THE GLOBAL JOURNAL OF ENERGY EQUIPMENT

INTERNATIONAL Turbomachinery

JANUARY/FEBRUARY 2019 • VOL. 60 NO. 1 • $7.50

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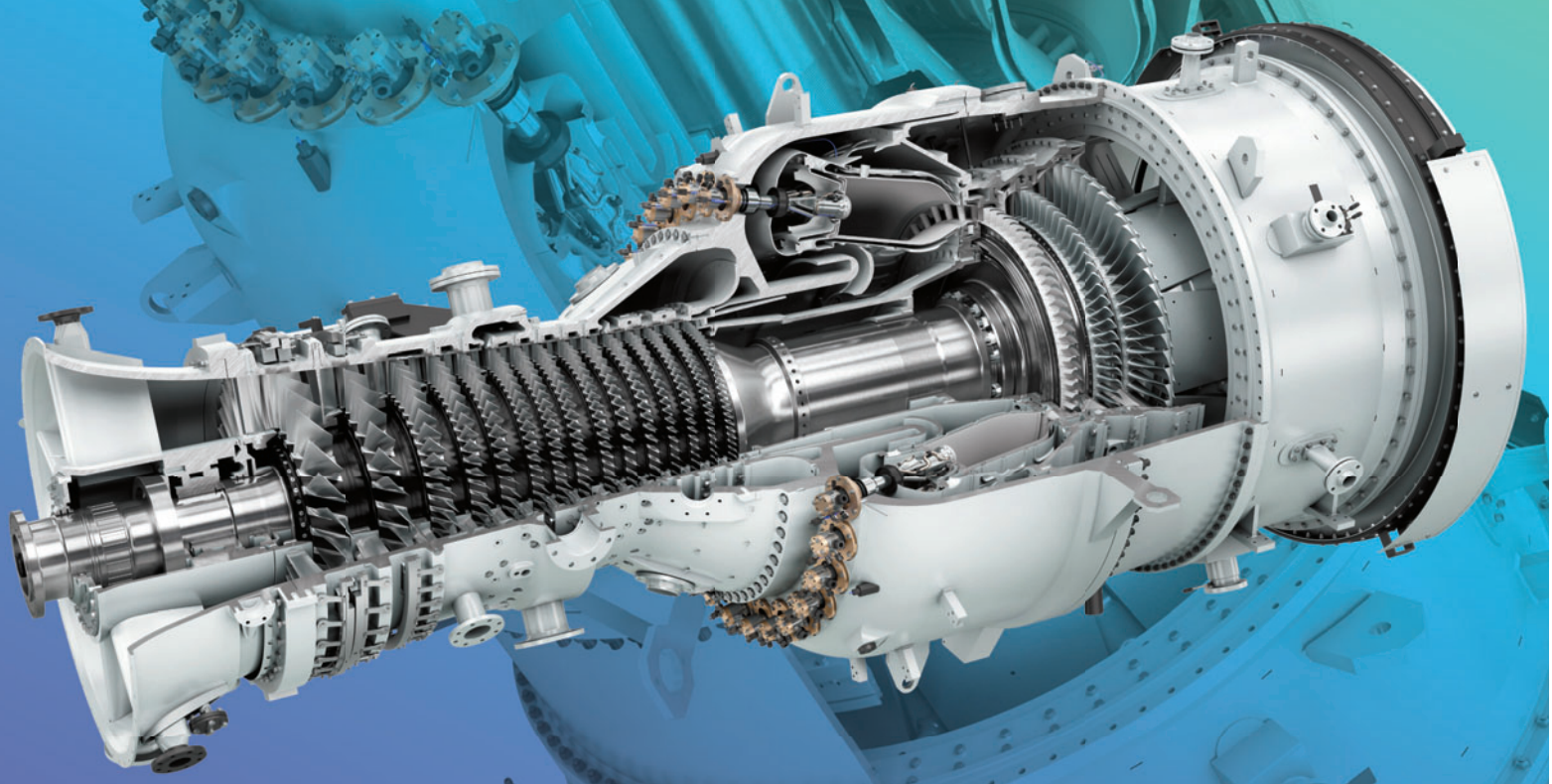
SMALL GAS TURBINES FIND THEIR NICHE



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Combined Cycle Power Plant Upgrades

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Drew.Robb@UBM.com

COVER STORY
18 SMALL AND MID-SIZED TURBINES FIND THEIR NICHE
OEMs have been racing for decades to deliver bigger machines, higher efficiency and larger combined cycle plants. Yet market forces may be dictating another direction — that bigger is not necessarily better. Small and mid-sized turbines are now receiving more attention as the power generation and oil & gas markets diversify. This trend is being driven by distributed generation, renewables, microgrids, combined heat & power (CHP), lower emissions and hydrogen-based generation.
Drew Robb

Cover image:
Siemens SGT-800 gas turbine

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23 GAS TURBINE COMMISSIONING
Commissioning of a gas turbine is often done against a rigid timeline. Even experienced engineers might miss certain details if they are engrossed in achieving project milestones. Despite this, steps should be put in place to maintain the integrity of the process. This story recounts problems with the commissioning of a Solar Turbine Taurus 70 installed in a high-pressure, high-temperature gas processing platform situated offshore.
Sarma Krishnamoorthy

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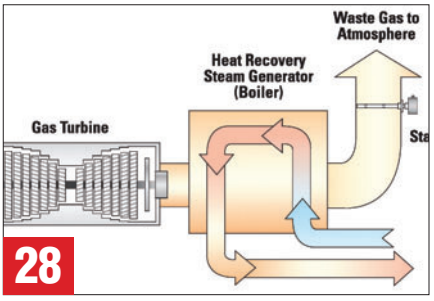
24 A MORE OPTIMISTIC POWERGEN
PowerGen International offers an annual barometer of the power generation sector. The December 2018 event noted challenges such as the influx of renewables, an aging power grid, price volatility and changing regulations. Yet the overall impression was one of optimism. Topics included digital transformation, the evolution of the grid, interaction with a new workforce generation, the rapidity of change, and how the industry can adapt.
Drew Robb



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Accurate, repeatable flow measurement of air and gases is critical to the safe, efficient and cost-effective operation of turbomachinery. There are at least nine common industrial flow measurement technologies available today. All have their strengths and weaknesses. Understanding these flow sensing technologies prevents costly mistakes.
Art Womack

OIL & GAS
30 DRY GAS SEALS IN OIL & GAS
Dry gas seals are right for some applications and not for others. They are favored in many applications due to several factors. Wet seals experience high-seal oil consumption. When new, this is about 5 gallons per day (gpd) per seal. After a year, oil consumption rises as high as 20 gpd. Even with lube-seal systems, at least 2 gpd are lost into the compressor on an average-sized machine. Contaminated lube oil may damage compressor bearings. The authors go into the pros and cons of wet and dry seals and factors to consider in product selection.
Chris Carmody & Heinz Bloch

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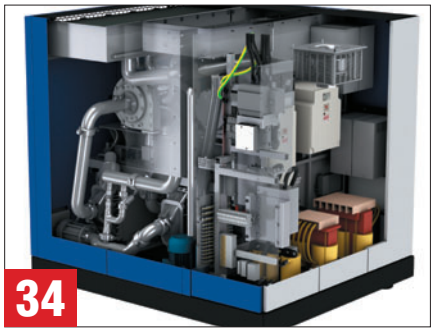

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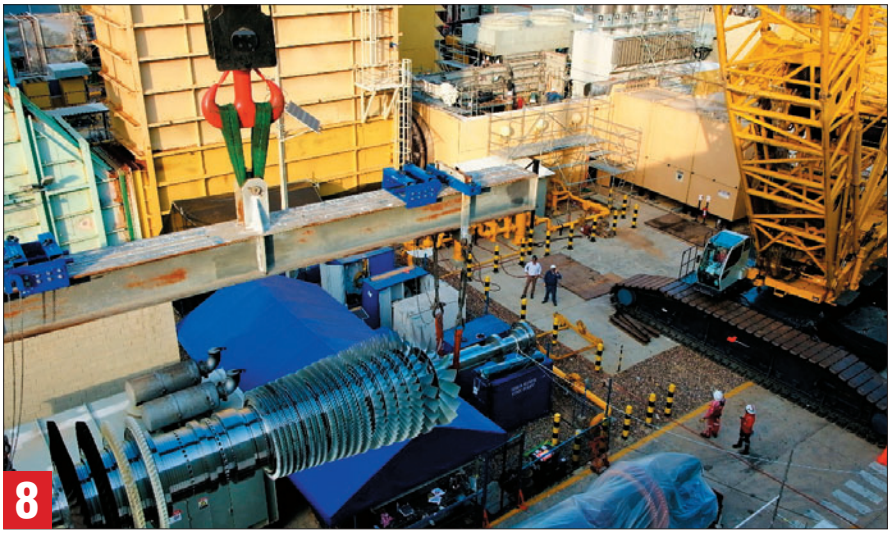

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Bigger is better, is an oft-repeated mantra. In our business, this has given rise to gas turbines that have become much larger with each new generation. There is certainly a place for this in the industry. But it is important to not lose sight of market needs. That's why small and mid-sized gas turbines continue to have their place.
Drew Robb

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Quick and frequent lubrication oil tests, particularly those related to contamination, are vital in maintaining the health of turbomachinery. In many cases, contamination can occur suddenly as the result of a malfunction or a developing problem. And oil contamination can quickly damage sensitive parts of these machines. Therefore, a fast response is essential.
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44 NATURE'S GIFTS FOR POWER GENERATION

Air and water are very basic, but wonderfully common, and easy to use. They represent the best option for a working fluid in power plants.
Klaus Brun & Rainer Kurz

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Subscription Service
For subscription/circulation inquiries, 888-527-7008.
Outside the U.S. call 218-740-7273,
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Turbomachinery International (USPS 871-500 : ISSN 0149-4147) is published bimonthly, plus an extra issue in October, by UBM LLC 325 W 1st St STE 300 Duluth MN 55802.
Periodicals Postage paid in Duluth MN 55806 and at additional mailing offices. POSTMASTER: Please send address changes to Turbomachinery International PO Box 6000 Duluth MN 55806-6000, USA.
Publications Mail Agreement No 40612608. Return Undeliverable Canadian Addresses to: IMEX Global Solutions, PO Box 25542 London ON N6C 6B2. Canadian G.S.T number: R-124213133RT001. Printed in U.S.A.

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RIGHTSIZING TURBOMACHINERY

Bigger is better, is an oft-repeated mantra. In our business, this has given rise to gas turbines that have become much larger with each new generation. There is certainly a place for this in the industry. But it is important to not lose sight of market needs. That's why small and mid-sized gas turbines continue to have a place, as you can read about in our cover story.

> **"Bigger turbines are often better, but smaller may sometimes be smarter.**

From a marketing perspective, there are two approaches that can bring success. The first is to create something and find a market for it. The other is to find out what the market really needs and design it well to fulfill demand. Let's look at both sides.

Bigger is better

Without the drive to build bigger, better and more efficient gas turbines, we would not be where we are today. In the early days of the industry, demand was absent. It was up to engineering pioneers and promoters like the founder of this magazine R. Tom Sawyer to bring new equipment to the world and create demand.

That approach remains important. It has given rise to huge combined cycle power plants capable of replacing large steam turbine-driven coal plants. But it is also a high-risk strategy.

Take the case of aeroderivatives. Successive generations of aeroderivative GTs such as the LM2500, LM5000, and LM6000 led inevitably to the much larger LMS100. But that machine has struggled to find its place in the new world power generation order. More than a decade after the release fanfare that greeted the LMS100, it remains far behind its smaller cousins in terms of numbers deployed.

Further, the manufacturers of ever-larger turbines are currently struggling due to a lack of orders. The forecast for large gas turbines remains sour for the next few years.

Find a niche

The alternate strategy is to find a niche and serve it well. The NovaLT line from Baker Hughes GE is a case in point. Designed in the 5 MW to 16 MW range to serve specific oil & gas needs, it is now finding new opportunities in power generation.

The cover story recounts numerous examples of small and mid-sized machines from a great many manufacturers that serve certain requirements. By fulfilling the needs of their corners of the oil & gas or power generation market, many are flourishing.

In some ways, this echoes how oil & gas facilities operate. Rather than buying a gas turbine or centrifugal compressor and trying to shoehorn their processes to fit it, they typically demand machines that serve specific needs.

Going forward, we need both approaches: bigger machines as well as products that the market demands.

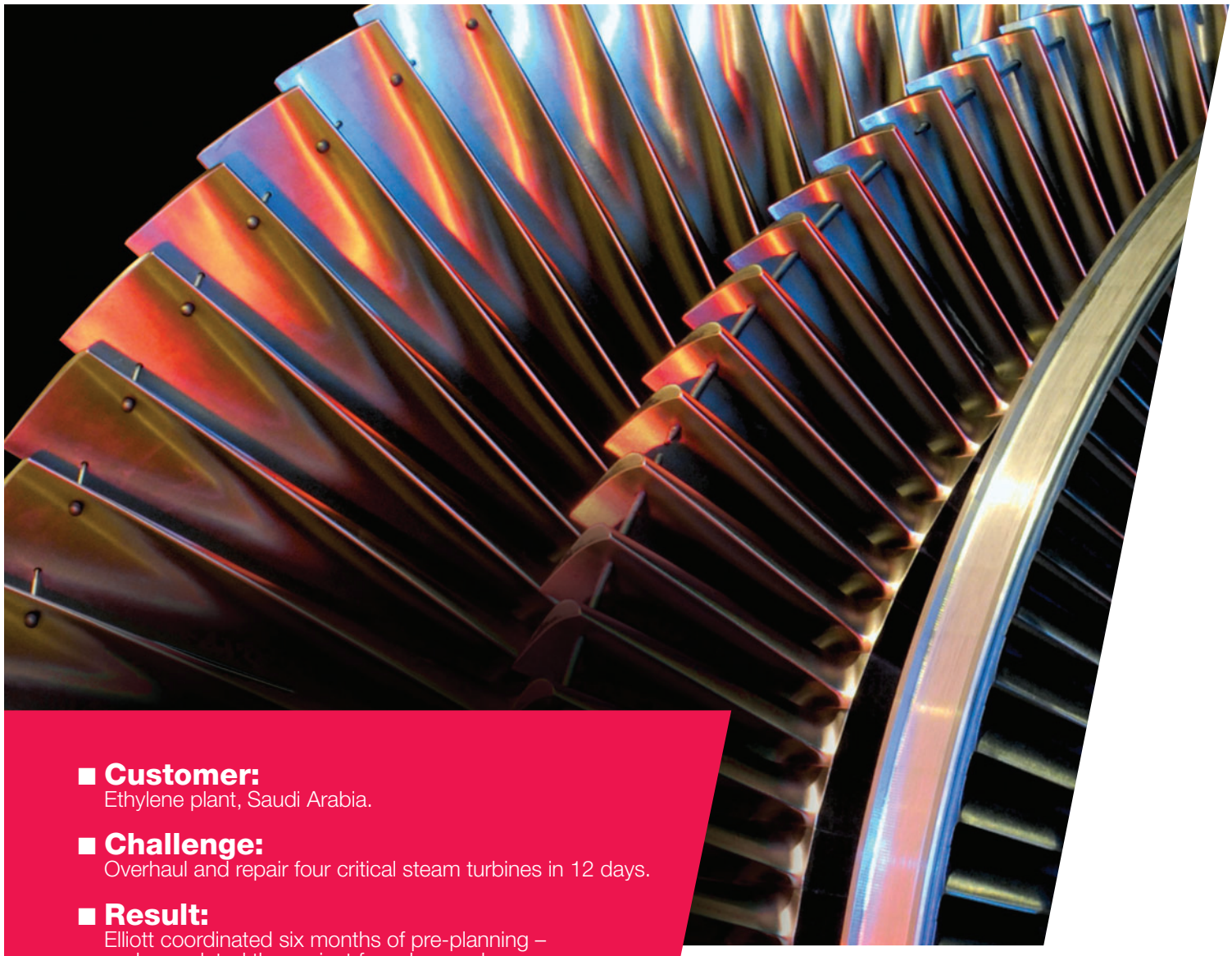
The morale of the story might be written as follows: Bigger turbines are often better, but smaller may sometimes be smarter.

Excellent issue

Beyond the cover story, we have an excellent issue for you. You can read about a more optimistic tone for the future in our PowerGen Show Report. There are also stories on: dry gas seals and when to deploy them; challenges in commissioning of gas turbines; and air and gas flow measurement. ■

Drew Robb

DREW ROBB
Editor-in-Chief



■ **Customer:**
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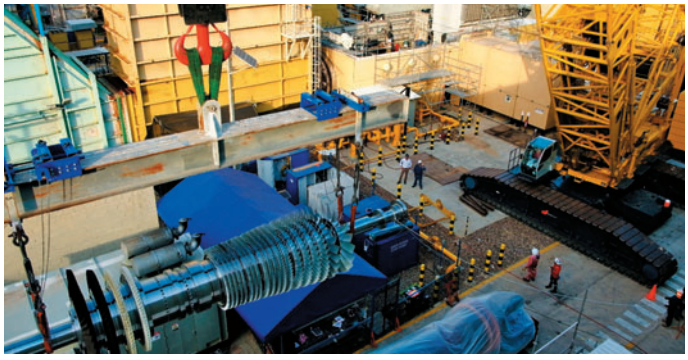
SIEMENS COMPLETES MAJOR UPGRADE AT COLOMBIAN POWER PLANT

Siemens has completed an extensive modernization and upgrade project in Barranquilla, Colombia. This was done for Zona Franca Celsia (formerly Termoflores S.A. E.S.P.), an energy company that provides generation, transmission and distribution via thermoelectric, hydroelectric, and solar plants. The plant on the Caribbean coast began operation in 1993. It is comprised of two combined cycle power plants (CCPP) originally operated by Westinghouse legacy control systems.



A new bolted rotor is brought onsite at Zona Franca Celsia

One plant is a 1×1 CCPP with a Siemens SGT6-3000E (formerly W501D5) gas turbine (GT) and a Mitsubishi ST 1138 steam turbine (ST). The other CCPP is a 2×1 Siemens SGT6-5000FC (formerly W501F) with a Siemens SGT6-3000E GT in combination with a Siemens SST-700-900 ST.

These plants were nearing the end of their lifecycle. Obsolete controls and aging turbines suffered from reduced efficiency, poor startup reliability and declining availability. Turbine trips accelerated the frequency of maintenance.

Turbine issues

Siemens investigated the cause of various turbine issues, low efficiency, and looked at ways to heighten reliability. An engineering study identified improvement opportunities in the auxiliary equipment, control system, and in the operation of the units. Additionally, Siemens specialists performed a Rotor/Casing Interval Inspection (RCIE) to determine the actual condition of rotors and casings to assess their ability to run beyond the 100,000-hour mark.

Celsia considered the option of bringing in new turbines. However, this would have required lengthy outages, which would have led to high periods of unavailability, loss of profits and higher initial costs. The fragility of the local grid necessitated a rapid turnaround. The preferred option was to enhance existing turbines.

Based on engineering assessments, Siemens provided Celsia with an integrated upgrade package consisting of:

- Siemens DF-42 2.0 Inspection Interval Extension Program (IIEP) combustor technology
- Si3D vanes and blades for the SGT6-3000E units
- SPPA-T3000 distributed controls system
- One SGT6-3000E GT was upgraded with a new bolted compressor rotor design
- Another SGT6-3000E unit was upgraded with a new hydraulic system for the operation of throttle valves and IGVs
- Each SGT6-3000E GT received Siemens' latest DF-42 2.0 IIEP combustor technology modernization.

The fuel nozzles for the combustor include new features that provide improved fuel and water injection patterns. This results in better control of combustion gas temperature and NOx emissions, as well as eliminating impingement of cooling water on walls of the combustor.

The cross-flame tubes have been redesigned. They now consist of two pieces and incorporate improved materials, coatings and cooling holes. The cross-flame tubes last the same intervals as the other combustor parts.

The combustor's plate-fin design makes more efficient use of cooling air. The original style v-bands and clamps have also been upgraded with advanced bolted combustor couplings which have scalloped bolting flanges and, like the cross-flame tubes, have the latest coatings, improved materials, and cooling passages for long life.

The redesigned transition piece reduces stagnation of combustion gas flow and impingement of combustion gas on transition walls. The new transition bolting flange is larger and stiffer, resulting in the elimination of the outer seal.

One of the SGT6-3000E units received a new bolted compressor rotor. This addresses issues experienced after extended operation with the original shrink–fit compressor disk. The new rotor has stacked, bolted compressor discs.

It uses design elements from the F-turbine rotor, which allows engine ramp rates of up to 24 MW per minute. It also has visible locking key hardware to facilitate rapid disassembly. This bolted compressor rotor has a 150,000-hour lifespan. Celsia's existing Siemens SGT6-5000FC+ GT already possessed a bolted rotor. The other SGT6-3000E unit was fitted with a refurbished rotor in 2009 during its second major inspection.

Si3D turbine vanes and blades were installed on both Siemens SGT6-3000E GTs. These blades provided Celsia with a power gain and a heat-rate improvement. The SGT6-5000FC+ GT already used advanced turbine vanes and blades. On-site inspection found them to be in excellent condition.

During this scheduled maintenance window, IIEP parts were installed on the SGT6-3000E units to enhance durability and extend the interval between inspections (hours and starts). Hydraulic throttle valves and inlet guide vanes (IGVs) were also replaced to increase precision and response time.

Control upgrade

The Siemens Power Plant Automation T3000 (SPPA-T3000) System has been implemented for turbine control, boiler control, balance of plant (BOP) and integration of third party systems. This boosted startup reliability and shutdown sequencing, and improved cybersecurity. In addition, the facility benefits from fan-free operation up to a temperature of 140°F.

Celsia can control both power generation blocks from a single platform. Remote diagnostics can be performed either by Celsia or via a Siemens remote monitoring center.

This upgrade program boosted efficiency, power output, reliability and availability at Zona Franca Celsia. The combined power boost amounted to 14.24 MW. It exceeded contractual commitments by 170 BTUs/kW-hr.

Adding the enhanced components with better design, material and thermal barriers reduced the trip factor from 20-to-8 equivalent starts per trip at full load. Scheduled maintenance intervals were doubled. With a combined installed capacity of 610 MW, Celsia is said to be the most efficient natural gas plant in the Caribbean area.

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The Forchem plant in Finland is to receive equipment from MAN Energy

MAN digest

MAN Energy Solutions has opened a new service shop in Senegal, West Africa. MAN earlier equipped the Tobene power plant in the country with MAN 48/60 engines. The service center will be able to reach out to neighboring countries. The team consists of 21 employees, including 7 technicians. Its onsite equipment includes a balancer, valve and seat rectification, de-icer, and engine performance control.

The Japanese Mitsui Engineering & Shipbuilding Co. has commissioned MAN to supply the central turbine technology for a biomass power station in the Bay of Tokyo. Equipped with a steam turbine (ST) group from MAN, the power station of Ichihara Biomass Power will generate around 50 MW from wood pellets and palm kernel shells.

MAN Energy Solutions has won the contract to design and deliver an LNG regasification terminal for the Forchem company in Rauma, Finland. Forchem has chosen to convert the boiler that generates steam for refinery processing to natural gas and biogas.

MAN will also deliver an offloading skid for LNG trailers to the Finish facility, as well as a vertically standing 200 cbm vacuum-insulated tank and vaporizer unit. The installation will be located beside the Forchems plant. This will enable it to receive deliveries of LNG and LBG (Liquified Bio Gas) via tank-truck deliveries.

Pump market

The power generation pumps market has witnessed steady growth with global demand exceeding 4,000,000 units at the end of 2018. The growth of the market is influenced by rising energy demand, especially in developing regions.

Integration of new technologies including sensors to monitor different parameters in the power generation pumps is also rising. This is according to a report by Fact MR. According to the report, small pumps with a capacity of up to 500 gpm are likely to witness the highest growth. Centrifugal pumps comprise 80% of the worldwide total.

Demand for centrifugal pumps, influenced by their small footprint and low cost, is expected to increase in the Asia Pacific region, especially in China, India, and Japan. Demand for power generation pumps is likely to grow significantly in coal and oil power plants with demand exceeding 1,400,000 units by the end of 2018. New power plant construction is also expected in the region, thereby driving further growth.

Chinese hot gas path

China's State Power Investment Corp. (SPIC) has claimed success in the design and manufacturing of a hot gas path component for 300 MW GTs. SPIC recently signed collaboration agreements with Siemens and Ansaldo and said on its website: "On the morning of December 25, China's first level I turbine vane casting of 300 MW/F class heavy duty gas turbine successfully passed the appraisal…"

Until now, China had developed capabilities to design and manufacture cold-end GT components. SPIC has acknowledged that end-to-end design and manufacture of an advanced gas turbine is still beyond its capabilities.

Hitachi power grids

Hitachi has acquired ABB's power grids business. This will allow it to combine ABB's grid-level technology with Hitachi's digital platform and expand Hitachi's reach through ABB's customer base.

The global power grids market is projected to be valued at US$100 billion by 2020, with growth predominantly driven by the transition towards renewable energy

Continued on page 12

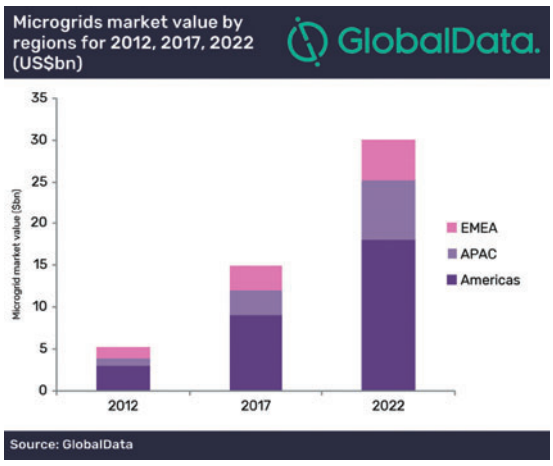
CCC digest

CCC (Compressor Controls Corp.) is expanding its capabilities to offer Front End Engineering Design (FEED) Services for upstream, midstream and downstream customers. CCC's FEED approach for turbomachinery control systems includes staffing project engineers onsite to work closely with customers and subject matter experts, to match a process with suitable machinery, instrumentation and control. This collaboration is required to develop a proper foundational progression for optimal designs and clear documentation.

CCC has opened a new sales and service facility in Al-Khobar, Saudi Arabia. CCC's Turbo Train Optimization Services enable oil & gas and petrochemical operators to improve efficiency, enhance yield and improve processes.

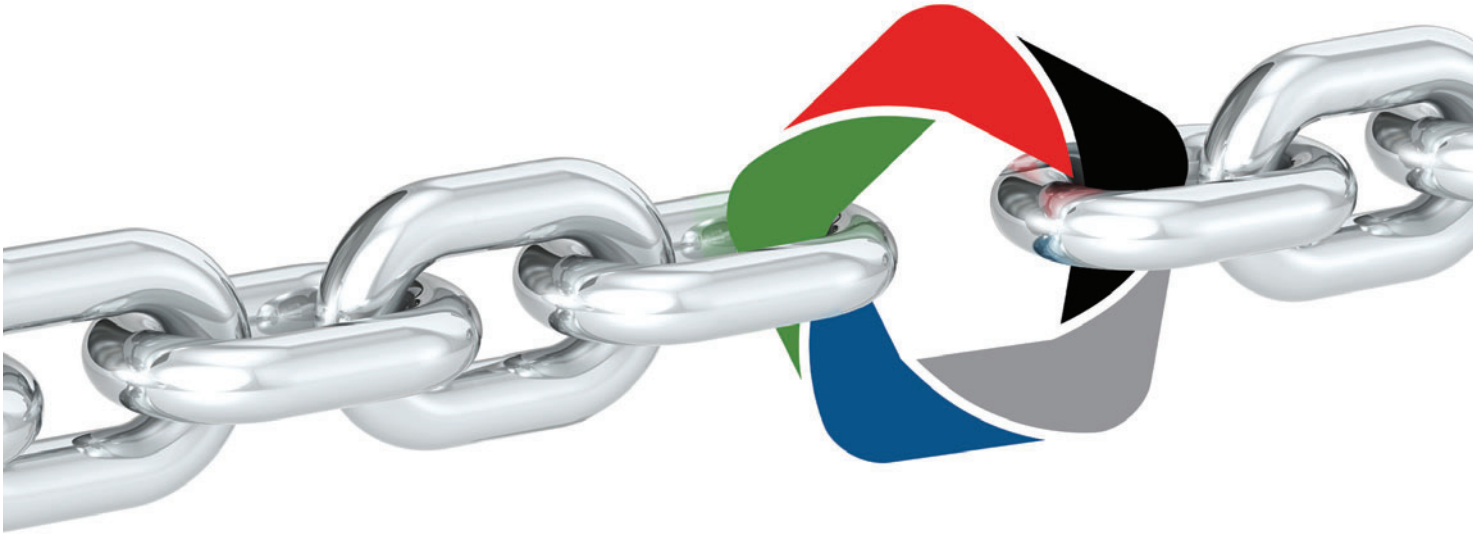
Microgrid boom

The global microgrids market is estimated to be valued at $30 billion by 2022. That equates to annual growth of 15% between 2018 and 2022, according to analytics company GlobalData. The Americas will continue to be the largest market, reaching $18 billion in 2022, underpinned by movements in the U.S. market. But the Asia-Pacific market is expected be the fastest growing area during that period.



Well-developed power markets, such as the U.S., Canada and Japan are often prone to natural disasters. Microgrids offer backup capabilities during periods of network downtime, reducing the impact on day-to-day activities. In addition, a microgrid allows end users to reduce their dependency on the grid in areas with high retail prices, such as in California, South Australia and Japan.

Is reliability an issue for you?



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GE digest

GE Gas Power has been split into two businesses — GE Gas Power Systems and GE Power Services. The GE Power Portfolio is comprised of the Steam, Grid Solutions, Nuclear and Power Conversion businesses.

GE's new leadership team will report directly to GE Chairman and CEO H. Lawrence Culp, Jr.

John Rice, retired GE Vice Chairman, returns to GE to serve as the Chairman of the GE Gas Power business. Scott Strazik, former President of Power Services, is CEO of GE Gas Power business. Russell Stokes, former CEO of GE Power, is CEO of GE Power Portfolio.

GE Marine Solutions has announced that 40 LM2500 marine GTs will power the U. S. Navy's next-generation of DDG 51 Arleigh Burke-class destroyers. The U.S. Navy awarded construction contracts to Huntington Ingalls Industries (six ships) and Bath Iron Works (four ships) with options for additional ships. Each of the destroyers features four LM2500 engines.

GE has provided over 300 LM2500 GTs for the U.S. Navy's existing fleet of Arleigh Burke destroyers. The LM2500 modules will use GE's lightweight composite that is said to offer advantages over steel in terms of weight, noise, access and lifecycle costs.

GE will deploy two 6F.03 GTS at the Korea Zinc Combined Cycle Power Plant (CCPP) by January 2021. Korea Zinc produces 18 types of non-ferrous metals as well as rare metals, such as indium. The plant will produce the electricity for the local industrial operations at the site. It will generate more than 270 MW using LNG.

GE will work with Tampa Electric (TECO) on a major modernization project at TECO's Big Bend Power Station. GE will provide Big Bend with two 7HA GTs, as well as an upgrade of the station's ST island. Chiahui Corp. will also rely on the 7HA.02, to increase the generation potential of its power plant in Chiayi province, Taiwan.

Veolia Kendall Cogen Plant in Massachusetts selected GE Fleet360 plant solutions

GE has completed a 9EMax GT upgrade at the Sokolovska Uhelna power plant in Vresova, in the Czech Republic. It was completed within ten weeks. This is Europe's first ever 9EMax upgrade. The plant uses coal gasification to produce syngas to power mining and industrial process. The upgrade improved heat rate, power output and flexibility, and lowered maintenance costs.

The 9EMax GT is part of GE's Fleet360 platform. In simple-cycle operation, it offers up to 37.0% efficiency and up to 145 MW of output, while in Integrated Gasification Combined Cycle (IGCC) operation, it offers up to 53.5% efficiency and up to 210 MW of output.

Leonardo DRS, a U.S.-based Defense Contractor, has delivered its 100th LM2500 GT package to GE to be installed on the U.S. Navy's Arleigh Burke-class guided-missile destroyer, the USS Louis H Wilson Jr (DDG 126). The engine packages have been manufactured by Leonardo DRS's Naval Power business.

The GTs have been installed, and full-load production acceptance tests have been carried out at GE's facility in Evendale, OH. With completion of the acceptance tests, the completed package unit was delivered to General Dynamics subsidiary Bath Iron Works for integration onto the U.S. Navy destroyer.

Veolia North America (Veolia) and Arizona Public Service (APS) have selected GE Fleet360 plant solutions to boost performance at power plants in Boston, MA, and Arlington, AZ. These services help utilities increase output, reduce startup times, lower emissions, and balance the growing role of renewables on the grid.

The modernization of the APS Redhawk Generating Facility, a 1,060 MW CCPP with four GE 7FA.03 GTs, includes the following elements: GE's Advanced Gas Path (AGP) technology and Dry Low NOx (DLN) 2.6+ combustion system. GE also will implement its Dispatch Optimization software to allow Redhawk to bank MW when the facility is operating at part loads. At other times, the plant can use the turbomachinery in peak firing mode during times of high power demand. This will incrase the viability of the APS Redhawk Generating Facilty.

and electrification. ABB will now focus on robotics and automation.

Geothermal plant

Turboden has started up the largest ORC system in Europe for the Turkish customer Geoen. The 17.5 MW Velika Giglena geothermal power plant is in Croatia. It exploits steam and hot water at 170°C to produce electricity to feed the local power grid.

Turbine insulation

Thermamax has created a turbine insulation business unit to expand its activities in the North American market. It can offer a package for GTs with an output of up to 560 MW and STs of more than 1 GW. The newly developed insulation systems will be produced in the U.S. and installed with local specialists.

Compared to conventional systems, the single-layer insulations from Thermamax is claimed to offer greater insulating performance and service life while reducing the maintenance efforts. This is directed not only at turbine manufacturers but also power plant operators who need to have their aging insulation replaced.

Baker Hughes split

Baker Hughes GE announced long-term agreements that amend the commercial and technological relationships with GE. It includes collaboration on aeroderivative and heavy-duty GTs, BHGE's access to GE Digital software, and operational and pricing agreements. These agreements accelerate the orderly separation of GE and BHGE.

Microturbine order

Capstone Turbine has secured an 800 kW order to power a landfill in Northern France. The compact 4-bay Signature series package was secured by Biogaz Services, Capstone's distributor in France.

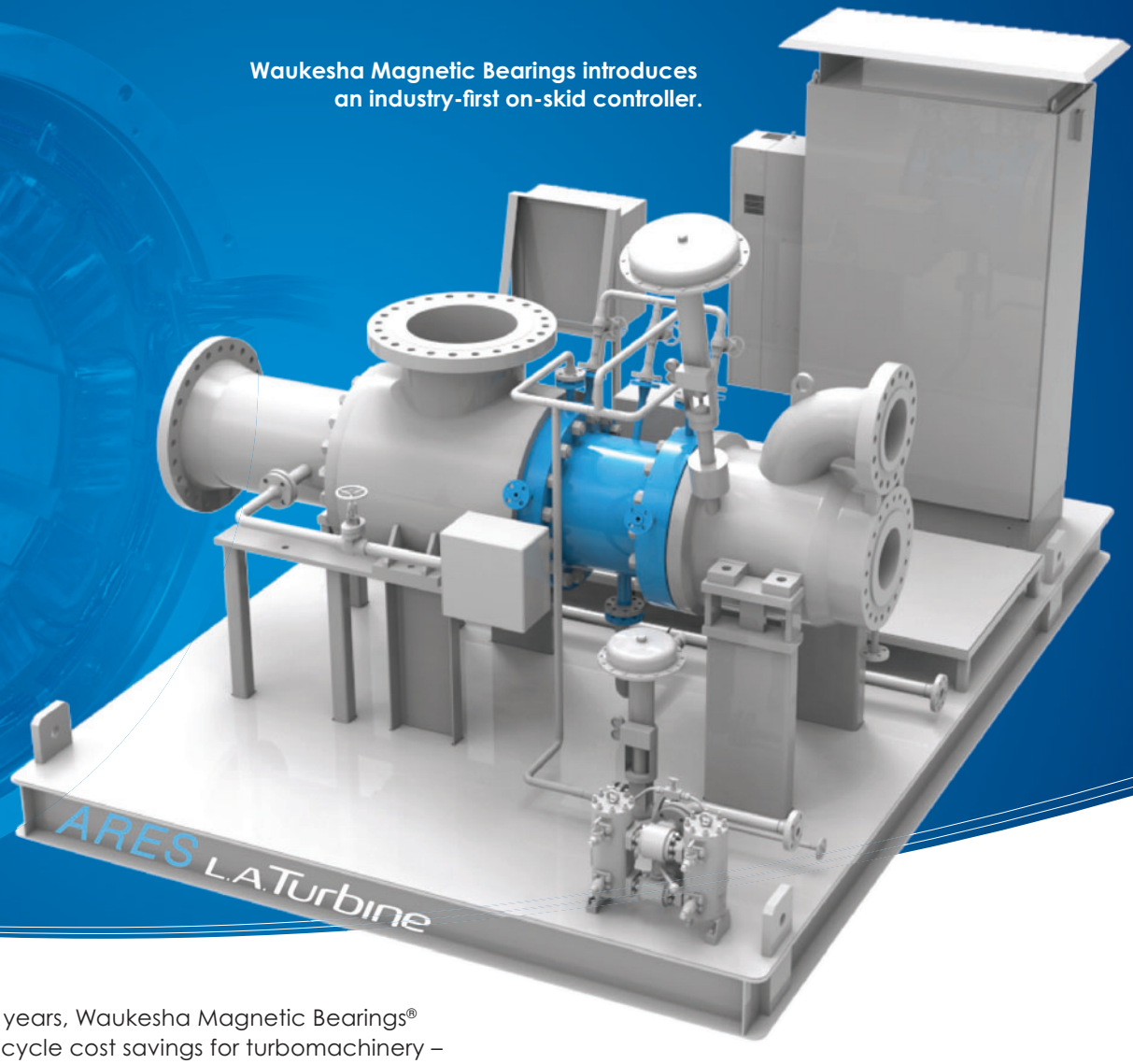
Deployed in combined heat and power (CHP) configuration, the microturbines will be equipped with Capstone roof-mounted heat exchangers. The microturbines will use biogas to produce electricity as well as thermal energy for the facility.

Continued on page 14

LOWER YOUR TOTAL COST OF OWNERSHIP

Magnetic Bearing Efficiencies Are Within Your Reach

Waukesha Magnetic Bearings introduces an industry-first on-skid controller.



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Sulzer digest

In a move to increase services, parts and new equipment availability, minimize repair times, and reduce downtime, GE Power Conversion has signed an agreement with Sulzer, making it an authorized parts, new equipment, and service provider.

GE electrical equipment, such as motors and generators, can now be maintained and repaired through Sulzer's service center network. The agreement between the two companies enables Sulzer to warranty work using OEM parts. Sulzer will offer service center repairs as well as installation, start-up assistance, troubleshooting, routine maintenance, testing and monitoring.

Sulzer has acquired Brithinee Electric of Colton, CA. This expands its electromechanical services business into Southern California. Founded in 1963, Brithinee offers electromechanical repair services, remanufacturing, redesign, upgrades, and modifications as well as custom electric control panel systems.

Sulzer can provide a range of services, including warranty work, ensuring customers receive high quality repairs using OEM parts.

Klaus Brun

They will power the on-site evaporator used to vaporize leachates that collect at the landfill.

Elliott hires Dr. Brun

Klaus Brun has joined Elliott Group as Director of R&D. Brun will lead Elliott's advanced development teams for all rotating equipment product lines and related systems, including materials engineering, reporting directly to Elliott Group's Deputy CEO, Toshihiko Miyashita.

Brun came to Elliott from Southwest Research Institute (SwRI) where he was the Director of SwRI's Machinery Program. He brings more than 20 years of experience, including a background in aerodynamics, thermodynamics, and rotordynamic design and testing. Prior to joining SwRI in 2003, Dr. Brun was the Commercial Director at Alstom Power Systems in Houston, Texas.

Centrax status

Centrax Gas Turbines has been

Siemens digest

Siemens has opened a 4,500 m^2 3D printing facility at its Materials Solutions location in the UK. Materials Solutions offers design services to help create a digital twin of the 3D printed component.

Materials Solutions is also supporting Siemens' latest HL-class GTs with components in serial production to drive emission reduction and increased performance. Siemens will manufacture combustion components for the SGT5-9000HL GT.

Siemens has signed a contract to build a 600 MW power plant in the United Arab Emirates (UAE) using its H-class GT. Signed between Siemens, Dubal Holding and Mubadala Investment Company, the agreement will see the development of a CCPP at Emirates Global Aluminum's smelter in Jebel Ali, Dubai.

Siemens and the marine arm of ST Engineering in Singapore have jointly received an order for a SCC-800 2×1C SeaFloat barge-mounted power plant from Transcontinental Capital. The project Estrella del Mar III in the Dominican Republic will be a CCPP with a capacity of 145 MW.

ST Engineering will be responsible for the engineering design, procurement and construction (EPC) of the floating power barge, the balance of plant (BOP) and the installation of the floating power plant.

Siemens will also deliver its hybrid Siestart solution, combining a flexible GT CCPP with a battery energy storage system. The SCC-800 2×1 SeaFloat concept has two Siemens SGT-800 GTs and one SST-600 ST. Fluence Energy is providing a 5 MW battery energy storage system to be integrated as part of the power plant for frequency regulation control.

The Abu Dhabi National Oil Company (ADNOC) inaugurated its Taweelah Gas Compression Plant, ensuring uninterrupted gas supplies to major Abu Dhabi industries and the UAE's Northern Emirates.

The plant, located 50 km north of Abu Dhabi, will use up to 450 mmscfd of gas, delivered to the facility by ADNOC Gas Processing's Maqta-Taweelah pipeline. The plant comprises three compression trains, each with a processing capacity of 225 mmscfd. At any one time, two of the compressor trains will be operational with the third on standby.

The Taweelah Gas Compression Plant contract included establishing an onshore compressor plant, supplying three electric variable frequency drives, three Siemens' Dresser-Rand Datum compressors, a 33-kV electrical substation, 10 km 33-kV cable corridor, 4 km of pipelines for gas suction and discharge, control building, auxiliary equipment and systems, flare tower, safety and control systems as well as facility design, construction and commissioning.

Siemens has been awarded a long-term service and maintenance agreement from Sinolam Smarter Energy (SSE) in Panama. It is also providing six SGT-800 GTs to the project. Support covers the SGT-800s and an SST-600 ST and electrical generators. The plant will operate with LNG. Commissioning is expected in the fall of 2020.

Siemens has opened of a 300,000 square-foot Pittsburgh Service Center (PSC), located in Mount Pleasant. It is home to Siemens Turbine Generator Specialty Services (TGSS), which supports about 150 employees working in the company's large-scale turbine and generator business. It specializes in field service maintenance, repairs, modifications, and the modernization of large-scale turbines and generators.

Siemens began construction on an energy service and training center in Bolivia. It is designed to provide traditional and digital services to energy customers in Bolivia and South America. It is located on a 9,200 m^2 site at the Parque Industrial Latinoamericano (PILAT) in the city of Warnes.

It will also function as a hub for servicing power equipment installed in the South America region. In addition, Siemens is helping expand three CCPPs in Bolivia: Termoeléctrica del Sur, Termoeléctrica de Warnes, and Termoeléctrica Entre Ríos. This will add more than one GW of capacity.

Doosan Škoda Power steam turbine

Doosan digest

Doosan Škoda Power has secured a contract from Hitachi Zosen Inova to supply machinery for the largest waste incineration plant in Turkey and Europe. The Istanbul WtE (waste-to-energy) project will use around one million m.t. of waste per annum. The WtE plant will be later operated by the city of Istanbul's subsidiary İSTAÇ.

It will be located near Istanbul's new airport, now under construction. The turbine island core is made up of a modular 85.8 MW Doosan DST-S10 ST, generator and other equipment. The units will be delivered by Q4, with plant operation scheduled for 2021. Once the airport is completed, Doosan Škoda Power's turbine will also serve as a cogeneration unit, supplying the airport with heat via newly built district heating system.

awarded MROC status by Siemens Energy, allowing Centrax to maintain, repair and overhaul the Siemens SGT-A05 GT at its new facility in England. Centrax had previously only been able to carry out maintenance to the hot section.

The move to MROC status means that Centrax' fleet of operational engines can now be fully repaired and overhauled by one party. The SGT-A05, formerly known as the 501K, is the core engine installed in over 340 Centrax CX501 generator sets. With its 3.9-to-5.7 MW power range, the SGT-A05 is suitable for CHP, standby and oil and gas processes.

Mobile power

APR Energy has commissioned a 120 MW power plant for AES Dominicana in the Dominican Republic. The project comprises four GE TM2500 mobile gas turbines (GTs). It was assembled and ready in 30 days. Fueled by natural gas, the turbines connect to the AES Andres Energy Complex.

GE divestiture

Air Products and Chemicals (APD) has acquired GE's gasification business. This enables APD to expand its synthesis gas (syngas) offerings and build, own and operate gasification projects. It will provide

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MHPS digest

Mitsubishi Hitachi Power Systems (MHPS) has announced that the ST generation facilities supplied for the Haiyang Nuclear Power Plant in China have cleared all functional, safety confirmation, and required performance tests. A handover was made at the end of 2018.

The plant, equipped with a 1,250 MW pressurized water reactor, was built by Shandong Nuclear Power in Shandong Province. It comprises two units, each with an output of 1,250 MW.

MHPS handled the designs for the turbine, heat exchanger and auxiliary equipment. MHPS also manufactured and provided six low-pressure turbines, two high-pressure turbines, the main valves, and other equipment for the two units.

Harbin Electric handled the manufacturing of the turbine casing, heat exchanger, and other equipment, while Mitsubishi Electric and Harbin Electric each supplied one of the two generators.

MHPS has decided on the series name "Megamie" for its pressurized hybrid power generation system that integrates solid oxide fuel cell (SOFC) stacks with micro-gas turbines (MGT). "Megami" is a Japanese word for a goddess of the land or beauty.

MHPS conducted demonstration tests of 250 KW class hybrid systems at four locations in Japan. It received the first order for this system at the beginning of 2018 as a distributed power system for the Marunouchi Building in Tokyo.

Installation is now underway, with full-scale operations scheduled to start in February of 2019. This hybrid system uses city gas as fuel and generates electricity with both ceramic SOFC stacks that operate at around 900°C, and MGTs.

The fuel is not burned, but rather the SOFCs generate electricity from the chemical reaction between oxygen in the air and hydrogen and carbon monoxide extracted from reformed city gas. The MGTs generate electricity from the post-process. Used in a cogeneration system, the remaining exhaust heat can be recovered as steam or hot water.

MHPS has received an order from Taiwan Power (Taipower) for refurbishment of two thermal power plants: Nanpu Power Plant in Kaohsiung and Datan Power Plant in Taoyuan. The order calls for low-NOx combustor and performance enhancement of seven M501F GTs previously delivered by MHPS to Taipower, as well as supply of spare components. Support will also be provided through MHPS-Tomoni digital solutions. Refurbishment is scheduled for completion in August 2019.

APD with a broad range of product and services to provide syngas with power, fuels, chemicals or refining.

Spectro Scientific acquired

Spectro Scientific, a supplier of fluid analysis instrumentation and software, has been purchased by Ametek for about $190 million. Headquartered in Chelmsford, MA, Spectro joins Ametek as part of its Electronic Instruments Group (EIG), specializing in advanced analytical, monitoring, testing, calibrating and display instruments with annual sales of $3 billion.

Turbine acquisition

Turbine Efficiency (provider of aftermarket services to Siemens SGT-100 (Typhoon), SGT-200 (Tornado), SGT-300 (Tempest), TA and TB GTs) has acquired Gas Turbine Applications, an aftermarket provider specializing in Saturn and Centaur GTs. The new group has overhaul facilities in the UK and U.S., and regional offices in Aberdeen and Dubai.

Chinese filtration

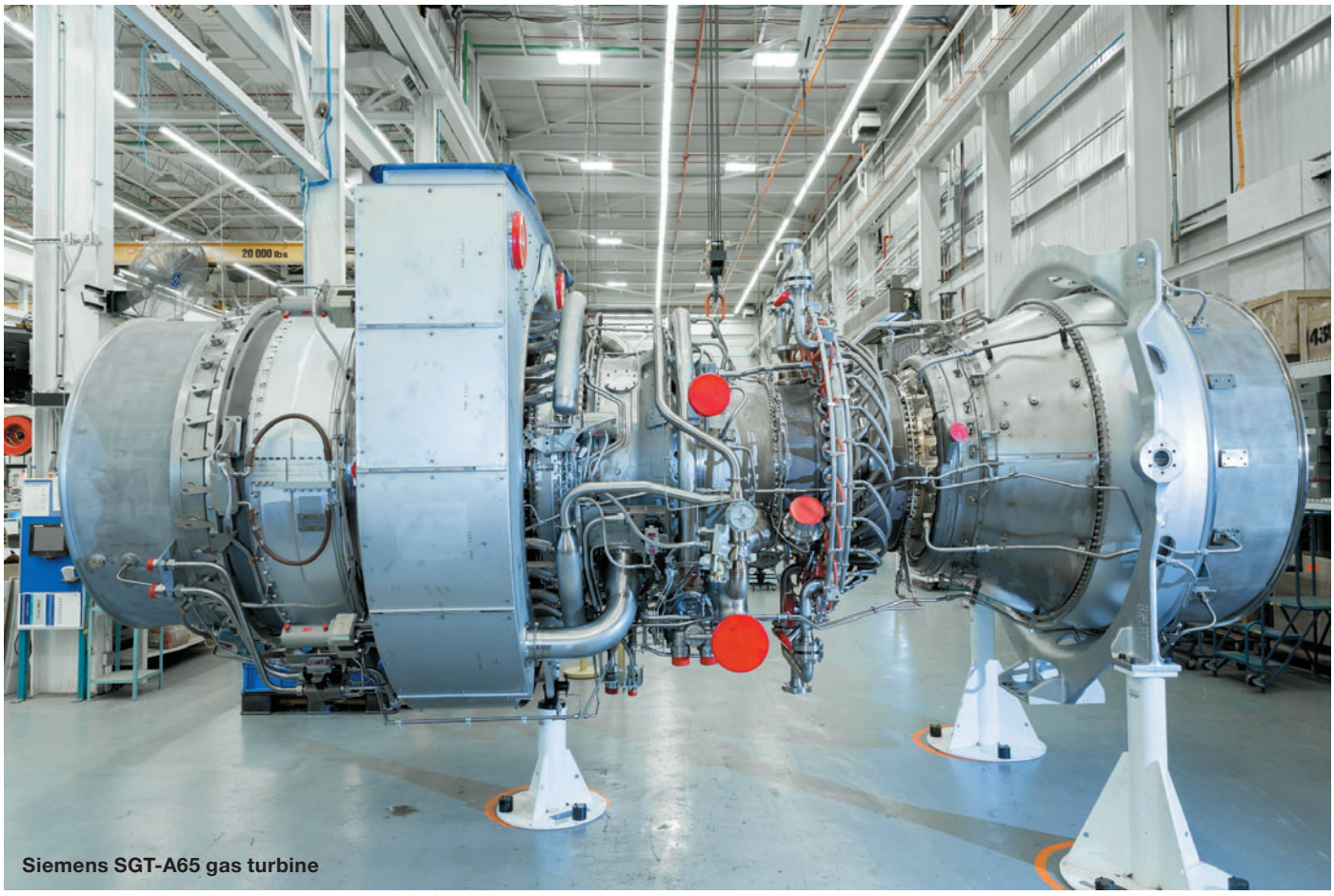
Freudenberg Filtration Technologies has signed a contract to purchase the majority shares of Apollo Air-cleaner, a supplier of air and water filtration solutions in China. Air and water filtration solutions are enjoying strong year-on-year growth rates, especially in China. The product solutions of Apollo keep air or drinking water free of fine particles, dangerous gases, odors and microorganisms.

The Apollo facility in China

Ansaldo Energia signs another big contract in China

Ansaldo contract

Shanghai Electric Gas Turbine and Ansaldo Energia have signed a contract worth about €60 million for the supply of the first Ansaldo Energia H-class GT36 GT for Minhang CCPP in China. This strengthens a strategic partnership between Shanghai Electric and Ansaldo Energia. The end customer for the 800 MW project is Shanghai Electric Power, which is controlled by SPIC (State Power Investment Company). ■



Siemens SGT-A65 gas turbine

SMALLER GAS TURBINES FIND THEIR NICHE

DISTRIBUTED GENERATION, COMBINED HEAT & POWER AND HYDROGEN ARE DRIVING THE MARKET FOR SMALLER AND MID-SIZED TURBINES

BY DREW ROBB

Gas turbine (GT) OEMs have been racing for decades to deliver bigger machines, higher efficiency and larger combined cycle plants. Siemens scored a world record with a 4,800 MW combined cycle plant in Egypt (*Turbomachinery International*, Nov/Dec 2018).

GE and Mitsubishi Hitachi Power Systems (MHPS) both claim to have the biggest GT. GE's 9HA.02 comes in at 557 MW, while MHPS's M701JAC provides 563 MW. GE, Siemens and MHPS all claim the world record on combined cycle efficiency.

Yet market forces may be dictating a completely different direction — that bigger is not necessarily better. Small and mid-sized turbines are now receiving more attention as the power generation and oil & gas markets diversify. This trend is being driven by distributed generation, renewables, microgrids, combined heat & power (CHP), lower emissions and hydrogen-based generation.

"The industry has been guilty of building ever-larger machines and then trying to find a market for them," said Mark Axford, President of Axford Consulting. "A better approach would be to find what the market needs and building machines to fit those requirements."

Solar Turbines

Solar is a leader in small machines, producing GTs ranging from 1.2 MW to 22 MW. Some use a diffusion flame combustor and others a DLE system. The DLE system keeps flame temperature much lower (1,600°C versus 2,300°C) to keep NOx emissions down. Solar machines can

operate with LPG, coke oven gas, landfill or digester gas.

"LPGs have become more common due to shale gas offering up more propane at low cost," said Luke Cowell, Group Manager, Combustion Strategy, Solar Turbines. "This fuel can be burned in a Solar GT with lower NOx emissions and lower particulates compared to diesel."

The composition of LPG around the globe can shift from 100% butane to 100% propane, said Cowell. With more butane, it is better to run it in liquid phase. Propane, though, has a lower dew point so is better in the gas phase.

At a Caribbean rum distillery in St. Croix, a Solar Centaur 50 is used with LPG for CHP. LPG is much lower priced there than diesel. As it has only 2.5% butane, the Centaur 50 is run in the gas phase with the fuel temperature maintained at around 200°F.

China's Liheng Steel, meanwhile, is using four Solar Titan 130s operating on coke oven gas with an HRSG and steam turbine.

"LPG is an excellent turbine fuel, but you need to determine whether it is optimum to use it in its gas or liquid phase," said Cowell.

MHPS

For the mid-sized turbine market, MHPS provides the H-100. At 119.9 MW (50 Hz) shaft power, it is being used to replace less efficient machines without requiring a modification to the bottoming cycle. It is also used in mechanical drive applications.

H-100 specifications: 38.9% efficiency, exhaust flow of 302 kg/s, and an exhaust temperature of 573°C. Its DLE burner is a scaled-down version of the combustor from the MHPS M501G and M501J. It provides 9 ppm NOx and CO.

"The MHPS H-100 GT has been successfully validated with lean gas (up to 40% N_2), rich gas with a high calorie value, such as LNG, and on-line switching between lean and rich fuel at a Wobbe Index rate of change up to 0.5% per second," said MHPS CEO Paul Browning. "It is the world's largest two-shaft turbine."

The two-shaft MHPS H-100 is finding a niche in LNG liquefaction as an alternative to the single-shaft GE 7EA, said Browning. The LP rotor has a continuous speed range capability of 70% to 105%. The two-shaft design allows full settle-out pressure starts. MHPS is partnering with MCO Compressor to deliver a complete solution to the oil & gas field.

Another smaller machine gaining traction is PW Power Systems' FT8, sold in modified form as a "Frack Pack." It offers 30 MW of mobile power to electrify the well pad. U.S. Well Services in Texas, for example, bought six of these units. Instead of diesel, it uses natural gas from the local site. They move them from well pad to well pad based on demand.

Zorya-Mashproekt from Ukraine offers a series of GTs ranging from 2.5 MW to 114 MW. Some 1,200 have been manufactured to date along with about 2,000 centrifugal compressors.

Despite embargoes from Russia, Forecast International predicts Zorya's sales to improve over the next decade with 25-to-30 sales per year on average. The UGT-15000, for example, is a 16.9 MW, three-shaft GT with an axial nine-stage low-pressure compressor and 10-stage high pressure compressor.

Vericor has two such gas turbines in its repertoire. The 3.3 MW ASE40 and 3.7 MW ASE50B GTs are compact units for stationary, continuous duty applications. These units boast 60,000 hours between scheduled shop visits.

They can run on natural gas or liquid fuel. In addition, they can be changed over from one fuel source to another while running under full load.

Vericor Power Systems is owned by MTU Aero Engines and is the OEM of the TF series and ASE series GTs. Its aeroderivatives are used in marine, offshore, industrial and mobile power applications.

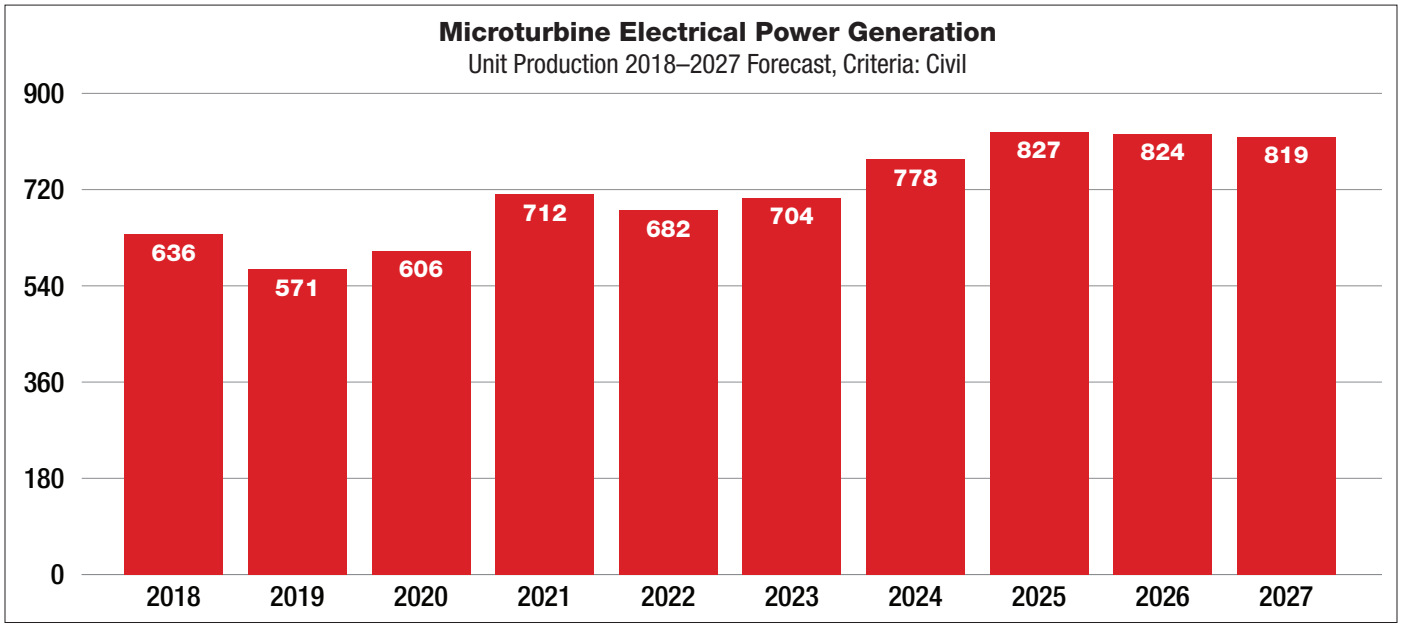
The TF40 (4,000 hp) and TF50 (5,000 hp) are used in the marine sector. Its VPS3 (TF40F) and VPS4 (TF50F) are favored in oil & gas. Its VPS3 (ASE40) and VPS4 (ASE50) are used mainly in the industrial sector.

Microturbines

The microturbine market has been stable for some time. But that may be about to change. Capstone Turbine, FlexEnergy and Ansaldo Energia are market leaders. Blandon (formerly Bladon Jets), a UK company, Micro Turbine Technology (MTT) from the Netherlands, and Aurelia Turbines from Finland have also entered the market.

Ansaldo's AE-T100 is a single-shaft, high-speed microturbine that delivers 100 kW. Some 600 have been made since its release in the nineties.

Primary uses include CHP with biogas feedstock, and areas where small amounts of power, less noise, vibration and emissions are needed. The GT comes with a



Forecast International's Platinum system has predicted a general upsurge in microturbine sales over the next decade

recuperator, electrical system, exhaust gas heat exchanger, control system and a single-stage centrifugal compressor.

Bladon's MTG12, a 12 kW machine, is designed to power cellular towers for telecom companies. Towers not connected to a grid are in demand, a market historically dominated by reciprocating diesel engines. The MTG 12 is said to have advantages over diesels, such as fuel flexibility and lower maintenance, and to require 90% fewer site visits.

MTT's EnerTwin can provide 3.2 kW of output for heat or electricity. Potential applications range from larger homes to restaurants and schools.

Aurelia Turbines has introduced a 400-kW model. This microturbine can be used for process steam, chilling and direct current applications. Efficiency is above 40%.

Combined Heat & Power

Smaller gas turbines are in demand in areas where CHP is growing in popularity. The complexity inherent in the development of smaller onsite power and CHP assets is being addressed by regulated utilities supporting and developing projects at customer sites, said Kurt Koenig, Vice President Project Development at DCO Energy.

Instead of fighting CHP and regarding it as a potential competitor, some utilities are embracing it, said Koenig. They realize that they have the grid and technical expertise to develop these projects and partner with industrial customers for mutual benefit.

DCO Energy has identified several major customer groups as CHP collaboration targets: healthcare, government and educational institutions, military, industrial, manufacturing, data centers, gaming and corrections. Projects can either be self-funded, privately funded, publicly funded or can be a combination.

"Drivers for CHP include cost, environmental impact, and fewer service interruptions," said Koenig.

Where public benefits can be identified, regulated utilities can be a catalyst for CHP and other distributed generation assets. Potential CHP sites may have a strong desire to build onsite power. But they lack the know-how, financing, and grid expertise to achieve it. By involving a willing utility, a mutually beneficial solution can sometimes be achieved.

For example, the local utility facilitated a CHP site at the Hudson Yards real estate project in New York by removing barriers to grid access. It included gas-fired boilers, centrifugal electric-drive chillers, a 7.2 MW GT with a waste heat recovery boiler, and gas-based reciprocating engines that provide, heating, cooling and power to commercial and residential space on Manhattan's West Side.

In another example, Duke Energy worked with Clemson University on a 15 MW CHP plant on campus. Owned by Duke, the utility provides access to natural gas and the grid. The facility includes natural gas turbines and duct-fired HRSGs. It supplies electricity and steam to Clemson. Duke gains steam and electricity. The campus also gains its own microgrid, partially funded by Duke.

"In this case, the public good was served as the provision of steam drove down rates for electricity," said Koenig.

A similar example was outlined by Ken Duvall, Managing Partner and CEO at Sterling Energy Group. He believes CHP is vastly underused with only 82 GW existing in the U.S. It is estimated that there is 200 GW of untapped CHP potential in the nation.

"Well applied, CHP is the most efficient method of generating power," said Duvall. "It is based on established natural gas technology that has very low risk."

He emphasized that a change of thinking is required. Instead of CHP only being viewed as a customer-owned resource, a variety of ownership and funding options are possible. Some utilities are happy to develop and own the entire facility, arranging attractive, long-term contracts for power supply.

The utility can sell the excess electricity to other customers. With steam as part of the equation, some industrial plants will take up much of the steam and some of the power. Many permutations are possible.

Duvall showcased a CHP project on Amelia Island in northeastern Florida. It serves Rayonier Advanced Materials a supplier of cellulose specialty products. Company expansion called for more steam for industrial processes.

Rayonier leased land to Eight Flags Energy (a subsidiary of Chesapeake Utilities) for the establishment of a CHP plant. Rayonier gains 20-year access to low-cost steam. It receives steam at 160 psi and 420°F. Eight Flags supplies electricity to Florida Public Utility (FPU, part of Chesapeake) to meet about half of Amelia Island's electricity requirements.

The guts of the CHP system include a 20 MW Titan 250 GT from Solar Turbines and a Rentech HRSG. The facility considered running the GT in simple cycle mode, but that would have given it too low an efficiency to make the project economics work.

Adding an HRSG for combined cycle operation changed the equation. The HRSG recovers around 70,000 pounds of steam per hour and has the capability to increase that amount using Rentech duct burners to 125,000 pounds per hour of process steam.

De-mineralized water provided by Rayonier is channeled through a hot water economizer in the HRSG to increase the water temperature by 70°F. This hot water is sent back to Rayonier for use in production processes.

Eight Flags has a capacity factor of 95%. This 22 MW CHP plant has lowered electric costs by 10%, while lowering NOx by 80% and CO_2 by 38%.

"Rayonier receives steam and power, which it needed for expand," said Duvall. "We built it on an elevated coastal site to be above any storm surge."

CUSTOMIZED LUBRICATION

ExxonMobil advises those running small or mid-sized turbines to take care when selecting lubricants. The decision should be based on the application environment and a thorough oil analysis.

Smaller turbines typically use gearboxes that run at a higher speed. However, their efficiency is lower than larger frame machines, which generally do not have gearboxes. For smaller machines, the choice of lubricant is important.

Mike Galloway, Equipment Builder Engineer at ExxonMobil, said the oil type should be tailored to the load. For the 6F, he recommended the Mobil DTE832 or 932GT meeting GE's required GEK 101941 specification.

"6F turbines run hot and need a thermally stable oil that is oxidation and varnish resistant," said Galloway. "If poor quality oils are used, varnish can quickly build up, and that can eventually lead to a trip."

COT-Puritech (a Circor company) also offers value-added service to turbine owners. Christopher Tomerlin, Director of Global Accounts at COT-Puritech, said his company can be called in to flush out the entire lubrication system.

An analysis is done to determine the chemical mix required. To remove varnish, a high-velocity flush is often needed, followed by a purge to get rid of any chemical residues.

"We sample the oil and conduct extensive tests," said Tomerlin. "This helps determine which process is best for cleaning. For example, a varnish flush might consist of 24 to 48 hours of circulating the chemicals to remove the varnish. Once completed, the system is drained and then purged to extract all the chemistry. After that, the new oil can be introduced.

This Rayonier plant receives power from a nearby CHP plant powered by a Titan 250 GT from Solar Turbines and a Rentech HRSG

The plant paid nothing for the power and steam plant. As it did not need any additional power, the utility sells electricity to other customers. But the plant would not have been possible without the tight partnership between the local grid authority, the utility, and the industrial customer. Plans are ongoing to open a second CHP plant on the island, said Duvall.

Ford goes CHP

Ford Motor Co., with DTE Energy, is building a 34 MW CHP plant at its site in Dearborn, Michigan. The Central Energy Plant, inclusive of the CHP plant, at the Dearborn Campus entails a $300 million investment.

The plant will be owned by DTE Electric, the regulated arm of DTE Energy, and constructed and operated by DTE Energy Services, a non-regulated arm of DTE Energy.

Michael Larson, Director Business Development, DTE Energy Services, said that the plant encompasses several components: 16,000-ton chiller system using mechanical and heat pump chillers; 40,000-ton/hr thermal energy storage; 6,400-ton geothermal system; 156 MMBtu/hr hot water supply system; two 14.5 MW GTs from Solar Turbines; 5 MW steam turbine from Siemens; and 370,000 lb/hr of heat recovery steam generators from Rentech Boiler Systems.

"Over the next 10 years, the steam load will sink and the electric load at the campus will rise while both will continue to have seasonal variations," said Larson.

That made sizing of the CHP plant more complicated than usual. Ford initially looked at a smaller CHP plant. But that would only provide power for its own need and might not satisfy fluctuating steam and electricity requirements.

In addition, project economics demanded a larger facility that generated enough electricity to sell to external customers. Ford will purchase power and steam from DTE Electric. Construction of the facility is scheduled to be completed by the end of 2019. ■

HYDROGEN TURBINES AND OTHER ALTERNATE FUELS

Hydrogen-fueled gas turbines continue to be an active area of research and development (*Turbomachinery International* Sept/Oct 2018). Hydrogen has the potential to be a greener and cleaner fuel source for GTs, said Elena McKenzie, Market Analyst at Ansaldo Energia's PSM division. Faced with the rapid growth of renewables, declining revenue, rising O&M costs, and the demand for cleaner generation, all OEMs are looking at how to further reduce emissions.

One approach is to mix hydrogen with natural gas. As well as lowering emissions, McKenzie touted the use of excess renewable capacity used to generate hydrogen through hydrolysis and then feeding that hydrogen into the combustion process. To meet modern power generation needs, though, all-hydrogen GTs would have to be supported by vast fields of renewable assets and colossal storage facilities.

Ansaldo Energia is currently testing a turbine running on 70% hydrogen. Combining hydrogen with natural gas has several benefits. Some 25% hydrogen offers 9% fuel savings, and a 9% reduction in CO_2. Far from being theoretical, a Frame 9E is running in the Netherlands with 25% hydrogen.

"As you add hydrogen, the speed of chemical reaction in the combustor changes," said McKenzie. "Inert gases, such as nitrogen, tend to reduce the speed of reaction; the flame shifts farther downstream, and you have greater risk of flame outs."

Hydrogen challenges

More tuning is needed, too, as the hydrogen content rises. PSM has devised an autotune solution to avoid combustor problems and optimize operations.

Most OEMs have an ongoing hydrogen initiative. "The challenge is to keep the flame stable, avoid flashback and at the same time keep emissions down," said Asa Lyckstrom, Commercial Manager Product Positioning at Siemens Medium GT Fleet. As hydrogen ignites and burns ten times faster than natural gas, the flame forms closer to the injector and has a wider flammable region than a fuel/air mix. However, only a fraction of the ignition energy is needed to get H_2 going compared to methane.

Siemens has designed a 3D-printed DLE burner to keep NOx levels down despite rapid burning. It can be used with hydrogen in the Siemens SGT-600, SGT-700, and SGT-800. Inside the 57 MW SGT-800, 30 of these burners operate within the annular combustor. Siemens is also testing a burner running 100% hydrogen. It is confident that it can run the SGT-800 with 50% hydrogen by volume while keeping NOx below 25 ppm.

The Siemens SGT-A65 (formerly the Industrial Trent) can burn 100% hydrogen using a Wet Low Emissions (WLE) burner that keeps NOx at 25 ppm. It is a three-shaft, axial-flow, aeroderivative GT that produces 60 MW to 71 MW depending on its configuration and is suitable for flexible peaking and combined cycle applications.

More than 115 SGT-A65 machines have been manufactured and installed around the world. Some units have also been installed in mechanical load drive duty for gas boosting in Qatar. In mechanical drive applications, its three-independent-shaft design is suited to the higher power, variable-speed demands of applications such as natural gas liquefaction, gas transportation and gas induction for oil recovery.

Continued 22

The SGT-A65 includes a two-stage low pressure (LP) compressor with variable inlet guide vanes (VIGVs). It has a high overall pressure ratio and high thermal efficiency. In addition, the LP compressor boosts the airflow so that the power level is attained at a firing temperature sufficiently low to meet severe NOx requirements. Yet it is sufficiently high to give good cycle efficiency.

The intermediate-pressure (IP) compressor has eight stages and three rows of variable stators. The high-pressure compressor has six stages, with no variable stators. Overall pressure ratio is 34.1:1 for the 50 Hz dry low emissions (DLE) configuration.

Further, the SGT-A65 incorporates a series of staged pre-mix, lean-burn combustion cans that allow the GT to achieve low NOx and CO simultaneously. Eight combustors are incorporated into a single module.

The SGT-A65 has a five-stage LP turbine, a single-stage IP turbine, and a single-stage HP turbine. Each of these turbines drives its own compressor. The SGT-A65 LP Stages 4 and 5 have a larger gas path area and a lower exit Mach number than the Trent aero version.

A Siemens or Allen-Bradley control system provides integrated operation of multiple control functions while offering remote monitoring. The control system is designed for easy site installation by using remote I/O technology to decrease the number of interconnect cables between the unit control panel and the equipment skids. All train control systems are accessed by a Human Machine Interface (HMI) in the main control room.

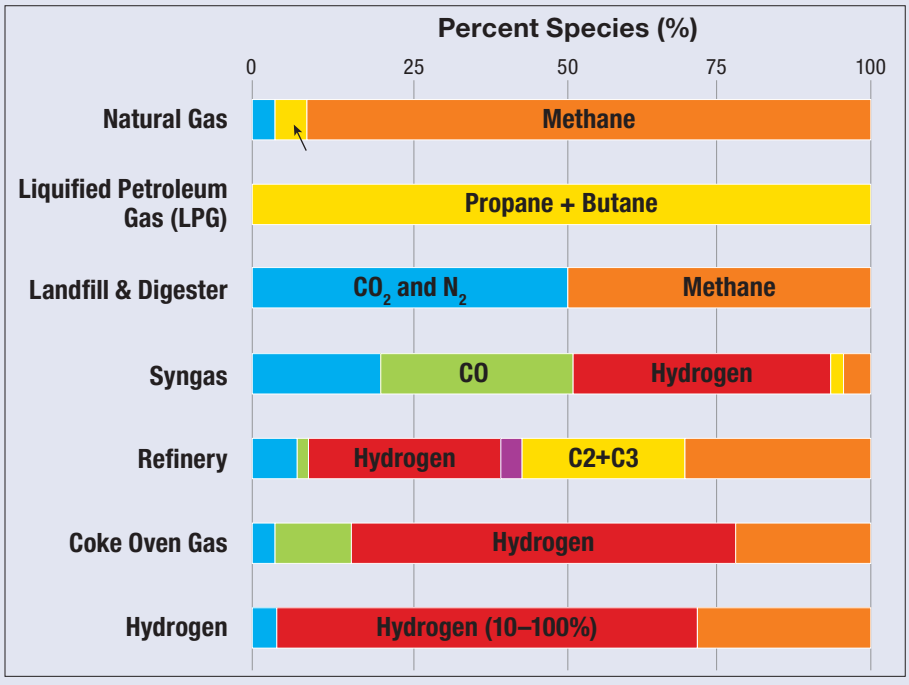
Alternate fuels

GTs can burn a great many fuels including biodiesel, lean methane, hydrogen, liquefied petroleum gas (LPG), propane, and more.

"Gas turbines are flexible by nature and we are seeing many requests for them to burn all kinds of fuel," said Jeffrey Goldmeer, Director of GT Combustion and Fuel Solutions at GE.

Biodiesel, for example, is experiencing a resurgence in Asia. Indonesia has mandated a blend of palm oil for power generation known as B20 (20% palm oil mixed with diesel). These fuels can be used by GTs.

Gas constituents and contaminants can vary widely depending on the source, said Goldmeer. Biodiesel typically has lower SOx emissions than heavy fuel oil, but its sodium content can be changeable. Sources include soybean oil, animal and vegetable waste, and canola oil.



The composition of fuels used in gas turbines varies considerably

Another alternative fuel of interest is LPG. However, one challenge is the lack of a universal definition: the propane and butane content can change markedly depending on geography or the season or the source wells. The scale of domestic supply logistics may limit build out in some countries.

GE has been running turbines with medium BTU gas, lean methane and fuels high in N_2, CO_2 or H_2S. In regions with limited access to LNG, such fuels may be all that is available. Goldmeer said GE has over 1 million running hours on its GTs on these fuels.

However, he questioned the viability of what is known as green hydrogen: it is produced through the electrolysis of water and powered by solar generation. In his view, it is unrealistic due to the sheer quantity of water needed for electrolysis. Despite that, he entertained the possibility that LNG could be replaced by hydrogen power by 2050.

"But full decarbonization could double the cost of electricity," said Goldmeer.

GE's advanced pre-mixer is available for high hydrogen applications. It can deal with up to 50% of H_2 by volume. Existing GTs can be upgraded to accommodate this change in fuel. But the rest of the plant may also have to be upgraded: ventilation, enclosures, safety procedures, and more. Heat Recovery Steam Generators (HRSGs) may have to be adjusted to deal with the presence of far more moisture.

"The more hydrogen you add into the fuel mix, the higher the moisture content," said Goldmeer. "This also impacts heat transfer in the hot gas path, and HRSG operation."

GE is putting renewed vigor behind its 6F machine in the medium-sized turbine market. With combined cycle plants owning 68% of the market and growing, GE is focusing the 6F in that niche.

"Given broad market dynamics such as the increasing penetration of renewables, the greater flexibility of combined cycle plants, and its high efficiency, the 6F has the right footprint," said Aileen Barton, 6F.03 Senior Product Manager for Medium-Sized GTs at GE.

The GE 6F.03 provides 68 MW to 87 MW and offers 57% efficiency in combined cycle mode. It has 32,000-hour combustion and hot gas path inspection intervals. All versions of the turbine can run on gases and liquids, and additional fuels are added with each technology advancement. This includes natural gas, LNG, lean methane, LPG, H2 blends, sour gas, light distillate, oil, naphtha, and light crude oils.

The 6F.03 AGP (Advanced Gas path) upgrade includes the DLN 2.6+ combustor, as well as improved materials, coatings and cooling. Better metal seals reduce leakage and tighter clearances are achieved with abradable coatings. GE is also promoting a way to upgrade a 6B or 6E machine to the 6F. This leads to a 3% efficiency gain and major fuel savings, said Barton. ■

GAS TURBINE COMMISSIONING

MINOR OVERSIGHTS CAN BE COSTLY WITH A SMALL GAS TURBINE

BY SARMA KRISHNAMOORTHY

Commissioning of a gas turbine (GT) is often done against a rigid timeline. Even experienced engineers might miss certain details if they are engrossed in achieving project milestones. Despite this, steps should be put in place to maintain the integrity of the process.

Take the commissioning of Solar Turbine model Taurus 70 GTs installed in a high-pressure, high-temperature (HPHT) gas processing offshore platform situated offshore. Units A and B were duel-fuel with auto fuel changeover. Each had a rated capacity of 7 MW but provided 5.5 MW due to site conditions. Turbine exhaust was channelled to a waste heat recovery unit (WHRU) to heat a thermal fluid used for process heating.

A function check

An onsite technician began commissioning procedures with the powering up of panels, a function check of balance of plant (BOP) components, a logic command and sequence check, and a sensor and actuator health check. Various problems were detected and located, such as the replacement of a faulty battery charger card, and the addition of a generator protection fuse in the alarm control board.

The liquid inlet line, air line and igniters were opened, and the units were dry cranked for five minutes to drive out dust or metal particles. The liquid fuel pump Variable Frequency Drive (VFD) panel HMI was configured, and the fire-suppression-system control heads were connected and made ready for start-up.

An attempt to start Unit A resulted in failure. Repeated start attempts confirmed that a signal was not reaching the VFD control panel. Two control wires were found to not have positive contact. These wires were tightened. Another attempted start-up led to the discovery of diesel leakage near the spark plug housing. A gasket was replaced and tightened.

In a subsequent start attempt, the unit achieved full power. During this test run, the doors of the enclosure were kept open to physically check and ensure no liquid fuel was leaking. Two more leakage sources were detected near the spark plug, which were handled.

Control wires must be checked for tightness and all hardware of the hot side should be re-torqued.

Another test run of the unit ensured readiness for operation in liquid-fuel mode. The unit operated for about 15 minutes at full power. All major operating parameters (vibration, temperatures, and so forth) were well within limits.

About five minutes into a normal shut down, a mild boom was heard. An emergency shut off was carried out. Enclosure alarms indicated a fire in the enclosure. The CO_2 suppression system had been in operation.

This confirmed an abnormal rise in temperature inside the enclosure. Subsequent inspection confirmed that a UV sensor inside the enclosure had been actuated. Fumes were spotted emanating from a burst portion of insulation mattress around the turbine portion flange joint.

Technicians made a short crank check of the unit to confirm there was no indication of rotor jamming and that the unit was mechanically healthy. The insulation mattress around the flange joint was opened to visually check hardware for any tell-tale leakage indications.

Dark brown patches were seen in the inside surface of the insulation mattress at the location where fumes emanated after the incident. This indicated trapped liquid fuel had burned outside the turbine flange joint actuating the fire-suppression system.

A further effort to start and load Unit A tripped on "ignition fail." Troubleshooting indicated the igniter needed to be replaced, but no spare was available. Work was transferred to the commissioning of Unit B.

It took months for the needed components to arrive. Gas production levels were constrained because a standby unit was not available.

Lessons learned

Thermal expansion that happens during factory tests and tests at the platform build-up yard can cause slight looseness in the hardware. Therefore, control wires must be checked for tightness and all hardware of the hot side should be re-torqued.

In this case, the turbine flange joint covered with the insulation mattress, did not have its tightness checked by the commissioning engineer. ■

Sarma Krishnamoorthy is in an Independent Consultant based in India.

A MORE OPTIMISTIC POWERGEN

NEW OPPORTUNITIES ARISE IN THE FACE OF GROWING CHALLENGES

BY DREW ROBB

PowerGen International offers an annual barometer of the power generation sector. The December 2018 event noted the many challenges the industry faces: the influx of renewables, an aging power grid, price volatility and changing regulations, to name a few. Yet the overall impression was one of optimism.

Organizations, such as Orlando Utilities Commission, ABB, MHPS, Emersion Power & Water and GE Gas Power, provided the view from the executive suite. Topics included digital transformation, the evolution of the grid, interaction with a new workforce generation, the rapidity of change, and how the industry can adapt. Overall, they presented a positive view of the future.

Keynotes

Teresa Hansen, Global Content Director, Clarion Events, MC'd the keynotes. She said 2018 had been a transformative year for power generation. As well as the struggle to stay competitive, renewable and small distributed energy installations are increasing steadily.

"Despite this, conventional thermal plants and combustion turbines will continue to supply most of the developed world's electricity for many years to come," said Hansen.

Orlando Utilities Commission President Gregory Lee described how his organization was adjusting to change. Its Stanton Energy Center, for example, has incorporated solar, natural gas, landfill gas and coal in one location. The city balances three factors: reliability, affordability and sustainability. By 2050, Orlando plans to be powered 100% by renewables, he said. "Power generation in 10 years will look vastly different from what it did a decade ago."

Digital transformation was the theme of Robert Yeager's keynote. The President of Emerson's Power & Water Solutions business began by showcasing his company's Ovation automation system that boasts 1.3 million MW of coverage worldwide.

"Digitization will eliminate human error, make it possible to innovate without fear, bring about effective knowledge transfer to retain and attract top talent," said Yaeger. "The new generation of workers grew up with digital technology that they expect to find in their workplace. They want a digital plant, and many facilities have already started to implement digital elements to stay competitive."

Digital twin

He urged attendees to adopt digital-twin technology. Rather than trying to innovate while a plant is online, the digital twin enables management to model potential changes, view the results and make any necessary changes to avoid risk.

These twins can be composed of as much as 10 million lines of software code. As they are automatically updated, they provide real-time synchronization of the entire power plant and its controls with the digital world.

"You can see if the changes you'd like

to make would de-rate or trip your plant without risking real downtime," said Yaeger. "It's a great way to avoid problems in the future."

A whole lot of software and IT changes are coming soon to the operational technology (OT) world of power generation: The cloud, augmented/virtual reality, artificial intelligence (AI), machine learning, blockchain, modern networking and edge computing. As such, power producers will need to find the right technology partners to help successfully implement them. But with all plants networked, a fix in one plant can be quickly exported to all plants.

ABB, for example, has embarked on a technology partnership to marry IT with OT. It collaborates with Microsoft and HP Enterprises to incorporate cloud and edge computing into its ABB Ability digital distributed control system (DCS) architecture.

"Digital solutions must be able to demonstrate tangible results that can scale across the enterprise," said Greg Scheu, President, Americas Region, ABB. An integrated approach to digitization must encompass everything: from sensors and controls to security to the health of all assets.

He also covered preparation for the new workforce. By 2025, some 75% of personnel will be millennials with digital competence and knowledge, he said. Quite different from that of today.

ABB is working with partners in education to lay out career paths for industry jobs, such as lineman and plant operators. Instead of getting a degree or other skill and then showing up to work without any experience or practical know-how, they need the right training and programs to fit them for workplace.

Second-day keynotes

Todd Buchholz, former White House economic policy director and economist, highlighted the "scissors economy" where the middleman gets taken out of the equation: transportation (Uber), hospitality (Airbnb), and even energy, where direct buying, microgrids and distributed generation challenge the role of the modern utility.

"Utilities and power generators need to adapt and evolve," said Buchholz. "You must be more flexible, not just running turbines or plants, but involved in the last mile, as well."

Scott Strazik, the new CEO of GE Gas Power (combining equipment and services for GTs under one entity), said that 700 GW of coal and nuclear power will be retired over the next two decades. He believes natural gas is needed to provide grid resilience to support renewables.

"Renewables may be growing faster, but there is a lot of opportunity for natural gas," said Strazik. "Gas is dispatchable, flexibly, low density and affordable."

He noted that CO_2 reductions hit their peak at 27% and have been trending downwards since. During that period, coal had dropped from 50% to 30% of the generation mix. In the same period, natural gas rose from 19% to 34%. Two-thirds of the reduction in CO_2 has resulted from the coal-to-gas switch and one-third from renewables, he said.

Another opportunity for gas is in liquefaction capacity. Currently, there is 369 MTPA of LNG capacity with another 92 MTPA under construction, and 875 MTPA proposed (half of which is in North America).

LNG markets are growing. Taiwan has decided to eliminate nuclear by 2025 and reduce coal to 30%. That opens the door for 13 GW of new natural gas combined cycle power plants.

- Bangladesh is adding 43 GWs of gas by 2041.
- Brazil may add 12 GW of gas by 2030
- North America will add 30 GW to 40 GWs of gas in the next five years.

Continued on 26

PowerGen keynotes struck an optimistic tone about the future for the power industry

This is showing up in a spurt of orders. GE has 30 of its HA turbines running with 220,000 operating hours to date. Its orders total 83 of which many are due online in the next year or two. The company is also pushing upgrades, of the GE fleet or cross-fleets. These typically involve GE's Advance Gas Path (AGP) or its DLN 2.6+ combustor.

"We can now turn down a 7F turbine from 40% to 26%, which lowers NOx and CO, as well as fuel burn down to 25%, and greater opportunity for energy trading via ancillary services," said Strazik.

Cross-fleet upgrades are on offer for machines, such as the MHPS 501F, the SGT6-5000F and the SGT-800. For example, at a Naturgy plant in Tuxpan, Mexico, 501Fs, steam turbines and generators were upgraded with the AGP to extend the maintenance interval to 32,000 hours, increase output by 9.2% and efficiency by 2.9%.

"We operate in a complicated and interesting power market, but gas will play a role in a cleaner energy future," said Strazik. "As gas requires 50-to-100 times less space per MWH than renewables, the world's many mega-cities will look to gas for their power."

MHPS takes lead

Mitsubishi Hitachi Power Systems (MHPS) CEO, Paul Browning, said that 2018 will be the first year where its GTs will earn the top spot in terms of megawatt orders. Browning estimates MHPS market share of around 35% for 2018. He puts this down to the transition from F-class to advanced class gas turbines, with MHPS having a head start on those machines over its rivals.

"We feel strongly that the power generation market will be dominated by natural gas, renewables and energy storage," said Browning.

MHPS is adding renewables and battery storage to its portfolio, and it will act as a technology integrator and project developer. MHPS will begin its solar initiative in the Northeast U.S. The company has already created a development team in that area. The focus will be on offices, industrial and commercial, rather than utility-scale solar.

The company is also a developer for natural gas projects. Many Independent Power Producers (IPPs) have land and existing relationships for transmission. But they lack resources to either upgrade or expand their facilities. "As a partner we can help with finance and technology," said Browning.

As an example, he cited a project MHPS developed in Brazil. The company arranged a 25-year gas contract with Shell, a 25-year power purchase agreement (PPA), and an investor. The project is moving forward using the MHPS JAC Gas Turbine and an MHPS Heat Recovery Steam Generator (HRSG).

The company recently announced the introduction of its 275 MW SmartER GAC (the M501GAC) turbine to compete against existing F-class peakers. It is an integration of MHPS's G-Series turbine and MHPS-TOMONI analytics and AI.

It enables a 10-minute start, 50 MW/min ramp rate, 9 PPM NOx emissions, and an output of 275 MW. The higher output and operational flexibility is said to exceed the F units. MHPS announced its first order for this turbine from a Midwest utility and expects to announce other new orders for this technology in the near future.

"We plan to convert F-class peakers into GAC peakers," said Browning.

Regaining the lead

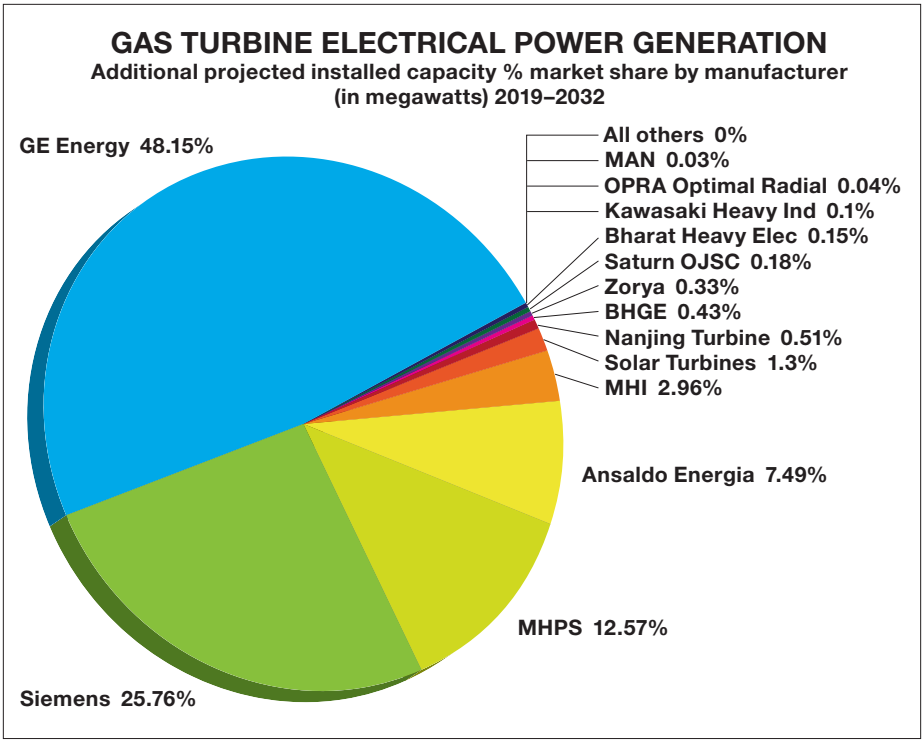
MHPS may have the megawatt lead for 2018, but the big question is whether it can solidify its position moving ahead. According to Forecast International, GE is likely to install nearly half the total electrical power generating capacity to be added over the period 2019–2032. When licensees and subsidiaries are included, GE Energy is projected to deliver 49.34% of capacity installed during this period. Siemens will follow with 25.76%, while MHPS will contribute 15.53% (Figure).

"The strength of GE Energy in the power generation market is the result of a deliberate drive by the company to maximize its market penetration at a time when reduced demand, overcapacity, and soft prices look set to continue until at least the early 2020s," said Stuart Slade, Industrial Gas Turbines Senior Analyst at Forecast International. "This strategy brought with it significant risks that were picked up by stock market analysts to reflect concern about the company's performance."

GE is partnering with Tampa Electric (TECO) to modernize Big Bend Power Station in Hillsborough County, FL using 7HA GTs and an upgrade to its steam turbine island. Similarly, IPP Chiahui Corp.is going to use the 7HA.O2 as part of a power-expansion project at Chiahui Power Plant in Chiayi Province, Taiwan. GE customers, such as Invenergy's Lackawanna Energy Center in Jessup, PA and Aluminium Bahrain (Alba)'s Unit 1 at Power Station 5 in Bahrain achieved first fire status for their HA units.

Siemens

In the past few months, Siemens has unleashed an avalanche of new orders, con-



tracts and upgrade projects. It received an order for SGT-800 GTs in Panama earlier this year, along with a long-term service and maintenance agreement for the plant.

IPP Sinolam Smarter Energy (SSE) is the end user. The deal encompasses six SGT-800 units, an SST-600 industrial ST, and electrical generators. The plant will operate with liquefied natural gas (LNG). Commissioning for the power block is expected in the fall of 2020.

Siemens received another order from Lansing Board of Water & Light (BWL) to supply three SGT-800 GTs and generators for its new gas-fired generating station in Lansing, MI. It will feature three SGT-800s, two operating in combined cycle and one simple cycle, capable of producing 250 MW. Siemens will also supply its SPPA-T3000 digital control system.

Siemens is building a new energy service and training center in Bolivia to provide education on traditional and digital services. It will also function as a hub for servicing power equipment installed in the South America region. At the same time, Siemens is upgrading three CCPPs in Bolivia: Termoeléctrica del Sur, Termoeléctrica de Warnes, and Termoeléctrica Entre Ríos.

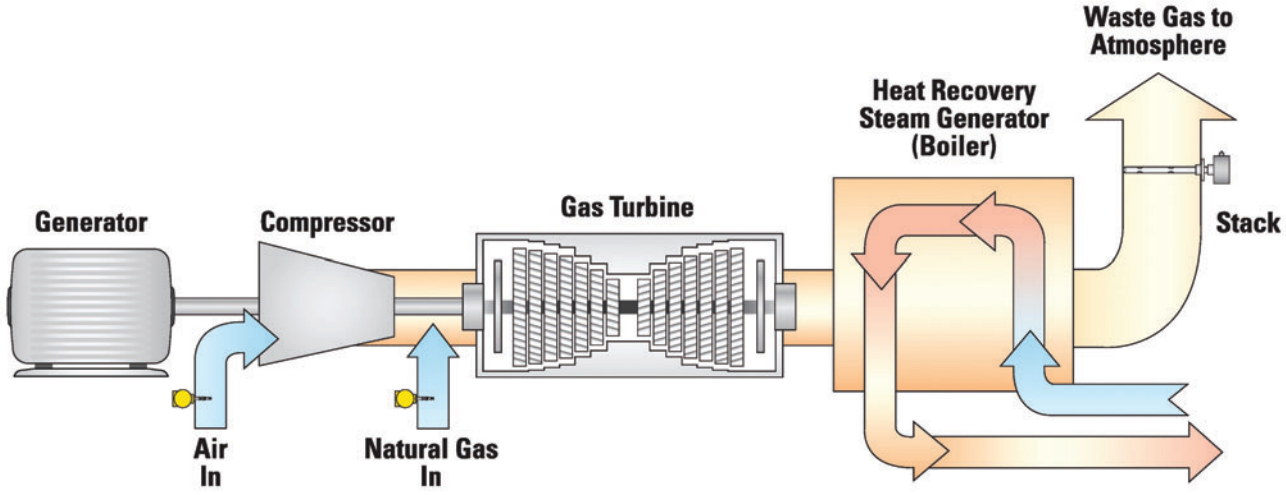
Doosan, meanwhile, showcased the Doosan DGT6-300H series gas turbine.

Now undergoing a battery of tests before being released to the market, it features an Advanced DLE combustor, new coatings and cooling systems, a 13-stage compressor, a flutter-free airfoil design, and over 3500 sensors inside. It will provide 270 MW in simple cycle and 400 MW in combined cycle. ■

AIR AND GAS FLOW MEASUREMENT

HOW TO CHOOSE THE BEST TECHNOLOGY FOR YOUR TURBOMACHINERY APPLICATIONS

BY ART WOMACK



The accurate, repeatable flow measurement of air and gases is critical to the safe, efficient and cost-effective operation of turbomachinery. There are at least nine common industrial flow measurement technologies available today. All have their strengths and weaknesses. Understanding these flow sensing technologies prevents costly mistakes.

Flow meters often measure both the fluid flow rate and total flow. Given the operating environment of electric power plants and oil & gas refineries, flow meters generally require hazardous area approvals and often must be IEC 61508/61511 (SIL) compliant as part of a Safety Instrumented System (SIS). The most common turbomachinery flow measurement applications involve turbines and compressors.

Accurate and consistent air and gas flow measurement over a wide turndown range is particularly important in the electric power industry for steam driven turbine systems, including combined cycle gas turbines (CCGT), combined heat and power (CHP), and co-generation systems using waste gases.

Repeatable measurement of the air-to-gas fuel mixture supports efficient boiler operations to generate steam as needed. Monitoring of the mass flow rate of hydrogen in cooling systems allows early detection of leaks to minimize environmental impact. The ability to operate over a wide turndown range is important to support variable power demand.

Similarly, the operation of these compressor stations requires accurate natural gas flow measurement from the pipeline. Monitoring the health of dry gas seals, which serve as a back-up leakage system to prevent the gas from accidentally leaking into the atmosphere, can also reduce operational costs.

Challenges

Gas flow measurement in turbomachinery applications can present many technical challenges. Sensitivity to low-flow conditions is required to identify and measure gas leaks that deviate from the normal low-flow condition in day-to-day operations.

Process upset conditions may cause high flows, requiring a meter capable of measuring flow accurately over a wide turndown range.

Many gas turbine and compressor applications require flow meter calibrations specific to the particular hydrocarbon composition in the gas. Matching the flow meter's calibration to actual process conditions with actual gas mixtures is essential.

In some applications, gas mixture variations periodically occur and require multiple calibration groups that can be called upon for improved repeatability.

Two methods are used in calibrating air and gas flow meters:

- The direct method, where the meter is calibrated to a specific pure process gas and/or to the actual components of a mixed gas
- The air equivalency method, where the meter is calibrated using air, and then the calibration is adjusted with a pre-defined correction factor.

Flow meter accuracy is improved when calibrations use actual gas mixtures and process conditions that best represent field conditions. Air equivalencies can be given consideration when there is sufficient data to support its use or it is unsafe to use the actual process media.

As pipe sizes increase, the number of effective flow meter technologies decreases. Few are capable of accurate measurement in air and gas lines supporting large turbomachinery equipment and processes. Single point measurements will introduce greater inaccuracies as line sizes increase.

All velocity-based flow meter technol-

ogies have straight-run pipe requirements upstream and downstream from the meter to achieve accurate flow measurement. These straight-run requirements may not be available in crowded production sites and process plants, especially when larger lines are involved.

Access, too, has to be considered. Access to piping for installation, maintenance or servicing is often difficult. For example, spool-piece (inline) flow meters can require prolonged process shut-downs and extensive on-site labor costs to install and continuously maintain the system.

Insertion style meters, on the other hand, can be easily inserted into or retracted out of the process through a single isolation ball valve.

When installing meters in hazardous locations, the entire flow metering instrument should carry agency approvals that demonstrate suitability for installation in environments with potentially explosive gases; enclosure-only ratings are inadequate. Acceptable approvals can vary globally and may further limit your options.

Measurement technologies

The fluid being measured typically determines the type of measurement — volumetric or mass flow. Liquids are primarily measured in terms of volumetric flow, while mass flow measurement is often preferred for air and gas because of the properties and compressibility of gases.

While some volumetric technologies can measure air and gas flow rates, there can be limitations in the measurement of total flow.

Coriolis

The principle of operation for Coriolis flow meters relies on a vibrating tube where the flow of a fluid causes changes in frequency, phase shift or amplitude proportional to the mass flow rate.

Coriolis meters are accurate and frequently used in custody-transfer applications. But they can be expensive, especially in larger line sizes, and often require bypass piping systems to accommodate field maintenance.

Differential Pressure (DP)

DP transmitters are often paired with primary flow elements such as orifice plates, averaging pitot tubes and Venturis. The typical DP meter design requires the fluid to move through or past two points of reference, creating a differential pressure rate equivalent to the rate of flow using the Bernoulli equation with some modifications.

If the fluid is dirty, orifice, impulse tubing and manifold blockage can occur that requires maintenance to maintain accuracy. Turndown capability can be limited if a single transmitter is used.

Ultrasonic

Meters designed with ultrasonic flow sensing technology rely on ultrasound and the Doppler Effect to measure volumetric flow rate. A transducer emits a beam of ultrasound to a receiving transducer.

The transmitted frequency is altered linearly by particles or bubbles in the fluid stream. The shift in frequencies between the transmitter and receiver can be used to generate a signal proportional to the flow rate.

Optical

Flow meters designed with optical sensing rely on laser technology and photo detectors. They require the presence of particles in the gas stream to scatter the light beam. The time it takes for these particles to travel from one laser beam to the other laser beam can be used to calculate the gas velocity and volumetric flow rate. These meters have good accuracy, and wide turndown but can be expensive.

Thermal Dispersion

Flow meters with thermal dispersion sensors provide direct mass flow measurement. Two thermowell protected platinum resistance temperature sensors (RTD) are placed in the process stream.

One RTD is heated while the other RTD senses the actual process temperature. The temperature difference between these sensors generates a voltage output proportional to the media cooling affect and can be used to measure the gas mass flow rate without the need for additional pressure or temperature transmitters.

Installation

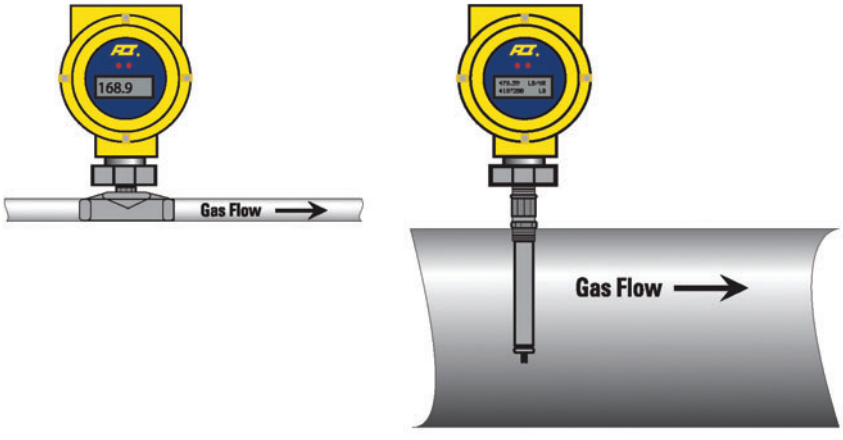
When choosing a technology, another concern is the intended meter location and the manufacturer's installation requirements. Most flow meter technologies require a stable flow velocity profile upstream and downstream from the point of meter installation; a specific number of pipe diameters in each direction.

Flow sensors are potentially sensitive to swirling conditions and velocity profile distortions created by obstructions before and after the metering point.

Irregular flow profiles can be addressed with flow conditioners. There are various types of flow conditioners that can be inserted strategically in the pipe to straighten the flow before it reaches the flow sensor.

They consist of tabs, perforations, tube bundles, vanes or other designs, which all straighten the flow to some extent. Some straighteners, such as the tab type, actually speed up the rate of flow by creating vortices, also minimizing head loss (pressure drop).

Spool type flow meters are installed as a section of the process piping. Insertion flow meters are mounted through a tap point to the pipe section. Some flow meters can only be installed using one method. Coriolis meters must be installed inline (part of the piping). Thermal meters, some DP meters (orifice plates and averaging pitot tubes), and others can be installed in either inline or insertion configurations. ■



Inline versus insertion flow meter installations

Art Womack is Senior Applications Engineer at Fluid Components International (FCI), a company that designs and manufactures thermal mass flow meters, flow switches and level switches for industrial process measurement applications utilizing thermal dispersion flow measurement technologies. For more information, visit www.fluidcomponents.com.

DRY GAS SEALS IN OIL & GAS

RIGHT FOR SOME PROCESS GAS COMPRESSORS AND WRONG FOR OTHERS

BY CHRIS CARMODY & HEINZ P. BLOCH

It is not unusual to find large process gas machines still in service four or more decades after commissioning. Many continue to operate well with wet seals as originally specified.

However, dry gas seals (Figure 1) are prevalent in new installations. DGS support systems are less elaborate and less expensive than older systems that almost always use oil as a coolant or separating layer in the narrow clearance between stationary and rotating seal components.

Dry gas seals are mechanical face-type seals available as single, double and tandem models. On existing installations with wet (liquid) seals, the cost of the seal-oil-supply system had been part of the physical asset acquisition. The original seals and support systems merit replacing only if they are troublesome and if good experience references are available for dry gas seals in the same service.

These days, DGS are favored in most, although not all, applications due to several factors. Wet seals experience high-seal oil consumption. When new, this is about 5 gallons per day (gpd) per seal. After a year, oil consumption rises as high as 20 gpd. Even with lube-seal systems, at least 2 gpd are lost into the compressor on an average-sized machine. Contaminated lube oil may damage compressor bearings.

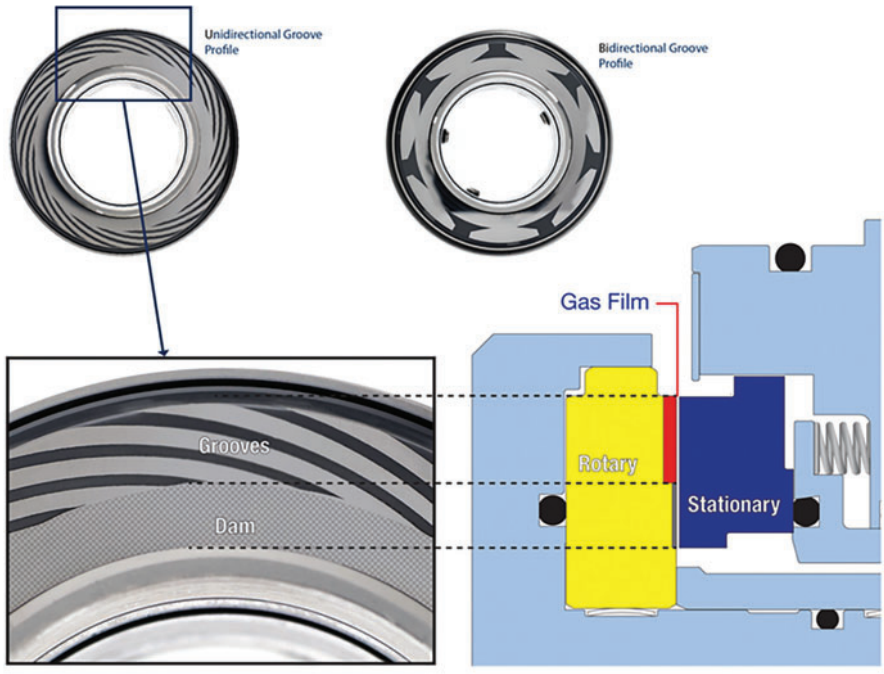


Figure 1: Generalized Dry Gas Seal (DGS) as used in process gas compressors

Wet seal systems

Wet seal systems require more operator attention due to the need for more physical inspection. Incremental energy requirements due to parasitic losses on wet seals are typically ~30 HP on 10,000 HP compressors. Adding seal oil pump energy demands (~35 HP) will increase the increment energy consumed to ~65 HP.

Hydraulic surges are a potential hazard on wet-seal systems, some more so than others. This can lead to seal-face damage and reduced component life. Manufacturers rarely mention this risk and seldom size the oil accumulators properly. Even then, bladder-type accumulators tend to become frequent maintenance items — partly due to internal gas leakage and elastomer failures.

Wet seal bushing life is about two to four years on average, although some wet bushing seals reach six years with well-designed late-generation components. Seal bushings wear due to microscopic abrasive particles that accumulate at the bushing seal edge and grind the shaft mechanically.

Experience points to the advisability of precautionary repairs on every second major maintenance intervention. At that time, the complete rotor must be removed to repair damaged shaft regions, even if the shaft is hardened (It should be noted that late-generation Isocarbon liquid film face seals do not have this problem).

With some wet seal systems, four pumps inspect and maintain on each compressor lube/seal oil skid; two are seal-oil pumps and two are lube-oil pumps. Significant gas leakage losses to flare from the sour seal oil traps should be considered.

Unless a flare gas recovery unit is available, or the gas is re-introduced at the compressor suction, gas losses can be as high as 30 times the equivalent dry gas seal loss. Up to 75 scfm per seal have been reported for a 10,000 hp compressor in average condition.

Instrumentation complications can also exist with wet seals because of the many control devices needed. The cost of instrument maintenance, too, can be high.

Troubleshooting oil seals, therefore, requires a qualified engineering or technical staff. Experience shows that seal oil system design, installation and maintenance problems are not always resolved. Constant vigilance is required. Dry gas seals, on the other hand, require lesser skills.

Contamination of the process gas path is frequent and can become a burdensome cost. On a per-compressor basis, the yearly reduction in efficiency of heat exchangers on a propane system can add $50,000 to $100,000 to operating expenses due to cooling losses.

For compressors equipped with bushing-type seals, no backup seal is available in case of power outage. Consequently, emergency power is required for safe operation or an immediate shutdown is required. Dry seals have a safer record in this regard due to the availability of secondary sealing.

The footprint needed by wet seal auxiliary systems is relatively large. The compressor skid for machines equipped with gas seal systems is physically smaller and less expensive.

Gas seals

Gas seals have many functional similarities with their predecessors that include variants of face, bushing and floating ring seals. Yet, there are also features that differ. The seal face of the rotating mating

ring can be divided into a grooved area at the high-pressure side and a dam-area at the low-pressure side.

The shallow grooves are often laser-etched, spark-eroded or chemically milled. A typical depth is ~0.0003 inch. T-shaped, V-shaped (bi-directional) and L-shaped (unidirectional) grooves have been produced; each configuration has its advantages and disadvantages. A stationary sliding ring is pressed axially against the mating ring by both spring forces and pressure exerted by the sealing gas.

The sealing gap is located between the mating ring and the sliding ring. For proper non-contacting operation these two rings must be separated by a gas film acting against the closing forces in the sealing gap. The gas film is achieved by the pumping action of the grooves and the throttling effect of the sealing dam. Groove geometry is critical for trouble-free operation of the seal.

The specification, review, purchasing and installation of a dry seal support system cannot be left to chance. A thorough review of the facility and the process unit may be the key to minimizing disappointments. Several factors should be considered when examining DGS support systems for centrifugal compressors:

Best available seal: Before opting for dry gas seals in retrofit situations, ask if the apparently flawed originally supplied liquid seals represent the best the vendor was able to offer. The claims of competing vendors and claims made for different styles of seals must be checked against actual experience. In some instances, these checks lead to the purchase of improved, late-generation liquid film face seals instead of dry gas seals. The areas of safety and reliability must always be given special consideration

Gas composition: Understanding the actual gas composition and true operating condition is often overlooked. It is also necessary to understand when and where phase changes start, and to ensure that condensing or condensed liquids are not allowed in the sealing gas

Control systems: Control system design must be understood. Is clean and dry buffer gas available at all anticipated compressor speeds? Is the seal protected from bearing oil? How is the compressor pressurized or de-pressurized? How is the machine brought up to operating speed and how will the seal react? Are all operating and maintenance personnel fully familiar with the compressor maintenance and operating manual? Is the full control system included and adequately described in the manuals or write-ups? Are the key elements of the system design understood and do they include buffer gas conditioning, heating, filtration, regulation (flow versus pressure) and monitoring?

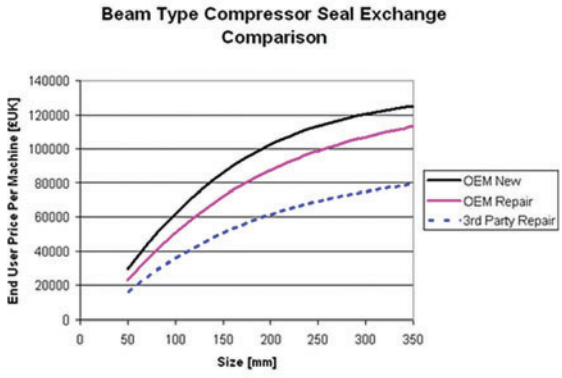


Figure 2: DGS repair cost versus nominal seal size (Courtesy of AESSEAL)

Safety and reliability

Positive sealing of the compressor during emergencies must always be assessed. In case the gas pressure in the compressor casing exceeds that of the seal oil pressure, shutdown pistons in face seal assemblies exert a force proportional to the gas pressure. This force keeps the seal faces closed and prevents gas release to the environment.

Dry gas seals may or may not provide positive gas sealing if the seal faces are damaged or distorted. The backup seal may show reasonable performance under low pressure but may fail to perform under higher pressure if the primary seal fails.

The alarm and shutdown devices of the seal oil system must be of reasonable range and sensitivity and provide reliable alarm and shutdown characteristics. Dry gas seal systems often rely on pressure switches of low range and high sensitivity. They might have the tendency to malfunction or give a false sense of security. Therefore, make sure the system will provide a sufficiently high degree of alarm and shutdown performance.

Some seal configurations excel at online monitoring. The favored seal must allow easy verification of a sound working condition. Beware of seal systems that are hampered by small diameter orifices that tend to plug. Also avoid sensitive pressure switches that can become inoperable.

As is the case with most other upgrade decisions, the user must go through a rigorous cost-justification analysis. In many cases, gas seals are a good choice only if an oil seal console will not be needed. If such a console already exists, it may be difficult to justify gas seals.

With hydrocarbon gas prices escalating, consider gas-leakage rates to justify a conversion to gas-lubricated seals. Not to be overlooked are advancements in traditional oil sealing technology for centrifugal compressors. Manufacturers are now marketing improved versions of the oil seals that were originally furnished with their compressors.

Along these lines, one researcher suggests studying the failure statistics of your oil type seals and comparing them with this: Current estimates of failure rates of gas seals are about 0.175 failures/year. That equates to a problem every six years or so. At least one dry gas seal manufacturer recommends maintenance intervals around gas seals on limits set by the elastomer aging process.

The following maintenance routine is recommended after 60 months of operation: Replace all elastomers, replace the springs, replace all seal faces and seats, and carry out static and dynamic testing on a test rig.

Informed choices

Here are some tips to help in making informed DGS choices: Consider gas seals only in conjunction with a clean gas supply. If your process gas causes fouling deposits, ask critical questions of anyone offering seals for that kind of gas.

If extensive micro-filtration is needed, factor in the cost of maintaining a dry gas seal support system. Look for seals that will survive a reasonable amount of compressor surging.

Consider dry gas seals that incorporate features ensuring start-up and acceleration to operating speed without allowing the two seal faces to make contact. Some manufacturers offer the option of repairing DGS systems from other OEMs (Figure 2). ■

Dr. Chris Carmody is Technical Products Manager at AESSEAL, a company that specializes in the design, manufacture and repair of mechanical seals and dry gas seals. For more information, visit www.aesseal.com

Heinz P. Bloch holds B.S. and M.S. degrees (cum laude) in Mechanical Engineering, is an ASME Life Fellow and was awarded life-time registration as a Professional Engineer in New Jersey. He has authored 20 books on practical machinery management.

LUBRICATION

OIL CONTAMINATION AND WEAR DEBRIS ANALYSES

BY AMIN ALMASI

Quick and frequent lubrication oil tests, particularly those related to contamination, are vital in maintaining the health of turbomachinery. In many cases, contamination can occur suddenly as the result of a malfunction or a developing problem. And oil contamination can quickly damage sensitive parts of these machines. Therefore, a fast response is essential.

Monitoring techniques for the detection of contaminants have advanced rapidly in past decades. Many methods can provide data on lube oil cleanliness and contamination level.

Online sensors are permanently installed in large-scale turbomachinery. Medium and small machines often rely on portable sensors and instrumentation. Two sets of sampling ports are typically identified as primary and secondary, used respectively for routine analysis and troubleshooting.

Ease of operation and application are important factors in the selection of monitoring instruments and contamination-detection methods. These are as vital as technical requirements. A moderate level of precision is often enough when coupled with the ability to rapidly and easily conduct regular analyses.

Wear debris analysis

Wear of sliding lubricated components results in debris discharged into the oil. Wear debris analysis, therefore, has proven useful in the monitoring of bearings, gear units and other turbomachinery systems. It can reveal true tribological conditions.

Monitoring techniques and other analysis methods should be used in combination. One method, used in isolation, can sometimes be misleading. False detection reports are common when people attempt to draw a premature conclusion from incomplete information.

Common technologies used for screening purposes include ferrous density analysis, elemental spectroscopy, particle counting and patch testing. Complementary monitoring and fault-detection methods include:

- Filter debris inspection
- Magnetic plug analysis
- Sump sediment analysis
- Ferrography
- Acid-dissolution spectroscopy
- Particle heat treatment
- Particle impaction testing
- Chemical microscopy
- Digital shape profiling
- Rotrode filter spectroscopy
- Gravimetric analysis
- Ultracentrifuge (separation of soluble metal fraction)
- Pore blockage particle counting

Reliance on only one of these methods may lead to damage going unnoticed or to misleading conclusions. However, when two, three or more trend lines show the same result, it is usually a reliable sign that could be used for further monitoring, investigation or even corrective action.

The cleanness of lubrication oil can strengthen the signal-to-noise ratio in a wear debris analysis. Without the background noise of dirty oil, weak signals can be detected.

Thus, correct positions should be selected for sampling points to identify particle or debris generating sources and potential locations for incipient problems. By sampling immediately downstream of a wear-generating source and upstream of filters or reservoirs, data is not stripped by filtration or muted by dilution.

The size and shape of particles is another important element in wear debris analysis. It is best to detect particles in their original size and shape close to their generating sources, such as bearings, gears and other particle generation points. Circulated particles produced long ago are not useful.

More than 50% of all failures and operational issues can be traced back to lube oil problems.

Wear mode

The identification of the wear mode and the location of a particle generation source is difficult for reworked and recirculated particles. Good places to find particles in their original form are in the sump sediment, magnetic plugs, chip collectors and filters.

Proper condition monitoring of lubrication oil in rotating machinery is rapidly becoming an accepted part of world-class operation, reliability and maintenance programs. It requires the examination of many parameters and factors, such as oil properties, contaminants, wear debris and more.

It is necessary to look carefully at many aspects to determine the condition and health of turbomachinery. As a rough indication, more than 50% of all failures and operational issues can be traced back to lubrication oil problems. ■

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.

SOLAR INVESTS IN THE FUTURE

Hans Drenth, Vice President of Oil & Gas, Solar Turbines, discusses Solar's product and service portfolio, ongoing trends, and how the company is addressing changing customer requirements.

Tell our readers about Solar Turbines

Solar Turbines is a manufacturer of industrial gas turbines (GTs), compressors and mechanical drive turbine packages. We provide custom energy solutions to the oil and natural gas industry, and power generation solutions for a range of commercial, renewable, institutional, industrial and electric power applications.

Solar has an installed base of more than 15,000 turbomachinery packages in more than 100 countries. Our gas compressors serve the upstream, midstream and downstream markets, and can be driven by either of our GTs or electric motors.

Explain your facilities and footprint

Solar has maintained its headquarters in San Diego, CA for more than 90 years. We also have sales and service locations in nearly 40 countries. For example, we have fabrication capabilities in Houston, TX and offer customized and standardized balance-of-plant (BOP) solutions, which includes single-lift modules for offshore applications as well as preconfigured modular buildings for compression or power generation applications.

What GTs do you offer?

Solar offers GTs in the 1-to-23 MW range (mechanical drive and generator set packages). Our turbines offer high thermal efficiency, low emissions, fuel flexibility, ease of transportation and installation, high performance, longevity, availability and reliability.

We also manufacture GT generator sets for combined heat and power (CHP), base load and distributed power, combined cycle, peak shaving, district heating and cooling, and mobile and standby power applications. They can burn gaseous and liquid fuels, such as natural gas, diesel, coke oven gas, digester gas, and landfill gas. They operate in a wide range of environments such as the Arctic, desert and deepwater offshore.

What compressor models do you offer?

We manufacture centrifugal compressors for applications, such as gas transmission, gas gathering, storage and withdrawal, gas injection, gas lift and LNG processing. They are API compliant and provide for ease of restage, allowing customers to adapt to changing field and process conditions without storing spare rotors.

What other products do you provide?

Solar Digital offers connected service programs to remotely monitor and manage fleets anywhere in real-time on any desktop or device. Our Insight Platform corresponds to the criticality and needs of each piece of machinery within a customer's fleet. InSight maximizes customer value by detecting adverse trends, increasing uptime and time between overhauls, and enhancing equipment reliability.

What trends have you observed in power generation?

As abundant gas supplies continue to be available, and as gas distribution systems expand, whether through pipeline networks or LNG, gas-to-power solutions will grow. In the utility sector, more distributed power solutions and micro grids are using renewables, GTs and energy storage. In industrial markets, CHP continues to grow.

What trends have you observed in the oil and natural gas industry?

There are growth opportunities around the world and particularly in North America as the commissioning of LNG export terminals will drive demand. Unconventional oil and gas development in the U.S. will require turbomachinery to drive compression and pipeline projects.

Technologies driving the growth of unconventional resource development are now emerging in international markets and therefore we anticipate these new markets developing rapidly. At the same time, we are working with customers to help them meet their sustainability targets and adapt to changing operating environments, such as in urban areas.

Our relationship with oil & gas customers is evolving from equipment supplier to energy solutions provider. We are playing a larger role in planning of site preparation, BOP equipment, and infrastructure development.

How about the aftermarket and services?

We offer total lifecycle support and an equipment health management system. We keep packages running for decades through remote monitoring and predictive diagnostics with the InSight Platform combined with field service. We also offer parts, overhauls, restages and technical training.

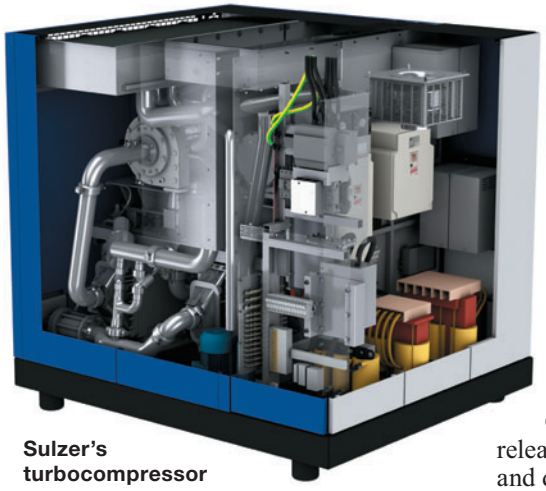
What trends have you observed in the aftermarket?

Our customers are facing competitive and challenging market conditions and are looking for solutions to optimize and reduce operating costs. We use our Insight Platform to increase equipment uptime and will incorporate more condition-based maintenance developments over time to ensure that the customer can benefit from reduced downtime and maximized time between overhaul.

We already have infrastructure in place for upgrades at outage, and are adding tools to assess condition, utilization and outage timing to better plan upgrade execution. With the latest computational fluid dynamics modeling tools and additive manufacturing capability, we can achieve efficiencies that were once considered the province of aeroderivative technology.

Anything you wish to add?

Compliance with environmental regulations and achieving sustainability targets drive our product design and development programs. Our GTs produce low-exhaust emissions that meet or exceed emission standards. We are working with customers to tailor equipment to their operating environments and meet their sustainability goals. One example of this is our development of systems that capture fugitive emissions from compressor dry gas seal vents. ■



Sulzer's turbocompressor

Sulzer HSR turbocompressor

The new HSR line of high-speed turbocompressors from Sulzer is designed for oil-free pressurized air in applications where contamination of the air must be avoided. The HSR uses magnetic bearing technology that maximizes the efficiency and minimizes the need for maintenance. HSR needs no oil. This means safe compressed air for processes where no contamination is allowed.

Active magnetic bearings (AMBs) bring the benefit of no mechanical friction and wear, and an almost total absence of vibration. Equipment of this kind maintains its efficiency without major overhaul for more than 20 years.

Thanks to the direct drive and magnetic bearings, there is no need for mechanical gears, bearings and seals. There is no oil or other liquid lubricant anywhere in the product. There are no wearing parts to be replaced, no oil to be refilled, and no consumables to be disposed of.

The HSR is cooled by water. The advantage is that both the heat generated by the compression and drive-related losses can be recovered as usable energy. Water cooling also ensures optimal performance and generally extends the lifetime of the components.

The two-stage or three-stage compression for maximum pressures of 4.5 and 9 bar (gauge), respectively, is done with turbo air ends, directly driven by a high-speed motor that uses permanent magnets. For reaching the necessary speed and for flow control, one or two variable frequency drives control the motor(s). The wide flow range can be extended by applying adjustable diffuser vanes. By using modulating blow-off valves, the flow can be adjusted between 0 and 100%.
Sulzer.com

Screw compressor

York Process Systems has released new high-pressure screw compressors for fuel gas boosting. These compressors ensure modern GTs have a steady gas flow rate at a high enough pressure. They have capacities of up to 8,212 cfm and pressures of up to 1,100 psi. The package is built around a Frick screw compressor and has a power range of up to 4.5 MW.
Johnsoncontrols.com

Vibration monitoring

GTI Predictive Technology has released VibePro 24/7 for vibration route and data continuous online vibration and temperature monitoring for rotating equipment and bearing health. It combines route data collection and analysis with wireless online vibration and temperature sensors.

It can be operated on an iPad platform to monitor nearly any asset. The VibePro manages wireless motes to acquire data for trending. All machine data are collected in one place. It is designed for demanding environments
gtipredictive.com

Dry bottom ash handling

In the 1980s, Magaldi invented Dry Bottom Ash Handling (DBAH) technology known as the Magaldi Ash Cooler (MAC). It is a system for dry extraction, air cooling and mechanical handling of bottom ash from pulverized coal-fired (PCF) boilers. It recovers energy from the bottom ash produced in coal-fired power plants thus improving the boiler efficiency, compared to a conventional wet system.

One challenge has been the application of this technology to bottom ash with high unburned content. This can be encountered in PCF boilers that burn solid fuels with milling difficulties, such as lignite, Refuse Derived Fuel (RDF) or biomass. The Magaldi Ash Postcombustor (MAP) has been released to control post-combustion of unburned particles (UBC). One system was installed in lignite fired boilers at the Işalniţa power plant in Romania serving a 315 MW steam turbine.

Prior to the MAP system installation, the combustion process generated high UBC content (up to 55%). The main benefit experienced from the MAP system was a reduction in natural gas consumption due to heat recovery from the conversion of the UBC residues contained in the bottom ash. In addition, the facility experienced a reduction in lignite consumption, a boost in boiler efficiency, and a reduction of water consumption.
www.magaldi.com

Pump detection

A new type of detection technology from Siemens protects centrifugal pumps from dry running in hazardous areas. Special current and voltage detection modules for the Siemens Simocode pro motor management system monitor the active electric power consumption of the pump motor to detect a diminishing flow rate and shut off the pump at defined limit values to prevent impending dry running. Additional sensor technology otherwise required to monitor the pump for dry running can be eliminated.
Siemens.com

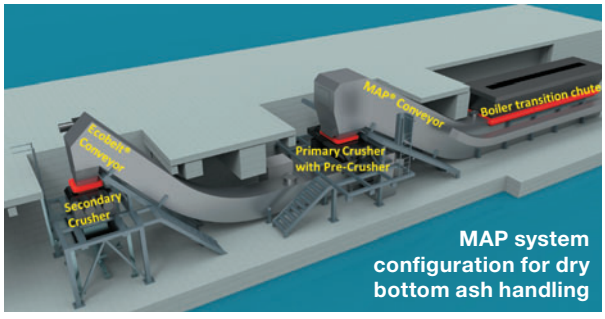
Valve actuators

Rotork has extended its CMA range of compact modulating actuators with new sizes for automation of larger linear control valves. The new sizes are capable of a maximum 4,500 lbf seating thrust and thrust performance of 3,000 lbf with a 114.3 mm stroke length for the automation of larger valves with higher pressure ratings.

CMAs can handle extreme temperature swings, corrosive environments and are available for explosion-proof areas. The CML-1500 and CML-3000 models, including those with hazardous area approvals, are watertight to IP68 for temporary submersion (7 meters, 72 hours).
Rotork.com

Vacuum pump

The Varodry from Leybold (part of Atlas Copco) is an oil-free, dry compressing screw vacuum pump. It is initially available in sizes VD65 (65 m^3/h), VD100 (100 m^3/h), as well as VD160 and VD200. These pumps handle vapors well. An integrated silencer means a quiet sound profile. The variable inlet flange arrangement enables flexible installation. The design also prevents rust and contributes to process reliability. It can be operated continuously at any inlet pressure and is resistant against repeated shock venting. Any number of cycles can be run without overload.
Leybold.com



MAP system configuration for dry bottom ash handling

Improving pump life

Netzsch Pumpen & Systeme has released the xLC unit. It triples the service life of its pump, particularly when conveying difficult, abrasive media. When wear occurs in the rotor-stator system, the xLC unit allows the performance of the pump to be re-established by adjusting the preload between the conveyor elements.

The xLC adjustment system uses an elastomer that is not vulcanized into the housing but rather is fixed through axial pressing. To regulate the preload in the rotor-stator system, the elastomer in the sheath is extended by pulling or shortened by pressing, which changes the preload between the pumping elements. In case of wear, compressing the elastomer increases the preload and re-establishes the reduced sealing line.

If the stator must be adjusted due to declining performance, the setting nuts of the system are adjusted, compressing the elastomer insert in the metal housing. A scale with seven defined stop points facilitates gradual adjustment of the stator with only two setting screws while also showing the remaining potential until a stator change is required.

Netzsch-Pumps.com

Cooling towers

SPX Cooling has released the Marley NC Everest crossflow cooling tower and the new Marley MD Everest counterflow cooling tower. These pre-assembled modular products are engineered for power and process cooling applications. The cooling towers are said to have nearly three times greater cooling capacity compared with other pre-assembled cooling towers.

spxcooling.com

Siemens motor

The Simotics HV C air-cooled range from Siemens completes the Simotics platform for compact high-voltage motors up to 3.2 MW. The cooling concept, involving a combination of fin-and-tube cooling, delivers improved temperature distribution in the motor and increases power density.

With their vibration-optimized, robust housing design, the motors have increased reliability. They can be connected to the Sidrive IQ digital platform using the Simotics Connect 600 connector box: This provides access to cloud-based analysis of the condition data. The motors are used in pumps, fans, compressors, and more.

Tube cooling elements have been integrated into the high-voltage motor's rib-cooled housing. The motor cooling is improved by the addition of a fan design that reduces the internal temperature of the motor. This increases performance by up to 15% and extends the operating life of components without changing the size.

Simotics HV C motors have an optional connectivity module for integration into the digital, cloud-based solution. This uses temperature and vibration sensors to capture and process data, such as bearing temperatures, winding temperatures, and housing vibrations and transmits this information for analysis. This increases the availability, efficiency and performance of the motors and improves service efficiency.

Siemens.com

Simulation tool

Applied Flow Technology has released AFT Impulse 7, a simulation and analysis tool used to calculate pressure surge transients in liquid piping systems caused by waterhammer. It can model a wide range of system components and surge devices, understand the transient response, and know how valves, pumps and other components dynamically interact. The software also evaluates the effect of pressure surges due to vapor cavity collapse by modeling vapor cavitation and liquid column separation. As well as a new interface, the latest version, improved safety, better file import and export formats

Aft.com

Starrett AV450 Automatic Vision System

Inspection system

The L.S. Starrett Company has introduced its AV450 Automatic Vision System. The 3-axis system allows users to achieve high throughput in inspections. Featuring a larger X,Y,Z measuring envelope of 18" × 14" × 8", the AV450 has high-resolution video zoom optics and it can be pre-programmed (CNC) for repetitive part inspection, or driven manually via a trackball for individual measurements.

Throughput is enhanced by either QC5000 or MetLogix M3 software that controls video-edge detection and multiple-channel fiber optic or LED illumination. Computer-controlled Quadrant (LED) ring lighting, sub-stage lighting, and optional through-the-lens lighting meets the most challenging illumination requirements.

starrett.com

Continued on page 36

New SPX cooling tower

Air monitoring system

Kemper's air monitoring system can be integrated into environments where there is an inadequate digital infrastructure, without interfering with corporate networks. It analyzes the amount of ultrafine dust particles. By connecting to an internet-based cloud, different users can monitor the systems via fleet management.

Kemper air monitoring system

Integrated mobile radio technology and sensitive sensors ensure that machine-to-machine communication operates efficiently. It can detect ultrafine dust particles that are smaller than 0.3 microns. Extraction and ventilation systems are controlled as required on the basis of specified workplace thresholds.

Kemper.eu

Shaft speed and position

Measuring and monitoring of rotary speed and rotary shaft position on machines, industrial installations and electric drives is a requirement in many industry sectors to ensure optimum performance. Rotary encoders and angle sensors are the preferred devices to achieve this.

Baumer offers Bearingless Encoders suitable for space-limited locations. They feature a short mounting depth and wear-free magnetic sensing technology. One version is designed for shafts up to 740 mm. Others are for shorter shafts up to 340mm.

Baumer.com

New controller

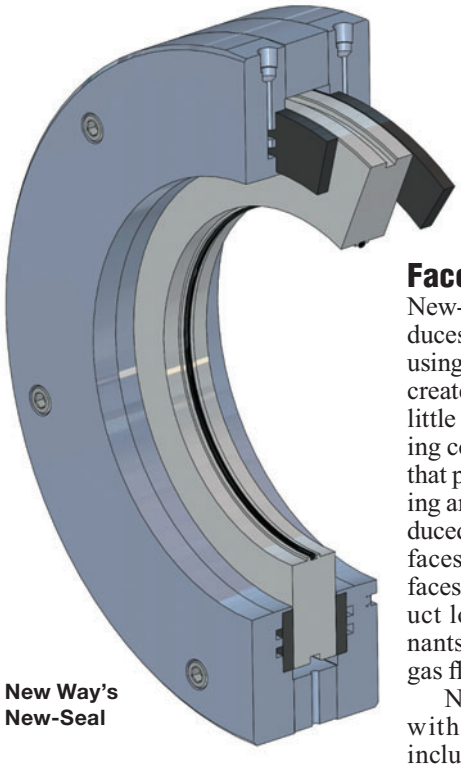
Industrial workers can strengthen their grasp of production and make more informed operating decisions with the new Allen-Bradley CompactLogix 5480 controller by Rockwell Automation. It marries a Logix control engine and the Microsoft Windows 10 Internet of Things (IoT) enterprise operating system in a single platform, allowing workers to view machine information at its source.

The controller can reduce latency by performing real-time data collection. Users can view control data, and other information can be sent upstream to the enterprise or cloud. The ability to run Windows applications on-premises can also reduce the need for a separate PC on the plant floor and shrink a machine's footprint.

"Companies deploying Industrial IoT technologies no longer have the luxury of choosing between cloud or on-premises architectures — they need both," said Matthew Littlefield, president and principal analyst, LNS Research. "The ability to access control-system data at the machine level and access insights from the cloud can deliver the agile decision-making that many companies desire."

The controller incorporates multiple security functions, including user authentication and authorization, role-based access and digitally signed encryption. And because the Windows operating system runs independently from the control engine, any disruptions to the operating system will not affect machine or line control.

rockwellautomation.com


New Way's New-Seal

Face seal

New-Seal by New Way Air Bearings introduces a new line of double-acting face seals using externally pressurized porous media to create a fully noncontact, leak-free seal with little to no maintenance required. The rotating collar is fitted to the shaft with an O-ring that provides rotational drive, ease of mounting and misalignment capability. Air is introduced to the seal gap through parallel porous faces creating high-pressure zones on both faces of the rotating collar eliminating product loss and ingress of external contaminants. The small seal gaps require less seal gas flow than other air seal designs.

New-Seal is ideal for rotating machinery with large misalignment requirements including various pumps and bulk-powder applications, including ribbon blenders, screw conveyors and agitators.

new-seal.com

Waste heat recovery

Industrial facilities and power plants generate waste heat that is usually released into the air. Kelvion has added two new waste heat recovery solutions to its product portfolio — the Exhaust Gas Heat Exchanger and the EcoMi modular economizer. They can transform waste heat into useful forms of energy, reducing emissions and boosting efficiency.

The Exhaust Gas Heat Exchanger transfers heat produced by exhaust gases from combustion engines to a liquid. When heated up, this liquid can be used in cogeneration plants, combined heat and power plants, district heating systems, on board ships, biogas plants and furnaces. Its compact design makes it suited to processes where space is limited. Made from high-alloyed stainless steel, the Exhaust Gas Heat Exchanger can handle temperatures up to 550°C. It is equipped with a compact finned heat exchanger module, which is easily replaceable. Compact fin tube bundles made out of stainless steel, are insensitive to soiling and easy to clean with high pressure as well as cleaning agents.

The EcoMi modular economizer is a type of heat exchanger that recovers residual heat from oil, gas or wood-fired boilers for reuse in other thermal operations. The new EcoMi model combines the economizer's economic advantages with a modular design. It can be used in the paper, food, textiles, power and HVAC industries. Multi-stage dry/wet systems using both carbon-steel and stainless-steel components are available. With its vertical, horizontal or horizontal-to-vertical installation it can be easily integrated into existing plants. The EcoMi can handle a wide range of gas flow volumes and be fitted with different tube variants or sheet types to suit operating conditions.

Kelvion.com ■

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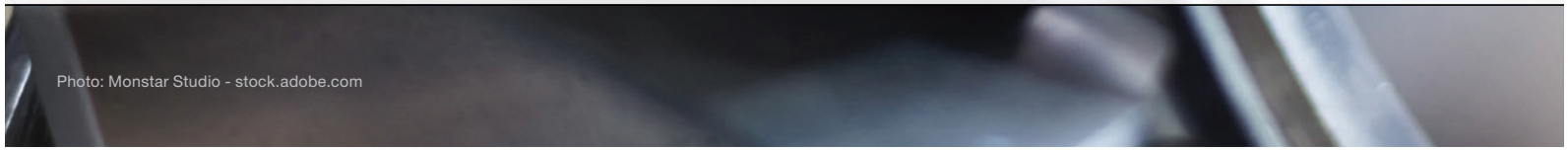

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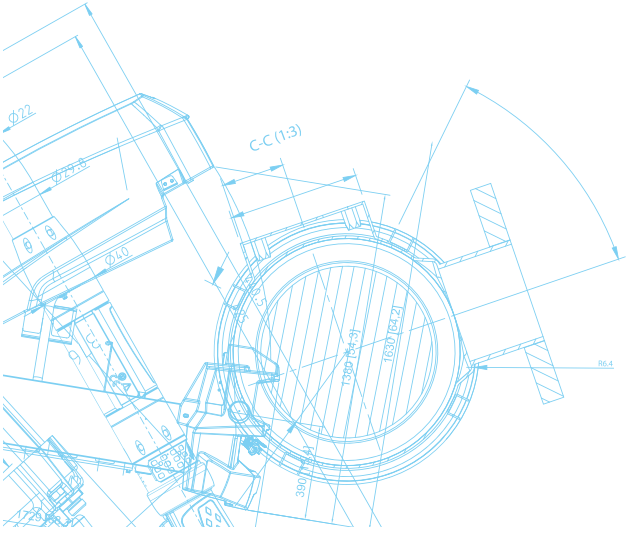

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NATURE'S GIFTS FOR POWER GENERATION

A common, somewhat disrespectful, saying — often erroneously attributed to Ben Franklin — is "Beer is proof that God loves us and wants us to be happy."

It could be taken one step further: "God gave us a liver which is proof that God wants us to drink beer." (Or, by inverse conjecture, given that we have a liver and drink beer, there must be a deity.)

Similarly, we can talk about many other of earth's natural circumstances that happen to be perfectly provided for mankind's existence and survival.

How does that relate to turbomachinery and our monthly Myth Buster column?

Air and water. We take them for granted in our daily lives. But from a power generation perspective, they are nearly perfect (if not absolutely perfect) working fluids for our heat engines. Through their use in gas turbines and steam turbines, they are responsible for over 90% of the world's electric power generation.

But over the last few years, attempts have been made by reputable scientists and engineers (including yours truly) to bad mouth them and paint them as imperfect fluids for the necessities of modern power generation.

Many bright inventors are in the pursuit of more advanced thermal fluids, such as supercritical carbon dioxide, organic hydrocarbons liquids, such as pentane, naphtha, acetone, and even some noble gases, such as Argon or Helium, with the aim of squeezing a last few fractions of efficiency out of heat engine thermodynamic cycles.

So, I would like to come to the defense air and water. They are very basic, but wonderfully common, and easy to use. Everyone knows how to handle them, we inhale and drink them daily, and nobody is afraid of them. In my seldom humble opinion, air and water still represent by far the best option for a working fluid in power plants.

Allow me to point out the obvious: Water and air are commonly available. They are clean, cheap, and definitely not toxic. Plant machinery, valves, vessels, heat exchangers, and so forth, have evolved over centuries into a highly efficient symbiosis for power generation.

From a thermodynamic perspective both water and air have good heat capacity and heat transfer properties, specific heats, and manageable densities over wide temperature and pressure ranges. The critical point of water is nicely matched for many available Rankine cycle heat sources. And for Brayton cycles, air has steep and flat isentropic lines at low and high pressures respectively, just what thermodynamicists want.

Nature gave us good air and water to make fine beer … and to produce excellent electricity.

There are other advantages of air and water, such as easily predictable near-linear behavior of most physical properties. This makes engineering that uses simple equations of state accurate and reliable.

But most important is this fact: By far the most highly efficient power plants by a significant margin compared to any other technology are gas turbine combined cycle power plants that use both air and water in their Brayton and bottoming Rankine cycles.

Efficiencies in excess of 63% have been demonstrated, which is approximately 20% higher than what has been demonstrated with any other working fluid. Combined cycle power plants also have demonstrated the lowest installed costs and the highest operational fleet reliability of any power generation technology.

Few of the proposed other technologies that are trying to compete with air and steam cycles have been demonstrated under real-world conditions, and none are fully commercialized. They often utilize costly, asphyxiating, explosive, poisonous, corrosive, ozone depleting, flammable, toxic, and sometimes carcinogenic working fluids.

But they have come nowhere near to the plant efficiency, reliability, commercial availability, and low operating costs already demonstrated by conventional air and water.

Safety systems, fluid handling, pipe design, materials properties, and engineering operation of these novel fluids are far from being established. We often do not even know their basic fluid properties, such as viscosity, specific heats, speed of sounds, enthalpy, entropy, and so on.

One last note: We certainly do not wish to discourage active investigation and research into other fluids and complex advanced power cycles. But nature, or a deity if you prefer, gave us air and water.

They happen to be perfect for electric power generation. So far, none of the other fluids that have been tried have really panned out. None have created a serious competitive threat to air and water. And maybe as a final philosophical conjecture: Nature gave us good air and water to make fine beer … and produce excellent electricity. ■

Klaus Brun is the Director of R&D at Elliott Group. He is also the past Chair of the Board of Directors of the ASME International Gas Turbine Institute and the IGTI Oil & Gas applications committee.

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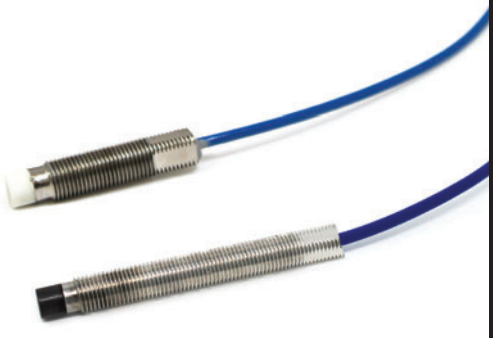

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