosting steam cycle output. ■

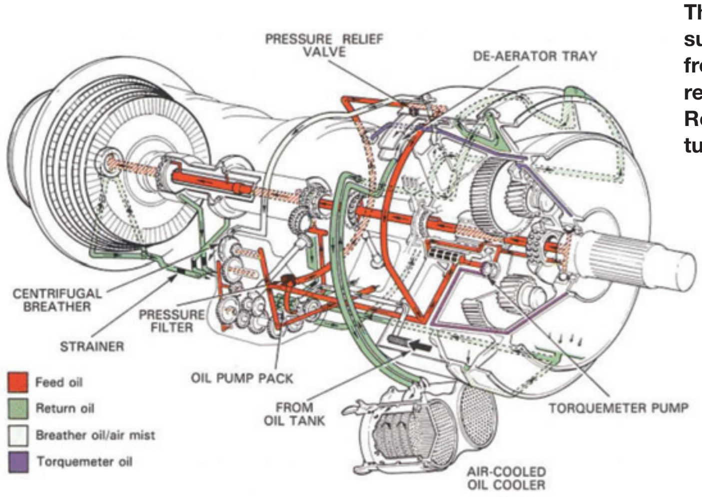


Repowering with duct firing includes the addition of a gas turbine and HRSG

LUBRICATION MAINTENANCE

BEST PRACTICES CAN PREVENT CATASTROPHIC FAILURE OF AERODERIVATIVE GAS TURBINES

BY SARMA KRISHNAMOORTHY



The internal oil supply lines to front, center and rear bearings in a Rolls-Royce Avon turbine

Aeroderivative gas turbines (GTs) are being deployed in power plants and petrochemical facilities in increasing numbers. However, onsite personnel skilled in their maintenance are often in short supply. The preservation and distribution of best practices, therefore, has taken on greater importance.

Consider a Rolls-Royce Avon GT used as a prime mover for process gas compressors in an offshore oil gas platform off the coast of Mumbai, India. There are over 90 Avons operating in the Mumbai High offshore oil gas field of Oil and Natural Gas Corporation (ONGC) of India.

All three of the GTs compressor trains were continuously operating and dispatching 6.9 Million Metric Standard Cubic Meter Per Day (mmscmd) of natural gas to shore facilities via a trunk line.

Consumption was monitored daily on all GTs. The oil consumption volume in one of the compressors in this GT was higher than the other two and steadily rising.

Leakage, spillage or both

Normally, an unusual increase in lubricating oil consumption is due to leakage, spillage or both. Detailed inspection of all components in the engine lubrication system showed no visible increase in leakage compared to the other two operating units.

The facility contacted the authorized Rolls-Royce repair and service agency in India. Their instructions were to continue observation and inform them if an internal inspection was warranted.

Due to incessant demand, all process gas compressor trains had to be operated continuously. However, doubt remained that there must be some kind of internal oil leakage, as yet undetected. Management approved a one-day borescope inspection of the engine internals.

A service engineer was called onboard for the inspection. Meanwhile, the one spare engine onboard was readied in case a rapid change out was needed. Borescope inspection revealed a thick dark brown or black coating on the internals of the turbine portion of the engine. Service personnel concluded that this oil sludge was from burnt oil.

The service engineer referred to cross-sectional drawings of the engine (Figure). He noted oil transfer piping running inside the turbine which distributed lube oil between three bearings: front, rear and middle.

This pipe had a joint, which was sealed with an elastomer O-ring. The service engineer considered it most likely that the O-ring had broken, and that this was the cause of leakage.

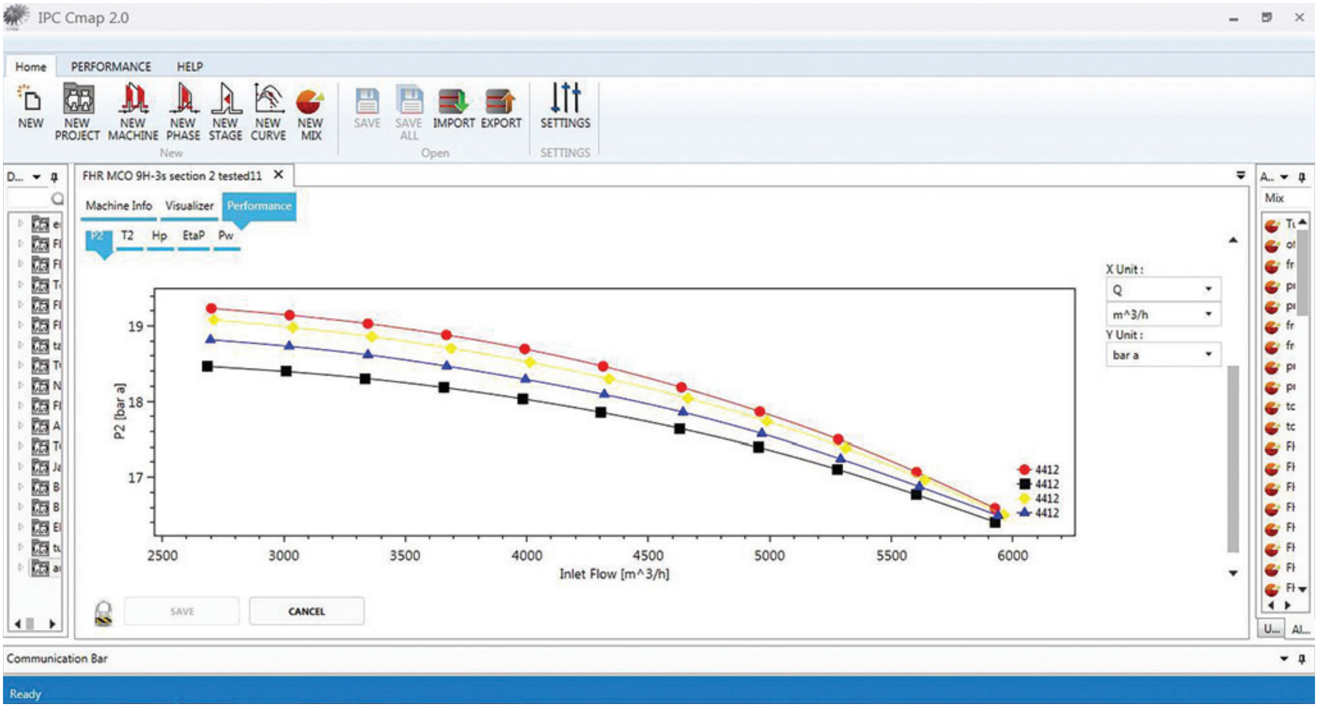
The borescope inspection proven to be timely. It helped the facility avoid a catastrophic failure traced to the following causes: Oil cakes deposited on hot path components over a period of time led to differential expansion of components; and the engine bearing downstream of the leaking seal lacked adequate oil and was close to premature failure. Both could have resulted in a lengthy outage.

The decision to take out the unit reduced the outage to four days. Borescope inspections were done after the engine cooled. It took one day for cool off, one day for inspection and two days for engine change out. The replacement engine was ready at the platform as soon as the inspection had been completed.

The lesson learned is the importance of isolating something as minor as over-consumption of oil. In this case, the willingness of maintenance personnel to dig for the reason behind a potential problem saved at least ten days of production time. The cost of the outage was far less than the massive repair expenses that would have followed a catastrophic engine failure.

This is a good example case on how gas turbine O&M engineers and maintenance personnel must continue to be vigilant. Every variation in operating parameters should be investigated. Doing so will lower overall costs and lead to higher productivity due to the avoidance of catastrophic failures. ■

Sarma Krishnamoorthy, BE, FIE is the retired General Manager for Mechanical at ONGC Ltd, India. He is currently a consultant for renewables and microturbines.



Cmap screen shot

RAISING PERFORMANCE

HOW GAS MIXTURES AFFECT THE PERFORMANCE OF CENTRIFUGAL COMPRESSORS

BY MASSIMILIANO DI FEBO & PASQUALE PAGANINI

Assuring the availability of centrifugal compressors is one of the primary tasks for maintenance teams. Quantitatively evaluating machine performance plays a key role in understanding if a compressor is working as expected. Software tools, such as Cmap, allow the user to predict compressor performance and obtain a quantitative indication of deviating parameters.

Compressor performance depends on gas composition and the operating inlet pressure and inlet temperature. Gas composition affects the way gas moves through the compressor.

Any assessment of compressor performance, therefore, requires the ability to predict pressure, temperature and gas composition. Computational models must incorporate compressor aeromechanics and compressed gas thermodynamics.

Field inlet conditions are sometimes different than the conditions given in machine specifications. An adjustment of design performance maps to actual operative conditions, then, is necessary to quantitatively assess the performance.

This approach to numerical analysis results shows how variations of individual gas mixture components effect compressor condition and can aid in performance prediction. All numerical evaluations were developed using the most recent thermodynamic theories and machine aero-mechanical models. These were done according to the prescriptions of the ASME PTC10 (Performance Test Code on Compressors and Exhausters) standard.

The starting point is the reference centrifugal compressor performance map. This can be taken from OEM datasheets or from "as tested" maps. The software combines the gas mix composition, pressure and temperature parameters with available reference performance maps to perform complex automated calculations to predict compressor performance.

That makes it possible to determine the consequence of each variation in gas components with regard to overall compressor performance. The study also looked at machine performance for gas mixes with the same molecular weight but with a different gas composition.

Four different variations of gas mixtures were considered (Figure 1). Inlet conditions were kept constant as follows:

- Gas mix MW (kg/kmole) – 42.09
- Inlet pressure (bar a) – 15.5
- Inlet temperature (°C) – 49.2

This analysis obtained the expected performance for the compressor in each of the

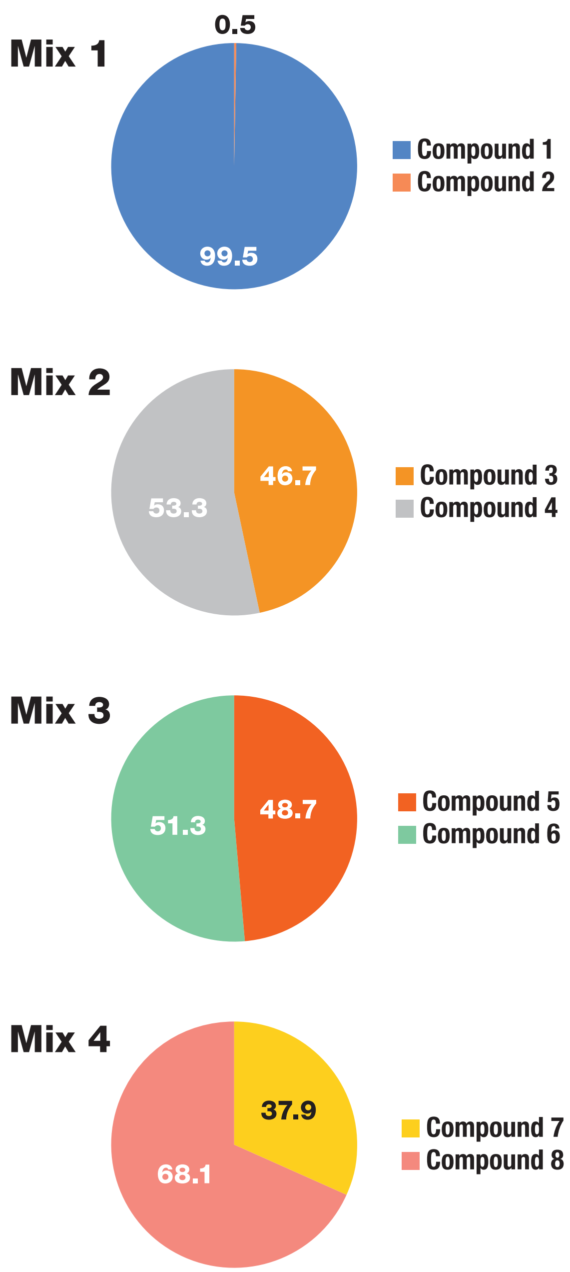


Figure 1: Gas mixtures modelled as part of compressor performance modelling

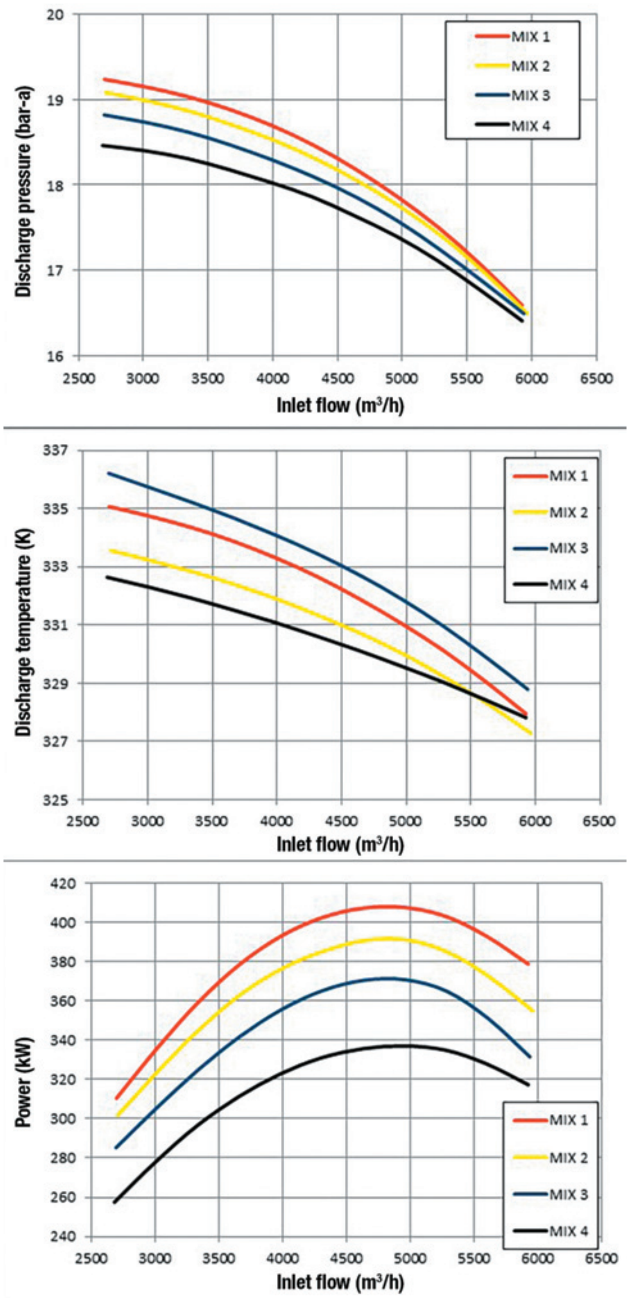


Figure 2: Performance maps under different gas compositions

four off-design conditions considered. Performance changes were mapped against discharge pressure, discharge temperature and power (Figure 2). These charts are also useful in noting shifts in the surge line.

It is possible using advanced computational tools, therefore, to accurately determine centrifugal compressor performance under varying inlet conditions. These performance curves aligned well with field measurements of real world equipment and conditions.

This method of predicting performance maps for a centrifugal compressor in off-design conditions, therefore, has been found to be accurate even at high pressures. It enables engineers to predict adjustments based on inlet pressure, temperatures and gas composition to implement advanced protection from surge. It also can be used for early identification of machinery trouble before other indicators, such as vibration or other mechanical parameters, appear. ■

Massimiliano Di Febo is Operation Manager for Industrial Plant Consultants (IPC), a company specializing in engineering services to the process industry (chemical, petrochemical, power generation).

Pasquale Paganini is Technical Manager for IPC. The company developed Cmap simulation software.

For more information visit www.ipc-eng.com, www.compressormap.com

REGENERATIVE CYCLE

POWER PLANT OPTIMIZATION VIA EXERGY ANALYSIS

BY PAULO ROBERTO GOMES DE SOUSA

The Rankine cycle is the most widespread cycle in the world. Used since the late nineteenth century, it was proposed by Scottish physicist and engineer W.J. Rankine, and simultaneously by R. Clausius, a German physicist. The thermal yield of this cycle depends on the average temperature of the supplied and rejected steam. Yield increases as the temperature of the supplied steam increases, or the discharged steam temperature decreases.

A regenerative cycle provides the heating of the boiler feed water via steam extracted from the turbine. This variation of the Rankine cycle reduces boiler fuel consumption and the work of the turbine. It has the objective of increasing overall plant efficiency.

This regenerative cycle has been applied in many power plants. Boilers, heat exchangers and steam turbines have been redesigned with this cycle in mind to achieve higher performance, greater efficiency, and more flexibility and reliability.

Energy and exergy

By simulating plant conditions using Microsoft Excel, it is possible to identify the best application of available thermodynamic capacity, thus obtaining the maximum work and the best overall efficiency of a power plant. This data can then be used to perform an economic analysis to optimize plant operations.

Exergy quantifies the maximum amount of work that can be achieved through the interaction of a system with the environment. An exergetic analysis of a power plant includes the study of the equipment that generates work and heat. This is particularly useful in identifying the maximum useful energy of a system. It is accomplished by modeling of the steam generator, turbine, feed water heaters, deaerator, condenser and pumps. This assists plant owners and operators in evaluating the costs of a thermal system.

Equipments	Energy available	Useful energy
Und.	kW	kW
Boiler	56160,8	48298,3
Total turbine	19589,8	16454,4
Condensate pump	70	16,4
Water pump	400	214,9
Turbogenerator	18948,4	15915,7

Table 1: Available energy versus useful energy (exergy) in a power plant

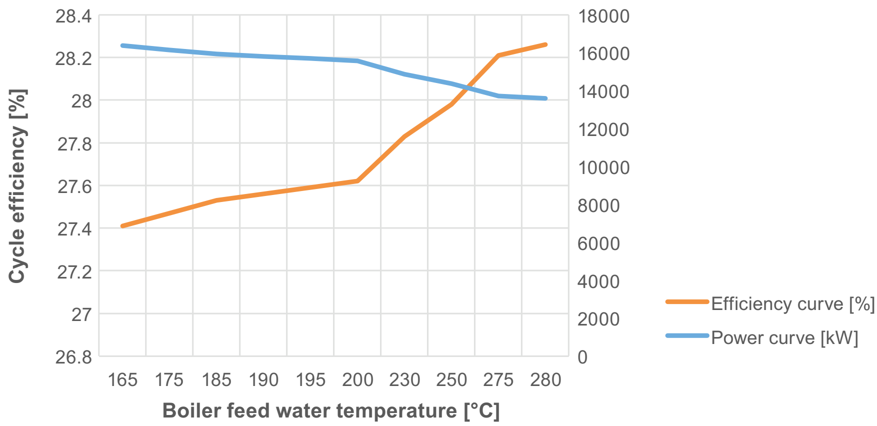


Figure: Comparison between cycle efficiency and turbine power output

The steam turbine supplies heat for the water in a regenerative cycle, as well as power in the form electric energy and mechanical energy. The boiler burns fuel to transform water into steam. This is where the greatest waste of energy occurs.

The boiler feed water heater is where the thermal exchange between the steam supplied by the turbine and the boiler feed water happens. Its design is important in defining the characteristics of the power plant. The pump pressurizes the system. The condensing system, on the other hand, rejects heat from the system and is mainly responsible for system inefficiency. However, the quantity of energy wasted by the condenser is relatively low compared to that of the boiler.

An analysis was carried out concerning the relationship between the boiler feed water temperature, plant efficiency and the power produced by the turbine. When the feed water temperature increases, the turbine produces less power, but the plant becomes more efficient. Raising the temperature of the feed water through steam extracted from the turbine reduces boiler fuel consumption. That cuts operational costs and lessens environmental impact. Each plant has unique operating characteristics. By subjecting any plant to this type of analysis, it is possible to identify the areas of optimum performance profitability (Figure).

By running software to simulate the regenerative cycle, a comparison of plant energy and exergy helps to identify how best to run equipment to improve economic efficiency. This simulation showed that the boiler is the biggest area of energy waste in a thermoelectric plant, not the condenser. In addition, net power of the turbine is inversely proportional to the temperature of the water entering the boiler. ■

Paulo Roberto Gomes de Sousa is Engineering, Project and Development Engineer for TGM-Weg Group, a Brazilian manufacturer of steam turbines, gearboxes and turbo-alternator sets. The company also performs maintenance services on its own equipment and other brands. For more information, visit www.grupotgm.com.br

NEW DIRECTOR AT THE TURBO LAB

Dr. Eric Petersen, the new director of the Turbomachinery Laboratory, discusses the purpose of the lab, his immediate plans and developing trends in the industry.

What is the purpose of the Turbo Lab?

The Turbomachinery Lab (TL) is a center of the Texas A&M Engineering Experiment Station (TEES) and part of The Texas A&M University (TAMU) System. First and foremost, the TL is a research center with the mission of providing educational opportunities for working professionals in turbomachinery and educational, as well as research opportunities for engineering students at TAMU. The TL organizes and hosts the Turbomachinery and Pump Symposia (TPS) in Houston, Texas each year. Spin-off symposia have recently been organized and held in the Middle East (METS) and in Asia (ATPS). Additional educational outreach to industry professionals includes short courses and a Turbomachinery Research Consortium (TRC).

What is the TRC?

It is comprised of about 35 companies whose fees go toward consortium-selected research projects conducted at TAMU. The TL center also represents the associated TAMU faculty members who conduct research related to all aspects of turbomachinery.

Tell us about your background?

All three of my degrees are in mechanical engineering. My Ph.D. is from Stanford University, where I worked in the High Temperature Gas Dynamics Laboratory under Professor Ronald Hanson. Prior to returning to graduate school for my Ph.D., I worked for three years at Pratt & Whitney in West Palm Beach, Florida. Post-Ph.D., I worked for The Aerospace Corporation in Los Angeles. I have been a professor since 2001, starting first at the University of Central Florida. For the past ten years, I have been at TAMU as a member of the TL. My research work is experiment-based and has been mainly in the areas of combustion, gas dynamics, and propulsion, focusing on both government- and industry-funded projects related to gas turbines and rockets.

We have faculty members working on research related to turbomachinery reliability, performance and fundamental understanding of the underlying physics.

Why did you accept this job as Director of TL?

I have a great deal of respect for Dr. Dara Childs, the previous director who retired. He wants to see the TL continue to thrive. Having someone as director who is also a mechanical engineer from within the TL was an important ingredient for continued success.

What do you hope to accomplish as director?

Foremost, I wish to oversee the continued success of the symposia. This requires a foundation in traditional TL technical areas. A critical component has been the participation of the technical advisory committees (Turbo and Pump). These are made up of dedicated industry representatives from end-user and OEM companies. My goal is to keep these committees strong. Growth areas will likely come from branching into turbomachinery- and propulsion-related technical areas.

What are your plans for the shows?

The basic formula for TPS works well and will not be altered near term. The TPS is successful due to its location in Houston, buy-in from the industry participants, the quality of the technical and educational events, and dedicated TL staff. We completed the 2nd ATPS in Singapore in March. We are assessing the likelihood and location of a 3rd ATPS in 2020.

What can the TL do to stimulate innovation, help manufacturers lower costs and make GTs more competitive?

TRC research projects are voted on by industry representatives. Member companies see the latest developments. They communicate to faculty researchers about challenges to solve or predictive models that can help them to remain competitive. Getting industry representatives together during the symposia technical sessions is another platform that brings individuals together to work on the latest problems.

Can you tell us about ongoing projects?

We have faculty members working on research related to turbomachinery reliability, performance and fundamental understanding of the underlying physics. We specialize in unique test rigs and measurement techniques that can explore phenomena at the pressures, temperatures, and revolutions per minute. One new area involves the design and operation of gas turbines operating in a supercritical CO_2 environment, all the way from bearings to combustion. Another new capability is in ultra-high-speed imaging and laser diagnostics. There, we have acquired a burst-mode pulsed laser system and related components.

What turbomachinery research excites you?

Research within the TL related to the fluid mechanic and gas dynamic aspects of turbomachinery excites me the most. ■

New combustor

GE has introduced the 7F DLN2.6+ Flex combustor upgrade. It is combined with Axial Fuel Staging technology. This upgrade is available for 7F gas turbines (GTs). The combustor features axial (sequential) staging of combustion in two zones.

This allows for increased firing temperature at baseload while maintaining the same NOx level. It is achieved by operating the later/second stage hotter than the first/primary stage. During low-load operation as the GT firing temperature is reduced, percentage fuel split in the staged fuel system can either be reduced or turned off. This keeps the combustion system in emissions compliance over a wider range of firing temperatures.

With a 15% lower turndown capability, 7F users can run more frequently, burn less fuel and reduce emissions. Operators can respond faster to bidding opportunities in regions that experience frequent shifts in grid demand due to renewable fluctuations.

gepower.com

Centrifugal pump

Allmarine centrifugal pump by Circor

Circor announced a new Allweiler centrifugal pump solution. This redesign of the Allmarine MA-S and MA-C series provides more vertical installation options for centrifugal pumps with axial inlets in marine and general service applications.

The Allmarine MA-S with spacer coupling and the MA-C (closed coupled) consume a smaller footprint and bring stability in heavy seagoing conditions. A shorter, lighter design modifies the suction flange with integrated fixing holes for pedestal mounting of the foot to the ship foundation.

This configuration promotes pump uptime and reduces wear on the bearings and shaft seal by redistributing pipe load forces through the foundation instead of into the pump aggregate. It also helps avoid damages at the impeller and casing.

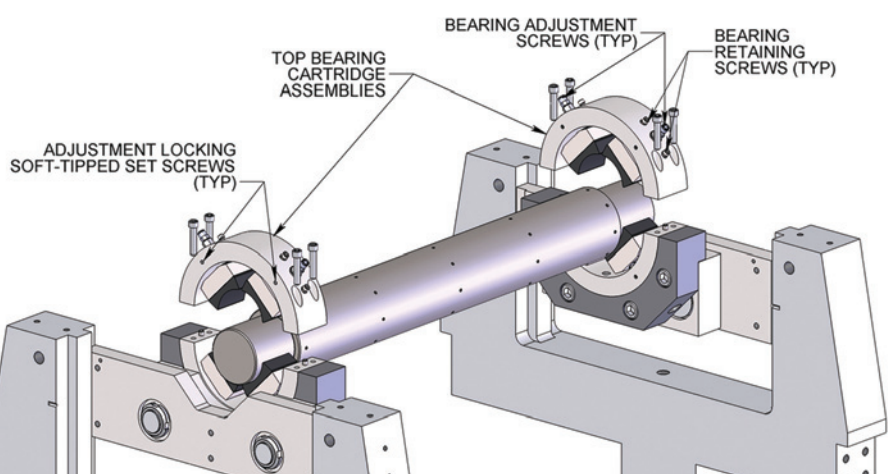
circorpt.com

Rotor balancing

New Way Air Bearings offers externally pressurized air bearings for non-contact support of rotors during balancing operations. Non-contact air bearings eliminate damage to the rotor from hard rollers and the mess of oil film bearings in vacuum chambers. They provide a precise axis of rotation with a cleaner signal for higher resolution in balancing.

For both hard and soft balancing machines, mechanical, electrical and audible noise in balancing operations is reduced by supporting the rotor being balanced on air bearings. With the rotor supported on air bearings, the roundness of the journal (often .0001 of an inch or better) is the only rotating reference surface and so the motion errors will be synchronous and averaged. That way, there will be less than one tenth of amplitude of the hard rollers' motion errors. This results in a clean signal that is the same each revolution, allowing for a finer resolution in balancing.

newwayairbearings.com



Pressure sensor

ITT's i-Alert Smart Pressure Sensor is Bluetooth compatible. It includes a machine health sensor, the i-Alert mobile app and the i-Alert Asset Intelligence (AI) platform. The pressure sensor provides the ability to monitor fluid conditions and gather operating data to troubleshoot undesirable operating conditions. It is good for non-hazard industrial pump applications or to monitor fluid process conditions.

Itt.com

Flameproof TMEIC

Toshiba Mitsubishi-Electric Industrial Systems Corporation (TMEIC) has introduced MV flameproof electric motors, available in two versions — rib cooled (IC411) and tube cooled (IC511) motors. The motors meet international standards including IEC, EN, NEMA, and ATEX directive. They are tested to withstand the pressure caused by an internal explosion without incurring damage. They prevent flame propagation outside of the enclosure and are certified for gas groups IIA, IIB and IIC.

TMEIC.com

Preventive maintenance service

Rockwell Automation has announced its Preventive Maintenance as a Service offering. It analyzes data from connected technologies, such as sensors, control systems and smart machines. Leveraging FactoryTalk Analytics and applying machine learning technology, engineers from Rockwell Automation can identify normal operations and build data models to help predict, monitor for, and mitigate, future failures or issues as part of a preventive maintenance strategy. This new service will be crucial in industries such as oil and gas and continuous-manufacturing operations.

Rockwellautomation.com

Energy storage

MAN Diesel & Turbo Schweiz has signed a cooperation agreement with ABB Switzerland for the development, production and commercialization of a three-way energy-storage system. The new Electro-Thermal Energy Storage system (ETES) stores large-scale electricity for distribution.

ETES uses surplus renewable electricity to generate heat and cold for storage in insulated reservoirs during a charging cycle. The heat and cold can be converted back into electrical energy on demand. ETES features MAN's hermetically sealed turbo compressor HOFIM within the charging cycle to compress the CO_2 working fluid to its supercritical state at typically 140 bar and 120°C.

ManDieselTurbo.com

Harder steel

Ugitech has introduced a type of stainless steel called UGIMA 4116N. It is extremely hard thanks to the addition of nitrogen and is more resistant to corrosion than standard-grade steel. Combined with improved machinability, it is an alternative to martensitic steel grades, which have comparatively low corrosion resistance.
ugitech.com

CAD nesting software

Hypertherm has released ProNest 2019 CAD/CAM nesting software for automated cutting. New features include: Raster-to-vector conversion to convert .jpeg and similar images into CAD files; fly cutting for faster laser cutting on thin material, and piercing without slowing down or stopping the cutting head; Design2Fab 6 integration so customers cutting sheet metal can access fittings directly from ProNest; and drag rotation for faster manual nesting and better plate utilization, especially when nesting around the contours of larger parts.
hypertherm.com

Liquid pump controller

Large-scale water systems that require controlled flow of high volumes of water rely on pump level controls to ensure smooth-running processes and carefully monitored current loads. To better help these municipal water, wastewater and sewage treatment plants meet their flow control needs, ATC Diversified Electronics (a member of Marsh Bellofram Group) has introduced its LPC series liquid level pump controller. This 8-pin, plug-in conductive unit uses two probes to sense tank level and lets users select the mode of operation.

In drain mode (pump down), the output relay picks up and the LED turns on when liquid reaches the high-level probe. The relay drops out and the LED turns off when liquid falls below the low-level probe. In fill mode (pump up), the output relay picks up and the LED turns on when liquid falls below the low-level probe. The relay drops out and the LED turns off when liquid reaches the high-level probe.
Marshbellofram.com

Battery storage

Siemens lithium-ion battery-based BlueVault is suited for both all-electric and hybrid energy-storage applications. BlueVault energy storage ensures continuity of power while also minimizing carbon dioxide emissions. The battery provides users with long life and is designed for performance and safety.
Siemens.com

Sealless pump

Lewa Nikkiso America offers non-seal canned motor pumps used in the chemical and petrochemical industries. The encapsulated and leak-proof design has the motor located inside a pressure-resistant stator housing. This enables a sealless pump design and minimizes both immediate and long-term hazard risks for personnel and the environment.

The bearings used are slide bushings, which can be designed with various materials depending on the liquid properties. The bearing material line-up ranges from carbon graphite to PTFE and silicon carbide to a mixed structure of carbon and silicon carbide that ensures wear protection. These bearings are lubricated by the pumped fluid, which is used as a coolant for the motor at the same time. Depending on the pump design and medium, a maximum delivery rate of up to 1,200 m³/h is possible, with fluid temperatures between –200°C and +450°C. The pumps are designed in accordance with API 685 and are certified in accordance with ATEX 2014/34/EU.

lewa.de

Asset integrity

Stress Engineering Services has launched NeoSight, an asset integrity management platform. The goal is to incorporate hindsight, insight and foresight into the evaluation of asset performance and integrity. The platform leverages new or existing digitalization efforts, integrating directly with business systems in real-time or near real-time.

A physics-based digital twin model is built into each NeoSight tool, which accurately simulates asset response. Digital twin models allow for the integration of inspection, analysis and measured data, providing previously unavailable insights into asset behavior.

stress.com

Gas chromatograph

Schneider Electric introduced the FXI Series 7 Process Gas Chromatograph, which is said to be a faster, more reliable and safer gas and liquid composition process analyzer. With enhanced capabilities, the analyzer enables petrochemical, refining and chemical plants to increase the real-time efficiency, reliability and safety of their industrial processes. It comes with better diagnostics, seamless communication integration with other devices and components, and certifications for hazardous areas. It is a core element of the Schneider EcoStruxure Plant platform. Equipped with parallel chromatography capabilities, the FXI Series 7 analyzer allows multiple detectors and ovens to be used simultaneously. This accelerates analysis time and increases the range of applications within a single gas chromatography platform. The system continuously analyzes and quickly reports component concentrations and physical properties of process gas and liquid streams in a variety of applications, improving quality and throughput, while reducing capital investment, project execution risks and operating costs.

Schneiderelectric.com

Turbomachinery design

TurboTides has announced the release of the TurboTides unified design software to the broad market. It includes all the necessary design tools in a single software package and user environment to design centrifugal, mixed-flow, and axial compressors, turbines, fans, blowers, and pumps for virtually any application. It also offers an integrated optimization capability that can be used at each design step or may be span multiple steps at the same time. It is designed to assist turbomachinery developers to optimize stage design for single-stage or multistage turbomachinery.

Turbotides.com

Digital gas flow computer

The HIT-4G by Hoffer Flow Controls is a compact digital gas flow computer with temperature, pressure and compressibility compensation. It is configurable from the instrument front panel keypad or via Modbus communications. Features include: an LCD display for total, rate, temperature and pressure; non-resettable grand total; up to 20-point linearization to correct for flowmeter non-linearity; AGA-8 compressibility compensation; and 4-20mA analog output proportional to flow. The HIT-4G has a 6-digit rate display and separate 8-digit resettable and non-resettable flow totalizers. It is configurable for 4-20 mA loop power or DC power. Several enclosure options are available including an explosion-proof enclosure (available in powder-coated aluminum or stainless steel option.

Hofferflow.com ■


MAN Diesel & Turbo
MAN Diesel & Turbo

MYTH: TEENAGERS AND COMPRESSORS CAN'T STAY OUT OF TROUBLE

As a teenager, I (Klaus) took chances and subsequently got into a fair share of trouble. No lasting damage was done … I think. From this, I learned lessons such as "nothing ventured, nothing gained," "do not fear mistakes," "swing for the fences" and other clichéd idioms that can drive a lifetime of poor decision making.

But one of the most important lessons was, "it is not how often you get into trouble, but how serious the trouble is." How is this relevant to turbomachinery? After years of running and testing centrifugal compressors, teenagers behave like compressors in many ways.

Teenagers are mostly nice. But sometimes they don't run where, how, and when they are supposed to run. They can fall apart at the least opportune time. Similarly, centrifugal compressors run into surge much more frequently than they should.

This is usually accidental due to unanticipated situations or operator error. But compressors also tend to be far more resilient than one would expect. Specifically, it may not be relevant that the compressor often surges or for how long. What matters most is the severity of the surge event.

What is surge? A typical centrifugal compressor performance map indicates that there are two limits on the operating range of the compressor. Global aerodynamic flow instability, known as surge, sets the limit for low-flow (or high-pressure ratio) operation. Choke or "stonewall" sets the high-flow limit.

The exact location of the surge line on the map can vary depending on the operating condition and the system piping. As a result, a typical surge margin is established at 10% to 15% above the stated flow for the theoretical surge line. Thus, every compressor has a limit on its operating map where the work input is insufficient to overcome the hydraulic resistance of the system. This results in a breakdown and cyclical flow-reversal in the compressor.

Surge occurs just below the minimum flow that the compressor can sustain against the existing suction to discharge pressure rise (head). Once surge occurs, the flow reversal reduces the discharge pressure or increases the suction pressure.

Eventually, this allows forward flow to resume until the pressure rise again reaches the surge point. This surge cycle continues at a low frequency until some change takes place in the process or the compressor conditions.

The frequency and magnitude of the surge flow-reversing cycle depend on the design, operating condition and piping of the machine. But in some cases, it is sufficient to cause damage to the seals and bearings, and sometimes even the shaft and impellers.

One should also note that strong flow pulsations that originate from reciprocating compressors with insufficient pulsation control upstream or downstream of the centrifugal compressor can move a centrifugal compressor into surge or choke. This can even take place when the steady state surge margins appear to be adequate.

What is weak?

Most compressors are sufficiently robust mechanically to handle weak surge events. The question is what is "weak" and how does one know if it is weak without having to take the risk of surge testing a machine in the field?

The primary surge forces in a compressor are in the axial direction. Therefore, usually the highest probability component for failure is usually the thrust bearing. Damage is likely to occur if axial surge forces exceed the thrust bearing load capacity (driven primarily by the dynamic pressure differential across the front and back of impellers). If these forces are smaller, nothing will happen.

A recent project funded by the Gas Machinery Research Council provides a method to qualify these axial forces. It uses surge testing on a laboratory centrifugal compressor and prediction methods to characterize and quantify these forces, and their frequencies. The results are published, and the models are in the public domain.

This is important since it is now possible to model when surge occurs and estimate if the surge has the potential to cause compressor damage. When performing a dynamic analysis of a centrifugal compressor and its surrounding piping system, we can predict if and where the compressor crosses the surge line.

But we can now also estimate if this surge event is relevant to the life of the compressor. One should cautiously note, though, that all surge events carry the (albeit sometimes remote) chance of damage, and repeated surge events can eventually affect the performance of the compressor.

So, what is the lesson turbomachinery engineers can take away from teenage behavior? Centrifugal compressors within complex piping systems can behave in strange ways and can accidentally run into surge.

This can happen during a compressor station piping system upset, an emergency shutdown, a slow startup, when load sharing and shedding, or even when sequencing machines run in parallel or series. In many instances the surge event may not be severe enough to harm the compressor or its components.

What is more relevant is not the surge event itself but how much permanent damage it causes. Unlike what's available for parents with teenage kids, we have capabilities to predict the effects of its behavior and how to correct it using state-of-the-art engineering tools. ■

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