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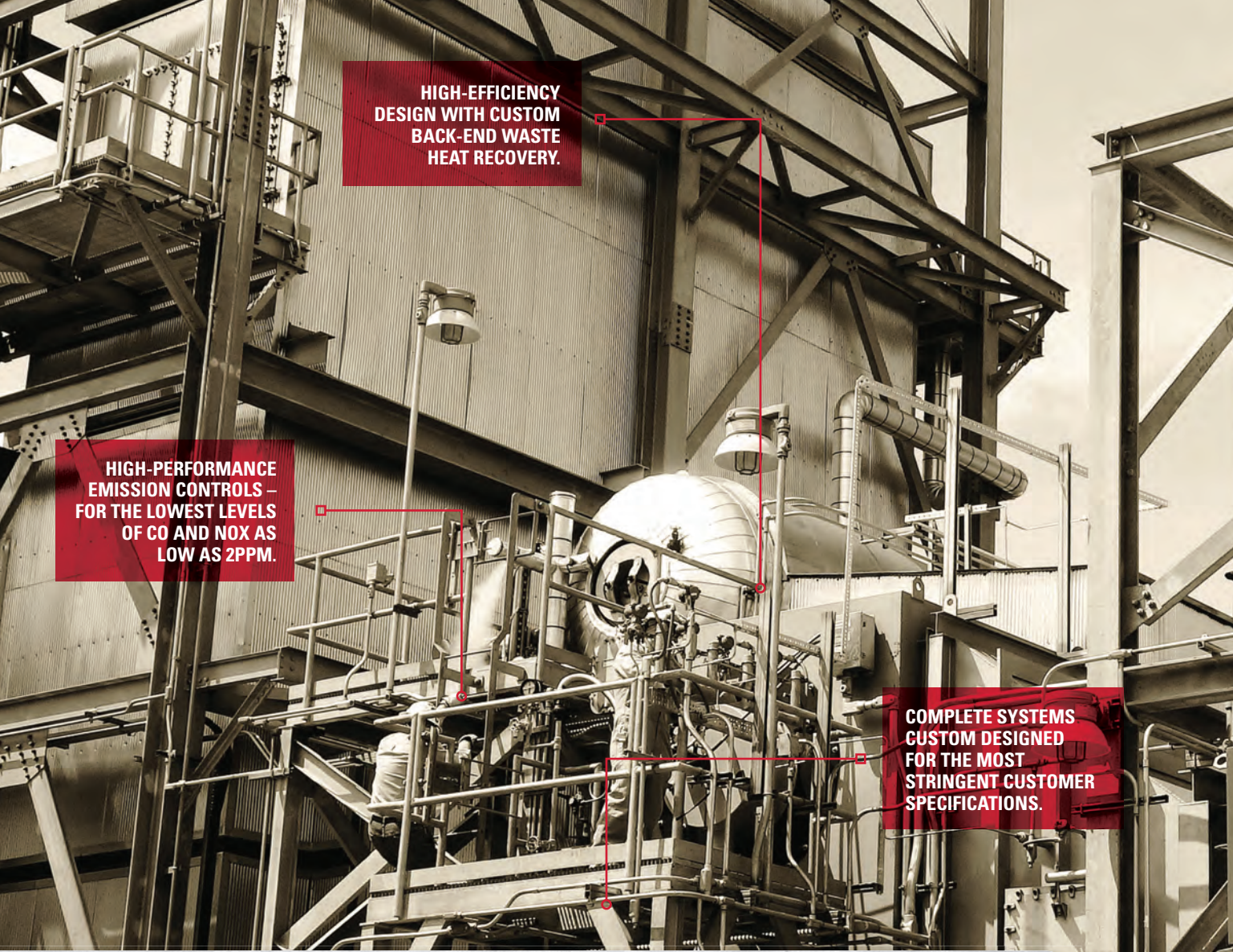
DOUBLE SHOW SPECIAL

PowerGen Show Report
Turbomachinery Symposium Show Report

Also in this issue:

Turbine Lubrication • Mobile Power • Virtual Prototyping

Centrifugal Pumps • Distributed Generation • Market Trends



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COVER STORY

TURBOMACHINERY SYMPOSIUM:

The Turbomachinery Laboratory at Texas A&M University hosted another recordbreaking Turbomachinery & Pump Symposia despite a three-month delay due to Hurricane Harvey. The 45th Turbomachinery and 33rd International Pump User's Symposia (TPS 2017) took place in December In Houston, Texas. It featured updates on enhanced oil recovery (EOR), component selection, supercritical CO_2, steam turbines, API standards, valve sizing and centrifugal compressors.The big news from the show, however, was the retirement of Dr. Dara W. Childs, Director of the Turbo Lab since 1980 and chair of the TPS advisory committees. He was honored with a banquet dinner during the Symposia.

Drew Robb

SHOW REPORT

20 DISTRIBUTED GENERATION RULES POWERGEN

Conventional power sources such as coal and nuclear are being displaced by renewables and battery power.This is turning the power market on its head. Yes, large plants will continue to be built, but their frequency will probably lessen. But distributed generation (DG) is gathering momentum.

Drew Robb

CENTRIFFUGAL PUMPS

23 AFTERMATH OF THE GLOBAL OIL CRISIS

Centrifugal pump demand from the oil and gas sector has plummeted, but that could soon be changing.

Joanne Goh

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The 3D multi-physics-based approach to virtual prototyping of gas turbines represents a more accurate characterization of the system, enabling engineers to analyze and explore novel concepts beyond the scope of correlation-based methods.

Chad Custer

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26 UPGRADING TURBINE LUBRICATION TO REDUCE TCO

Pure hydrocarbon base oils can be created with a narrow molecular distribution, a high viscosity index and a low level of contaminants (such as nitrogen and sulfur). These latest gas-to-liquid base oils respond well to performance additives, enabling the production of turbine oils with good performance even under severe operating conditions.

Volker Null

Q & A

28 RELEVANT POWER LAUNCHES MOBILE GENSET

Siemens wanted a large mobile gas turbine generator in its product lineup. The SGT-A45 was developed for this purpose. To build the SGT-A45 gensets, Siemens manufactures the gas generator and power turbine hardware in Montreal. The GT is shipped to Relevant Power Solutions in Houston for trailer mounting, package assembly and genset testing prior to shipment. Richard Wolf, President & CEO of Relevant Power Solutions, discusses this new startup venture and the launch of a new 45 MW mobile gas turbine generator product.

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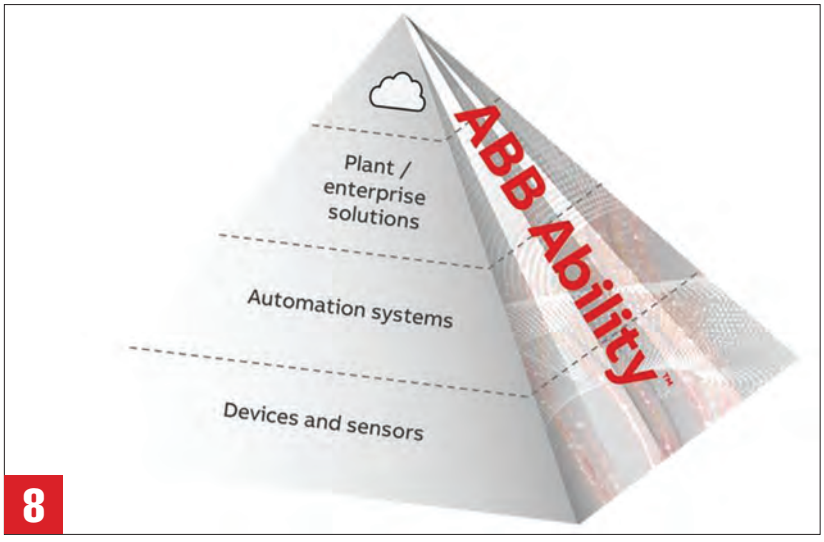

COLUMNS

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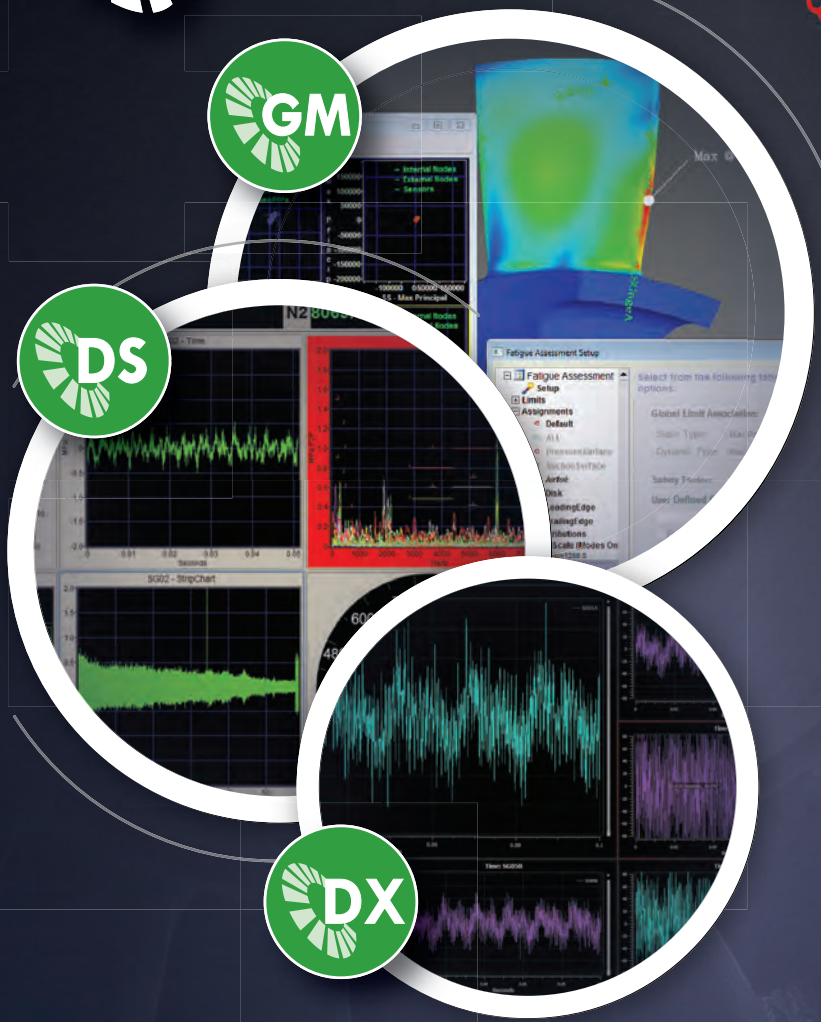

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INDUSTRY IN FLUX

Recent announcements from GE and Siemens appear to have dampened hopes of a revival of fortunes in the power industry. Bad news, it seems, is everywhere: The gas turbine (GT) market is experiencing heavy pressure from the renewable sector. Wind power and solar are going from strength to strength. Both are taking business away from GT manufacturers. If that wasn't enough, battery power is now emerging as yet another threat. Backed by grants and legislative mandates, batteries are advancing rapidly in terms of technology, battery life and cost.

Gas engines, too, are seizing market share from GTs in the lower end of the market. But their manufactuers can sense more opportunity and are moving upwards, collaborating on the design of combined cycle plants which use multiple gas engines to provide power plants of 100 MW and more.

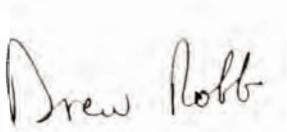
The industry response? Siemens announces lay offs of 7,000; GE says it will lay off more than 10,000. Predictions of tough times and slumping sales prevail. Layoffs and bleak forecasts are one thing. But what appears to be missing is any GT-focused strategy to combat competitiveness from elsewhere.

Having just returned from the Baker Hughes (formerly GE Oil & Gas) conference in Italy, I was briefed on how the NovaLT GT is being sold successfully into the power industry. The company conceived it as an oil & gas product to drive compressors. Yet its light footprint and other features have led to a surge in sales for power.

This got me thinking. It may be time for the industry to step back and reevaluate its place in the power market. What does the market actually need and want? Baker Hughes is succeeding with the NovaLT. MHPS is making serious headway with its J-class machines. Both represent wins in the marketplace. There are surely others.

The MHPS machine is a large-scale GT, while the NovaLT serves the lower-end. So any pronouncements about "the end of the large frame market," or there being "no hope for small turbines" appear to be little more than defeatist talk. How about we find out what the market really needs and develop steps to provide it rapidly?

"It may be time for the industry to step back and reevaluate its place in the power market."



DREW ROBB
Editor-in-Chief

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OUR COMPRESSORS ARE OVER-ENGINEERED FOR A REASON. THEY HAVE TO OPERATE IN HOSTILE ENVIRONMENTS FOR A LONG, LONG TIME.

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ABB's digital strategy

Digitization, big data and analytics may offer a way to address today's industry challenges:

- Ever-widening regulations
- Large-scale integration of renewables and distributed energy resources
- Risk of cyberattack
- Generational shift in the workforce
- Aging plant equipment
- Volatile dynamic pricing and business model disruption.

They can also give power companies insight into the performance of their equipment, plants and fleet that open new ways of operating more competitively.

"Digitization brings about gains of 10% for productivity, maintenance and reliability compared to 1-2% when digitization is not embraced," said Matthew Littlefield, President and Principal Analyst at LNS Research. "Some 35% of power generation companies have invested in the Industrial Internet of Things (IIoT) in 2017."

ABB claims the world's largest installed base of digitally enabled industrial products and devices. It has developed for the power industry the Ability Symphony Plus portfolio of digital solutions.

More than 6,800 Symphony Plus systems have been installed in the past 35 years and more than 60 GW of additional power capacity has been installed during the last six years, much of it in the power generation and water sectors. The company reports that around one-third of the 70 million ABB-connected devices in existence are linked with power generation control systems.

One key area of ABB's portfolio is the Cyber Security Workplace. It provides a suite of security applications and automation to reduce cyber security risks, increase system reliability and minimize efforts in sustaining and maintaining security best practices.

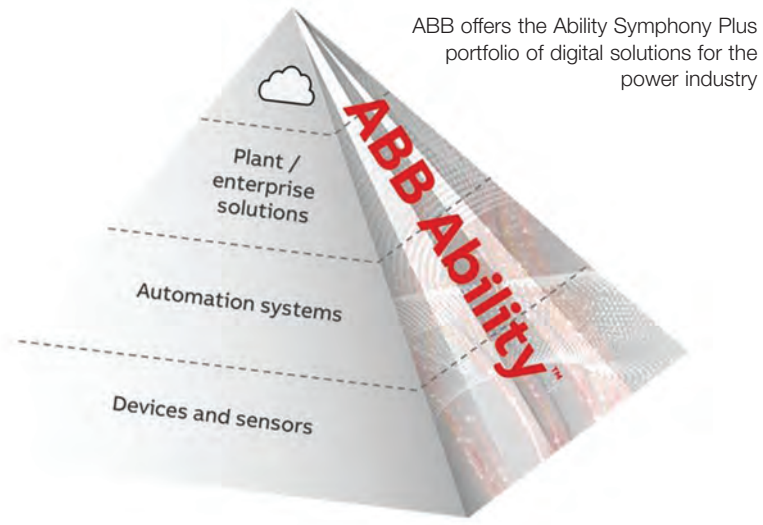

ABB offers the Ability Symphony Plus portfolio of digital solutions for the power industry

It complies with national and international regulations and recommended security best practices. With it in place, power generators can enforce corporate industrial control security policies and improve visibility into the status of security without burdening plant personnel.

"Industrial control systems that increasingly use open standards and commercial technology have introduced major operational benefits, but also cyber security concerns," said Kevin Kosisko, Managing Director of ABB's Power Generation & Water business, part of the Industrial Automation division. "ABB's security solution gives customers a way to embrace foundational security practices while minimizing time demands on plant personnel, who are facing growing demands associated with security, regulatory compliance and corporate risk."

The ABB Ability Symphony Plus and Ability System 800xA 5.1 distributed control systems (DCS) provide:

- System hardening: Monitoring and reporting, including identification of unnecessary software, components, ports, services and programs, including status showing present, removed or disabled
- Patch management: A centralized service for auditing and deploying security patches, which validate applicability and compatibility. It includes documented procedures for patching. Patches are validated, packaged and delivered securely, enabling customers to meet chain-of-custody requirements
- Malware protection management: A centralized service for auditing and deploying antivirus signature updates, which are evaluated, tested and verified to not contain false positives which could cause a system to stop on their deployment.
- Backup and recovery management: Automated and supported by best practices, procedure documentation and automation to backup and recover from a system failure. Maintains a detailed backup strategy, including recovery plan, according to business continuity needs.

Philippines adoption

ABB recently won an order to supply a high-fidelity operator training simulator from its Symphony family of control systems to a power plant in the Mauban municipality of the Philippines. Quezon Power, owner of this 460 MW coal-fired facility, will use the simulator to ensure operator competence.

The simulator will offer a virtual recreation of the Quezon plant, including non-standard scenarios and faults. This allows operators to become more familiar with their working environment and learn how to react in challenging situations. Quezon Power also upgraded the facility's human-machine interface (HMI) to ABB Ability Symphony Plus Operations.

Additionally, ABB will supply its Symphony Plus distributed control system to the largest solid refuse fuel power plant in South Korea. Construction of the plant, owned by Naepo Green Energy, has begun in Naepo New City, around 100 km southeast of Seoul.

Scheduled for commissioning in 2019, the 66 MW plant will provide heat and electricity for the local district, producing it from domestic waste. ABB will provide design, engineering, commissioning and training for its Symphony Plus DCS, including the latest generation of SD Series energy-efficient control and I/O modules.

The modules use less than 50% of the energy required by others in the market. Upon commissioning, Symphony Plus will offer plant performance monitoring of the boiler, turbine and its auxiliaries to provide actionable insights based on data analysis.

ABB and Hewlett Packard Enterprise (HPE) have also announced a strategic partnership that combines ABB's Ability digital offerings with HPE's information technology solutions. The partnership will provide solutions that generate actionable insights from vast amounts of industrial data to increase the operational efficiency and flexibility.

ABB's domain expertise in operations technologies (OT) and HPE's in IT will be merged to turn industrial data into insights

(Continued on p. 10)

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and automatic action, combining cloud platforms, such as Microsoft Azure with IT systems running in corporate data centers and at the edge of the network.

Opra acquired

Opra Turbines has been acquired by the Dalian Energas Group. Jan and Hiroko Mowill who founded OPRA in 1991 have retired from the company. Opra Turbines will continue its operations at a new headquarters in Hengelo as a member of Energas Group.

The company develops, manufactures, markets and maintains generator sets in the 2 MW power range using the OP16 series of radial gas turbines. This compact industrial gas turbine (GT) is used in oil and gas as well as industrial markets.

The generator sets can be installed as single or multiple units to cover installation requirements from 2 MW to 10 MW. Generator sets can be provided with low emission and dual or multifuel capabilities. Dalian Energas Group headquartered in Dalian, China, includes Dalian Energas Gas System, Dalian Energas New Energy Development, Calorifer Engineering, RMG Messtechnik and Opra.

Elliott LTSA

Elliott Group has signed a long-term service agreement (LTSA) to provide service and support for Borealis Group's fleet of rotating equipment in Europe. The five-year contract includes general service, equipment upgrades, rotor repairs, technical support, emergency response, and turnarounds for all of Borealis' European production facilities.

Borealis is one of Europe's largest producers of base chemicals and polyolefins, with operations in Europe, the Middle East, and the U.S. Elliott will service the contract from their repair facilities in the UK and Italy. Preparation is already underway for a planned turnaround in the spring of 2018 at a Borealis site in Linz, Austria.

LNG startup

A 490 MW onshore combined cycle power plant (CCPP) near Darwin, Australia, has started up, providing power for the $34 billion Ichthys LNG Project. This will allow LNG processing trains to cool and liquefy natural gas. The facility will use natural gas from the Ichthys Field.

It features five GTs and three steam turbines (STs). The Ichthys LNG Project will have peak capacity of up to 8.9 million tons per annum (MTPA) of LNG, up to 1.65 MTPA of liquefied petroleum gas and 100,000 barrels of condensate a day.

While European and North American markets are sluggish, Siemens continues to sign deals in other regions, such as one for a new plant in Argentina

Siemens slashes jobs

Siemens is cutting 6,900 jobs worldwide, half of them in Germany. This comes just a few weeks after GE Power announced job cuts in excess of 10,000. Siemens cited falling GT demand amidst a growing market for renewables as a primary reason.

Declining global demand for large GTs (more than 100 MW) is expected to level out at around 110 turbines a year. By contrast, the manufacturing capacity of all producers worldwide is estimated at around 400 turbines.

The power generation business will account for 6,100 job losses. In Germany, plans call for an adjustment of around 2,600 jobs and the closure of the Görlitz location (currently about 720 jobs) and the Leipzig location (around 200 jobs).

In addition, the solutions businesses (Solutions) of the Offenbach and Erlangen locations will be combined. These three measures will lead to the elimination of 1,600 jobs in total. For the location in Erfurt, several options are under review, including a sale. Around 640 jobs are to be cut in Mülheim an der Ruhr and about 300 in Berlin.

Outside Germany, the restructuring measures will eliminate a total of just over 1,100 jobs in European countries. In countries outside Europe, another 2,500 jobs will be affected, including 1,800 jobs in the consolidation of production facilities and administrative functions in the U.S.

"The power generation industry is experiencing disruption of unprecedented scope and speed," stated Lisa Davis, member of the Managing Board of Siemens AG. "With their innovative strength and rapidly expanding generation capacity, renewables are putting other forms of power generation under increasing pressure."

Siemens sees little future in large GTs, and is cutting back in several other areas of its manufacturing empire. However, the company continues to ink deals around the world. It has signed contracts with the state-owned utility GECOL to expand Libya's power generation capacity by 1.3 GW. The company will build a 650 MW open cycle power plant equipped with two F-class GTs, and a 690 MW open cycle power plant in Tripoli West with four E class GTs.

Siemens has received a contract to expand the Genelba gas-fired power station in Argentina. Working with its Argentine partner Techint, it will expand the power station for Pampa Energía. Known as Genelba Plus, it involves converting the existing power station in Marcos Paz, Buenos Aires Province, into a CCPP.

This will increase capacity from 168 MW to 364 MW. The plant is scheduled to be commissioned in mid-2019. Genelba Plus is a multi-shaft CCPP, in which two GTs and one ST each drive their own generator. Siemens will supply one SGT5-2000E GT, one SST-5-5000 ST, and two SGen-100A generators, in addition to two NEM high recovery steam generators (HRSGs), the SPPA-T3000 distributed control system, and medium and high-voltage components.

Siemens has signed contracts with Iraq's Ministry of Electricity. The project will see the maintenance and upgrade services of seven power generating units inside four power plants. The Iraqi Ministry of Electricity is working towards improving the availability and reliability of power supply, while minimizing power losses.

Siemens will carry out service and maintenance works across the four plants. The outage and upgrade services will enhance the reliability and efficiency of these units, helping them collectively generate more than 1 GW, 400 MW more than today, and save up to 10% in fuel consumption.

Iran has taken delivery of the two F-class GTs from Siemens for use at a 600 MW power station under construction in Bandar Abbas. The contract covers two SGT5-4000F GTs and SGen5-2000H generators and the associated power plant instrumentation and controls.

Siemens has opened a new MindSphere Application Center for Power Generation Services. It has been designed so that energy customers, software engineers and Siemens engineers could explore the value offered by digital tools. It also showcases digital offerings such as a Digital Power Plant running on MindSphere.

Siemens has received an order from Nizhnekamskneftekhim to build a CCPP in Tatarstan, Russia. Siemens will cooperate with the Turkish company Enka to build the 495 MW facility. The contract includes the delivery of two SGT5-2000E GTs, one SST-600 ST and the corresponding power distribution systems as well as a 13-year service agreement. The plant is scheduled to begin operation in May 2021.

Gas processing plants

Rockwell Automation is main automation contractor (MAC) for Encana as it builds three new gas processing plants in the Montney region of Canada. All three Encana facilities have begun production. Rockwell Automation provided control systems, safety instrumented systems and interfaces to the third-party OEM skids in each facility.

LNG carriers

GTT has received an order from the Chinese shipyard Hudong-Zhonghua Shipbuilding for two dual purpose vessels capable of operating as LNG Carriers and Floating Storage and Regasification Units (FSRUs). These vessels will be built at Shanghai, China, for the owner Dynagas.

Their delivery is due in 2021. GTT will design the LNG tanks of both units, each representing a capacity of 174,000 m^3. A membrane cryogenic containment system with glass wool insulation will be used for the LNG storage on board. Currently, 14 vessels in operation and 42 on order use this technology.

MHPS digest

Mitsubishi Heavy Industries (MHI), Mitsubishi Hitachi Power Systems (MHPS) and Mitsubishi Heavy Industries Compressor (MCO) have successfully completed testing of MHPS's 2-shaft 120 MW H-100 GT. The H-100 uses the latest combustor technology and offers single digit ppm NOx for full-load operations.

MHPS has been technically selected by Gaz Et L'Energie (GEL) for the Humay Power Station project in Peru. The project includes one M501JAC GT, an HRSG, and an ST. The projected completion is 2020. The facility will produce 500 MW.

MHPS has received an order for two H-25 GTs for an 80 MW LNG-fired CCPP project developed by Qingdao Energy Kaiyuan Thermoelectricity. The turbines are scheduled to begin operations in December 2018 and will be the core components of the cogeneration plant, which will provide power and heat for industrial processes.

The facility requires GTs, STs, generators, and exhaust heat recovery boilers. MHPS will produce two 32 MW H-25 GTs, and supply them through the local main contractor Harbin Guanghan Power Technology Development. Using an energy-step-utilization process, high-temperature waste heat from the GTs will be converted into steam by the exhaust heat recovery boilers and that steam will be sent to the ST. The extracted steam will also be used for heating.

Parker factory

Like many engineering firms, Parker Hannifin has established a new factory in Dammam, Saudi Arabia, in partnership with Tamimi Energy. This will facilitate the production of inlet filters for GTs in Saudi Arabia and the surrounding region.

Pico Alto Geothermal Plant

New Geothermal plant

Exergy has inaugurated the Pico Alto 4 MW geothermal power plant in the Azores. Owned by EDA, the Azores power utility company, it is now in commercial operation. The plant uses a geothermal high-enthalpy resource, exploiting the heat available both in steam flow and geothermal brine. An air-cooled ORC unit is equipped with an Exergy radial outflow turbine.

(Continued on p. 12)

Aussie power plants

APR Energy has commissioned two new power plants in South Australia to defend against summer power outages. In August 2017, SA Power Networks contracted APR Energy to install and operate power plants in the suburbs of Adelaide that would add 276 MW in advance of peak seasonal demand. The plants feature the latest generation of GE TM2500 mobile GTs of 30 MW capacity.

Keeping Rawhide rolling

Using simulation technology embedded in Emerson's Ovation control system platform, Platte River Power Authority has enhanced operator proficiency and boosted plant performance at Rawhide Energy Station Unit 1 in Wellington, Colorado. In the first four months, operators experienced a 44% reduction in startup and shutdown time.

This 300 MW baseload Rawhide Unit 1 uses the system to test control logic changes without risk to the actual plant, verify patches prior to install and to improve plant operating procedures.

Ansaldo partnership

Simest, which with SACE forms CDP Group's Export and Internationalization Center, has acquired an 11% stake in Ansaldo Energia Switzerland. Simest has also made an interest contribution against a €60m loan granted by UBI Banca, offering financial coverage for Ansaldo Energia Switzerland's capitalization and investment plans. This will provide support for Ansaldo Energia Group's investments in research and development relating to GT technology (class F and H) and service work on operating GTs.

Oil and gas cloud

The oil and gas cloud applications market is expected to grow from $3.33 billion in 2017 to $5.68 billion by 2022, at a Compound Annual Growth Rate (CAGR) of 11.3%, according to the new market research report, "Oil and Gas Cloud Applications Market - Global Forecast to 2022," published by MarketsandMarkets.

Major drivers of this market are the slump in oil prices and the emergence of big data and advanced analytics for fostering and enhancing operational efficiencies. Growing trends of mobile computing and rapidly increasing adoption of hybrid cloud are the key opportunities that would fuel the market growth.

Ethos contract

EthosEnergy has been awarded a contract in South Korea for a controls system upgrade on a Pratt & Whitney FT4C-3F TwinPac GT. The new control system provides increased flexibility, availability and risk reduction. Using open-architecture solutions, this allows the control system to be tailored to specific needs.

EthosEnergy has also been awarded a three-year contract by ITM O&M for refurbishment at the Umm Al Nar station in Abu Dhabi. This entails butterfly valve refurbishment at the station with repair & services work carried out at the EthosEnergy Abu Dhabi workshop and on-site.

Subsea VSD

A variable speed drive (VSD) has undergone testing in a simulated harsh subsea environment to investigate its reliability. This was carried out in a sheltered harbor in Vaasa, Finland. A VSD is needed to boost the productivity of oil and gas processes and improve energy efficiency. The test is the latest in a five-year Joint Industry Project between Statoil, Total, Chevron and ABB.

It aims to develop transmission, distribution and power conversion systems for subsea pumps and gas compressors, operating at depths of 3,000 meters and over vast distances. By providing the large power needs closer to the reservoir, production improves due to the increased flow and pressure of the stream.

The subsea variable speed drive, designed for subsea gas compression, was operated, over three weeks in a back-to-back configuration directly with the grid, without motor loads. The subsea VSD features a pressure compensated design, whereby all its power components are cooled by being submerged in oil.

The water test proved that the electronic and power components can meet the thermal performance demanded. Prior to the test, the main drive sub-assemblies and components were pressure tested at 300 bars in Statoil's R&D facility in Trondheim, this test performed to demonstrate that the drive can tolerate a pressurized environment.

GE Digest

GE Power has been selected by Jiangsu Etern to supply its LMS100 GT for an upcoming 100 MW simple-cycle natural gas-fired plant in the city of Shahjibazar in Bangladesh. The project is expected to be commissioned in the second quarter of 2019. The embedded dual-fuel capability gives enables the GT to operate on natural gas and LPG.

Aluminium Bahrain (Alba) has installed three GE 9HA GTs, three STs and three HRSGs at the PS 5 facility, a 1,792 MW CCPP with an efficiency of 54%. The Gama Consortium is the engineering, procurement and construction (EPC) contractor.


GE LMS100

GE Power said its 9HA.02 GT has exceeded 64% efficiency in CCPPs. The company attributes part of the achievement to advances in additive manufacturing (3-D printing). Some 18 months ago, the EDF Bouchain facility in France entered commercial operation at 62.22% efficiency. New 3D printed blades have improved fuel-air mixing in the latest version. The 9HA.02 has an output of 826 MW in 1 x 1 CCPP configuration.

GE Additive has acquired GeonX, a privately owned developer of simulation software. Headquartered in Belgium, GeonX provides software for engineers when developing new products, to simulate additive manufacturing, welding, machining and heat treatment processes in various industries such as aerospace, automotive and energy.

GeonX's simulation software tool, Virfac (Virtual Factory), assesses products prior to production, predicting defects, distortions and stresses and the impact manufacturing has on durability. This helps to reduce the number of prototypes built during the development phase, while improving the quality and lifetime of the manufactured products, minimizing time-to-market and development costs.

MAN digest

MAN Diesel & Turbo has won an order for nine compressor trains for the state-owned Kuwait Oil Company (KOC). MAN technology will be deployed in Kuwait's Burgan field. The British plant manufacturer Petrofac has been contracted by KOC to build a gas gathering center to process accompanying gases and to improve the quality of the oil produced.

Nine electric motor-driven MAN type RB35 and RB28 compressors are designed to handle sour and wet gas; high proportions of hydrogen chloride and hydrogen sulfide mean demanding requirements for machines and materials.

MAN has received orders for compressor systems from steel producers Tata and JSW, where they will be used as blast fur-

nace blowers. JSW Steel has ordered two MAX1 compressor trains for the expansion of its steel works in Dolvi, India.

Each system comprises an axial compressor with an electrical motor, as well as auxiliaries and supply units. Another order has come from Indian steel producer Tata. MAN is supplying a MAX1 compressor to one of Tata's largest production sites in the Dutch city of Ijmuiden. An ST acts as driver, converting waste heat into rotating energy.

The offshore production platform Ivar Aasen, run by Aker BP, is first to use the hermetically sealed HOFIM compressor system. The HOFIM compressor system is similar to MAN's subsea compressors, in operation at Statoil's Åsgard field in 300 m water depth with more than 30,000 running hours.

The offshore production platform Ivar Aasen, run by Aker BP, is the first to use the hermetically sealed HOFIM compressor system

The Ivar Aasen field lies in the Norwegian North Sea, about 175 km west of Karmøy, and contains about 200 million barrels of oil equivalents. Oil and gas from Ivar Aasen will be transported via pipelines to the Edvard Grieg platform, where it will be processed and exported to the market.

It is anticipated that the field will have an economic lifetime of about 20 years. MAN's compression system for Ivar Aasen comprises a multi-stage radial compressor (1×100%) arranged in tandem configuration around a centrally positioned 9.5 MW, high-speed electrical motor. The integrated active magnetic bearings are provided by Mecos, a MAN company.

Steam turbine

A new 70 MW steam turbine from Doosan Škoda Power provides steam and electricity for one of the largest petrochemical plants in Europe. It was delivered to Poland's petrochemical giant PKN Orlen in the second half of 2017. The back-pressure bleeding ST in Plock is now in full operation. The order also included building work on the site.

Industry giant retires

Dr. Dara W. Childs has stepped down as Director of the Turbomachinery Laboratory at Texas A&M University, and chair of the Turbomachinery & Pump Advisory Committees following 46th Turbomachinery & 33rd Pump Symposia (TPS), after 55 years of research and teaching.

Childs got his start in NASA's American Society for Engineering Education (ASEE) program, whose focus was to develop the space shuttle main engine. He then landed a NASA-Marshal Space Flight Center contract in 1975 to analyze the vibration characteristics of the high-pressure oxygen and fuel turbo pumps of the engine.

(Continued on p. 14)

Through his research, he found the shuttle's main engine to be unstable. NASA offered Childs funding for a research program, which he established at the Texas A&M Engineering Experiment Station (TEES) in 1980.

"My research career was built from the one 1975 study I led that predicted the space shuttle main engine pump would be unstable," said Childs said, referring to the 37,000 square foot high-bay Turbomachinery Laboratory research facility, adjacent to Texas A&M's main campus.

While other turbomachinery research labs have downsized, the Turbo Lab continues to flourish because of funds from the TPS. Childs chaired the TPS turbo and pump advisory committees since 1984, when he was named Director of the Turbo Lab.

"Almost all professors end up working only with other professors, and I have the privilege of working alongside successful industry engineers," said Childs. "These advisors are the best in their fields in the world. The advisory committees are the single greatest resource that the Lab has."

In 1984, Childs co-founded the Turbomachinery Research Consortium (TRC). This is an organization of developers and users that evaluate turbomachinery performance and reliability. The TRC has 38 member companies and 17 active projects. Childs was honored with a banquet at TPS in December 2017. The search for a new Turbo Lab director is underway.

Filters for high humidity

Between May and October, humidity in parts of Thailand remains above 80%. Filters without permanent moisture protection quickly lose their separation efficiency under these conditions and wear out faster.

As a result, penetrating moisture can pollute the machines and damage them. Two GT power plants in Ratchaburim, Thailand had to be changed out to better handle these climatic conditions.

They selected filters from Freudenberg Filtration Technologies (Viledon GTS Pulse-Jet filter cartridges of filter class F 9 / ISO ePM1 80 %). The synthetic organic filter material serves as a coalescer and protects the filters and turbines against excessive moisture and penetrating water.

Coarse dirt particles are also trapped by the protection. While the previous filters had to be replaced in the rainy season after three months, the new filter cartridges have been functioning for two years.

Saudi Aramco order

Baker Hughes, a GE Company, gained an order from Saudi Aramco with 27 gas compression trains for the Haradh and Hawiyah gas fields. The goal is to double gas production in the region to 23 Bcfd (0.65 X 109 m3) over the course of the next decade. The trains comprise centrifugal compressors, gearboxes, electric motors and loop oil systems. They will be manufactured in Italy and packaged in Saudi Arabia.

Malaysian combined cycle

Pöyry has bagged an engineer services contract for a 1,440 MW CCPP in Johor, Malaysia. The plant is operated by Southern Power Generation. The project consists of two 720 MW natural gas-fired blocks, each powered by a GE 9HA.02 GT with a triple pressure reheat, once-through heat recovery and ST in single shaft configuration. Pöyry's assignment includes assistance in project management, design review, site supervision services, quality assurance and quality control, commissioning supervision services and services during warranty period. Pöyry is assisted in the assignment by its local partner, Minconsult Sdn Bhd. The overall schedule for Pöyry's services is about four years. ■

HAZARD AND OPERABILITY ANALYSIS

Hazard and Operability Analysis (HAZOP) is a structured and systematic technique for package examination and risk management. It is used to identify potential hazards in a system or package as well as operability problems likely to lead to nonconforming operation.

HAZOP is based on a theory that assumes risk events are caused by deviations from design specifications or operating intentions. The identification of such deviations is facilitated by using sets of "guide words" as a systematic list of deviation perspectives. This approach is a unique feature of HAZOP methodology that helps stimulate the imagination of team members when exploring potential deviations.

HAZOP reviews are intended to reduce the probability and consequences of a major incident that would have a detrimental impact to operators, facilities, the public's wellbeing, and the environment. The target of HAZOP is continued business operation and long-term profitably.

The analysis looks for major incidents with potential for severe impact as opposed to minor issues of limited consequence. Such reviews should be updated and revalidated every six to ten years for machinery in operation, particularly if major changes have been made.

As a risk assessment tool, HAZOP contains brainstorming techniques and qualitative risk assessments. The success of a turbomachinery package review relies on the ability of rotating equipment engineer, operators, safety and risk advisors, and other subject matter experts.

They predict deviations based on past experience and comprehensive knowledge of package operation. This should not replace or duplicate design reviews. Rather, it is a formal safety and risk audit review to reduce or eliminate the possibility of major incidents.

Turbomachinery packages

HAZOP reviews are communication exercises. Information and data about turbomachinery packages are presented, discussed, analyzed, recorded and followed. Safety and risk aspects are identified to determine if adequate measures have been taken to prevent major accidents. Communication and qualitative evaluations are the primary facets of HAZOP procedures.

A specialized HAZOP chairman should guide the review team. Sequential failures, operability features and operational control methods, for example, can be investigated for potentially varying conditions.

"Hazard and Operability Analysis (HAZOP) is used to identify potential hazards in a system or package as well as operability problems likely to lead to nonconforming operation."

Representatives from the client and operation teams should attend a HAZOP meeting, as well as engineers and experts from the contractor and vendor side. They should be supported by someone to record the information and facilitate the overall process. A well organized and properly manned HAZOP team should consist of at least seven people.

During a HAZOP meeting for turbomachinery packages the HAZOP chairman and operation representatives raise any concerns or potential problems. Vendor representatives reply to questions and clarify such issues. Others observe and participate in discussions when needed.

Ideally, a HAZOP chairman is from an independent HAZOP specialist company or consulting firm. He or she is senior to other review team members. The chairman and at least 30% of the review team are not directly involved in the facility or package design. This allows them to offer an independent assessment of the review process.

Typically, the constraints of manpower availability dictate that most of the HAZOP team is composed of those familiar with project design as well as vendor representatives. In any meeting, consultants should be included to ensure evaluation independence. Vendor representatives should be authorized by the vendor to negotiate and accept changes to turbomachinery packages.

The role of risk engineers or safety representatives is also important. They provide risk evaluation, safety assurance, loss prevention, and environmental policies and practices to the HAZOP review meeting. They also confirm the underlying philosophy concerning risk acceptance and protection methodology. These experts should have reviewed cases of recent loss incidents applicable to similar turbomachinery packages.

HAZOP reviews should be conducted in a timely, efficient and cost-effective manner. Meetings for all turbomachinery packages from the same vendor should be done in one session and completed within one week, if possible. ■

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TURBOMACHINERY SYMPOSIUM

UPDATES ON ENHANCED OIL RECOVERY, COMPONENT SELECTION, SUPERCRITICAL CO_2, STEAM TURBINES, API STANDARDS, VALVE SIZING AND CENTRIFUGAL COMPRESSORS

BY DREW ROBB

The Turbomachinery Laboratory at Texas A&M University hosted another record-breaking event despite a three-month delay due to Hurricane Harvey. The 45th Turbomachinery and 33rd International Pump User's Symposia (TPS 2017) took place in December In Houston, Texas.

The exhibition hosted 359 companies and spanned 216,000 square feet. Some 4,620 delegates representing 46 countries visited the exhibition or attended technical sessions.

The Symposia comprised 15 short courses, 23 lectures, 16 tutorials, 23 discussion groups and 21 case studies. Topics included compressors, steam and gas turbines, expanders, pumps and drivers, and auxiliary equipment, such as couplings, bearings, gearboxes, dry gas seals and annular seals.

The big news from the show, however, was the retirement of Dr. Dara W. Childs, Director of the Turbo Lab since 1980 and chair of the TPS advisory


Dara Childs

committees. He was honored with a banquet dinner during the Symposia (pp. 13).

The keynote by Jody Elliott, President of Oxy Oil & Gas, covered Enhanced Oil Recovery (EOR). Oxy has over 2 million horsepower of compression assets:30% centrifugal compressors, 60% reciprocating compressors and 10% screw compressors. All are used in upstream operations. Some of these machines are involved in EOR compression.

Oxy is the largest operator in the Permian Basin, which spans New Mexico and Texas. CO_2 is used to boost oil production in developed fields. The CO_2 mixes with and releases the oil, then it is separated and reinjected in a closed-loop process. Most of the CO_2 comes from natural underground domes, but captured emissions from power plants are also employed.

Pipelines transport CO_2 from external sources to the oil fields where it is used for EOR. Elliott reported that 5% of total U.S. domestic oil production is already coming from CO_2-based EOR. Much of this is from the Permian Basin.

It is all about maximizing value from existing oil fields. Primary oil production only recovers about 15% of available oil reserves in conventional fields. A method known as waterflood EOR is used to extract another 30% of the oil. After that, CO_2 EOR is needed to take out another 15%.

"Other technologies will add to that to get above 60% of the actual oil present," said Elliott. "For unconventional resources, primary oil production only brings out 6.5%, so that is a big opportunity for EOR."

Component Selection

Garry Studley, Process Simulation Engineering, Dresser-Rand business, part of Siemens Power and Gas, delivered a session on optimizing component selection in synchronous motor compressor trains.

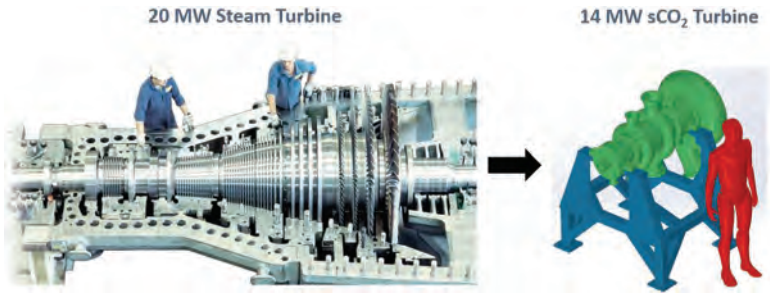
Compressor trains driven by constant speed synchronous motors need to be designed to withstand high levels of oscillating torque during startup. The importance of accurately predicting peak torque levels at resonance is critical for proper component selection.

Studley offered various tips during the tutorial: The motor and shaft line need to be designed for startup and steady-state operation. The peak torque capacity of the flexible coupling elements is typically the weakest link. The shaft diameter and the overall stress concentration must be considered to determine weak-link locations. Integral flanges are best suited for the motor and gear shaft ends as they have good torque capacity and fatigue characteristics.

Supercritical SCO_2 power cycles

Another tutorial by Timothy Allison, Manager of Rotating Machinery Dynamics at Southwest Research Institute (SwRi) delved into supercritical (SCO_2) power cycles. A fluid is considered to be supercritical if its pressure and temperature are greater than its critical values. This produces a very dense fluid, which acts both like a liquid and a gas. From a thermodynamic power cycle perspective, fluids such as SCO_2 can be superior to water and air, he said. Its higher density, means smaller equipment, lower costs, lighter weight and better enthalpy. SCO_2 takes less energy to compress, but when it expands, it produces an abundance of energy. Its low viscosity means there is little pressure drop in the system.


One of the many discussion group sessions at the Turbomachinery Symposium



Size comparison of 20 MW steam turbine with a 14 MW sCO_2 turbine

Steam turbine in ethylene service (Courtesy of Elliott Group)

SCO_2 power cycles offer high efficiency and power density relative to incumbent steam Rankine and air Brayton cycles for power generation over a wide range of applications, said Allison. These include waste heat recovery, concentrating solar power (CSP), geothermal, nuclear and fossil energy.

Above 500°C, SCO_2 is 2% to 4% more efficient than steam. Below that, a conventional Rankine cycle is probably a better option. As CSP deals with temperatures of up to 1,000°C, it is ideal for SCO_2. While many of these applications have not progressed beyond the laboratory stage, waste heat recovery has made the greatest headway with several commercial projects already operating.

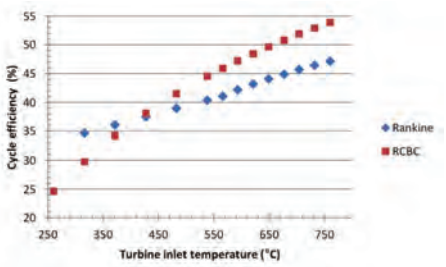
"Compact machinery reduces material costs and is beneficial in low space and potentially low weight applications," said Allison.

However, the combinations of pressure, temperature and density in SCO_2 power cycles lies outside the experiential base of existing turbomachines. Common challenges in the design of SCO_2 turbomachinery include rotordynamics, pressure containment, sealing, thermal management, and transient/off-design operation.

Steam turbines

Many large steam turbines (STs) are deployed in oil and gas applications. They are used to drive compressors and pumps, and produce electricity. The Prelude floating LNG vessel, for example, only has STs driving its compressors. STs in LNG were the norm until the eighties when gas turbines became more popular.

Within the sector, many different steam turbine conditions exist. What worked for one application may not be good for another. An ST in a refinery may operate at 40 bar and 400°C at less than 20 MW, whereas a cracked compressor in ethylene service may need steam operating at 100 bar, 510°C and 85 MW.



Efficiency comparison of steam Rankine and sCO_2 recompression Brayton (RCBC) cycles (DoE)

Condensing STs run below atmospheric pressure at their exhaust, while back pressure STs run above atmospheric pressure. Whichever type is involved, the API 612 standard requires sizing for worst steam conditions in power requirements.

"As a contractor, we don't want a totally new product, but at a minimum, a referenced part" said Emmanuel Bustos, Head of Rotating Machinery Department at TechnipFMC. "We check the casing and blades size, tip speed and existing applications, especially for the last blades."

Valve sizing

Controls dedicated to centrifugal and axial compressors require different valves, which are the final element in the control loop. These include anti-surge (recycle), suction throttle, hot gas bypass and quench control valves.

Wayne Jacobson, Global Technology Manager Compressor Control Corp. (CCC) explained the objective of each type of valve, its ideal location relative to the compressor and the optimum performance characteristics for the valve.

Anti-surge control valves, he said, are heavily influenced by piping layout as this influences controllability. The discharge volume of the compressor should be reduced to minimize the system's dead time and lag time.

"Make the distance as short as possible between the compressor and the recycle take off, and from there to the check valve," said Jacobson. He offered several tips: In multistage compressors, anti-surge valve calculations are more complicated and can lead to oversizing of valves downstream in multistage compressors.

When the impellers are matched, the surge limit line and the choke line will likely be covered by one anti-surge valve. Fast and precise stroking of the anti-surge valve is needed (two seconds or less stroke to time to open and close).

Tips on the use of suction throttle valves (STV) were also provided. As the STV closes, it creates a higher pressure drop across it. This causes the inlet pressure to the compressor to drop accordingly with the consequence that the pressure ratio across the compressor rises.

This causes the flow through the compressor to fall. For performance maps, closing the STV leads to the curve shifting vertically downward. This shift should not go down to the point where a surge can happen.

Another compressor session authored by Patrick Smith, Principal Engineering Associate at Air Products & Chemicals, offered strategies to prevent catastrophic compressor failures during transient operating conditions. "Simple changes in machinery condition monitoring, machinery protection and maintenance strategies could have prevented many failures," said Smith. "Hot gas bypass valves are needed when a machine trips."

API standards

Brüel & Kjær Vibro held a press conference on the evolution and application of API 670. Steve Sabin, Brüel & Kjær Vibro's SetPoint Product Manager, who served as secretary of 4th and 5th edition task forces, summarized the development of the standard since its beginning.

"If a standard is good, it will have many editions and updates," said Sabin. "The 6th edition will be coming out in a couple of years."

API 670 is an instrument standard measuring vibration. It highlights a major upgrade compared to the early days of putting a screwdriver on a bearing housing to listen for vibration. In those days, it was all about being outside and inferring what was going on inside.

Then along came Don Bently with the idea of putting proximity probes inside a bearing housing that could measure shaft vibration. Initial systems were complex, composed of many different cable lengths, each with specific parts.

In addition, the ST, gearbox and compressor of the same train had different

Edition	Date	Scope
1st	Jun 1976	Radial vibration and axial position systems using proximity probes only
2nd	Jun 1986	Added bearing temperature measurements
3rd	Nov 1993	Merged content from API 670 and API 678 (accelerometer-based vibration monitoring) into a single harmonized 670 standard and discontinued 678; added digital link for DCS / control system communications
4th	Dec 2000	Allowed for "blind" monitoring systems with DCS communications as primary HMI; allowed for 4-channel instead of 2-channel monitors; added reciprocating compressor measurements; added overspeed measurements
5th	Nov 2014	Added Safety Integrity Level (SIL) content; added recip annex; added condition monitoring annex; added wireless content; added surge detection and emergency shutdown (ESD) systems

probes and systems. API 670 was introduced, in part, to provide standardization and simplification. The first version specified how many sensors were needed and where so OEMs could standardize (Table).

"API standards reflect acceptable operating practices rather than catering to the least common denominator," said Sabin.

The 6th edition is likely to include changes related to SIL, wireless guidance, cybersecurity, rolling element bearing monitoring, cylinder pressure sensors, and overspeed enhancements.

"Wireless is good for condition monitoring but is not yet good enough for safety systems," said Sabin. "Wired systems are still the standard for machinery protection."

Range versus efficiency

Striking the proper balance between range and efficiency was the topic of choice by Jim Sorokes, Principal Engineer at Dresser-Rand, a Siemens business.

"A balance between peak attainable efficiency and overall operation range must be addressed when specifying, designing and selecting centrifugal compressors," said Sorokes.

Engineers, overly dependent on computers and CFD data, can occasionally become lost in a computational haze, he said. Such data must be interpreted correctly against the fundamentals of aerodynamic design.

Compressor user requirements can be widely variable because there are many styles, each with a different performance characteristic.

"Range and peak efficiency are typically mutually exclusive," said Sorokes. "You can attain high peak efficiency at the expense of flow range or vice versa. But in most cases, it is a compromise."

Component designs are based on the choices made: impellers, guide vanes and diffusers. However, the impeller is by far the most critical decision, followed by the guide vane.

Users and designers, then, must compromise between machine requirements and what the OEM can deliver. To achieve that, both should each a strong agreement on nomenclature.

For example, one party might be talking about turndown while the other responds about aerodynamic stability. Therefore, it is important to define terms and not make any assumptions. Another example: different flow coefficients used within the same firm — one by the European branch that was different from what was used in the U.S. ■

Vaned diffuser

The exhibition hosted 359 companies and spanned 216,000 square feet

DISTRIBUTED GENERATION RULES POWERGEN

CONVENTIONAL POWER SOURCES, SUCH AS COAL AND NUCLEAR ARE BEING DISPLACED BY RENEWABLES AND BATTERY POWER

BY DREW ROBB

The annual PowerGen International show has traditionally been the showcase for large power plants. Coal facilities and more recently, combined cycle and natural gas-driven peaking plants have been the focus. But that changed this year with distributed generation (DG) stealing the spotlight.

The concept is simple. Instead of large centralized plants, localized pockets of power generation predominate to replace or augment these facilities. These include wind, solar, combined heat and power (CHP), and battery systems. These resources can operate as part of the overall grid, as a separate power island, or as backup power. Further, groups of DG assets are collaborating to create micro-grids to serve specific areas.

This is turning the power market on its head. Yes, large plants will continue to be built, but their frequency will probably lessen. However DG is gathering momentum. A couple of years back, the idea was to support renewable resources with large, flexible gas turbine plants that could come online rapidly as wind and solar capacity dropped off the grid (*Turbomachinery International*, May/June 2017, p. 24). Now, it is up to the GT marketplace to find a role within DG. This will probably involve smaller GTs operating as either backup power, for rapid start and stop, or when favorable prices prevail.

Companies, such as Mitsubishi Hitachi Power Systems (MHPS), OSIsoft, Rockwell Automation, Wärtsilä, Hydro Quebec, Beaufort Rosemary, Pacific Power and SVG Consulting had plenty to say about distributed generation during the show.

The PowerGen exhibit floor included over 1,100 booths

Keynotes

The 2017 PowerGen show took place in December in Las Vegas. A 1,100-vendor exhibition and 60 technical sessions anchored the show. Several keynotes kicked things off.

Dr. J Patrick Kennedy, CEO and Founder of OSIsoft, took up DG. He zeroed in on the data-intensive nature of trying to efficiently manage solar, battery storage, fuel cells, and traditional generation systems.

"Things are heading towards the creation of community systems or grids," said Kennedy. "But this trend is being held back by problems related to who owns the data."

For example, is the data coming from a smart meter, owned by the utility, or the home or business owner? Is power plant data about turbine operation owned by the plant or the OEM?

"Ownership rights for data have to be established for distributed generation to realize its potential," he said.

Cost and data management are also serious concerns. Billions of sensors are being added to components, equipment and facilities, added Kennedy. But any analytics engines seeking to harness this information must be cost effective. That requires the establishment of multiple tiers of data. Some tiers will be based in the cloud, others within the plant or fleet, and others will be in the hands of small DG assets.

"If everything comes to one point, you receive too much data too fast," said Kennedy. "You have to build a toolset that allows many different data sets to be analyzed at various points in the value chain. Cloud providers are already making these tools available in ways that may be more cost effective than building your own."

Replacing outdated infrastructure and legacy controls increases productivity, according to Blake Moret, Rockwell's CEO and President. By adding software tools to the Eight Flags CHP Plant in Fernandina, FL, for example, Rockwell Automation was able to quickly collect and interpret data, resulting in increased efficiency, he said. "We are seeing the convergence of IT and Operational Technology (OT)," said Moret. "IT used to be separate from the processes on the plant floor, but that is changing."

Moret does not believe everything should go to the cloud, however. Some functions will go there while others will remain on-site. But he foresees more analytics at the smart device level, and being able to add insight across multiple facilities. The benefits are said to include lowered down-

time, faster response to market demand, improved plant availability, greater regulatory compliance, reduced operational costs and secure access to IT and OT systems.

"It all starts with real-time data on voltage, kWh, running time, temperature and vibration," said Moret. "That is turned into useful information which has context in terms of energy. Only when you have that can analytics come into play."

The power market is undergoing rapid change, according to Paul Browning, President and CEO of Mitsubishi Hitachi Power Systems Americas (MHPSA). In the developed world, the levelized cost of solar and wind have fallen dramatically, he said. Over the past decade, wind power has experienced a 12% per year drop, while the price of utility-scale photovoltaic (PV) solar has been going down at 20% per year.


Paul Browning

What has been largely unnoticed, though, is that natural gas combined cycle power has decreased 12% per year over the past ten years. Part of that is due to new drilling technologies that have resulted in a 70% reduction in the price of gas, part from a 30% reduction in the $/KW installed cost of large combined cycles, with the rest coming from significant efficiency gains. Browning cited a price for a 50%-50% mix of gas and renewable power costing $41 per MWh and being 85% more carbon efficient than retiring coal-fired power.

The Grand River Dam Authority's (GRDA) Grand River Energy Center 3 in OK is a 505 MW example of this mix of renewables and natural gas. It is a combined cycle power plant (CCPP) equipped with a MHPS M501J GT, operating at 62% efficiency. The plant replaces an aging coal facility and works in conjunction with the abundant wind energy resources that are present in Oklahoma.

"Retiring old coal and adding a carbon-efficient combination of gas turbines and renewables, is the way forward," said Browning.

In the developing world, the picture is a little different. There, said Browning, buyers used to gravitate towards older technology. However, now they are opting for the newest and most efficient products available, including a big shift to more affordable Liquefied Natural Gas (LNG). Its price has dropped in some parts of Asia from $16 to $8 per million BTUs.

While many carbon capture, projects have underperformed in Europe and North America, he highlighted the recent success of NRG's Petranova project in Houston.

Carbon capture will be a critical issue in Asia, due to the presence of newer coal plants in the region. Utilities in Asia need to recoup their investment, while in the developed world, they are more willing to retire aging facilities.

Browning sounded a positive note about the North American market, which is shifting from the F-class to next-generation turbines. Along with higher inlet temperatures and pressures, these machines are more intelligent and more connected. They include analytics functions and the ability to create digital turbines which are an exact mirror of their physical equivalent.

"The physical and digital turbines travel together through the lifecycle of the machine to help predict what will happen in the future and to streamline maintenance," said Browning. "Thus, we are transitioning from real-time monitoring to complete operations and maintenance support, as well as performance optimization at the fleet level. Eventually, we will arrive at autonomous operation across the entire generating portfolio, under automatic grid control."

The cost of wind and solar is now comparable with coal and natural gas, said Stefan Bird, President and CEO of Pacific Power, He advocated regional diversity to lower risk from intermittent resource generation.

The need for regional diversity is apparent when you consider that the grid is gradually becoming more unified. Pacific Power, for example, is partnering with the California Independent System Operator (CAISO) and others to create a unified western energy market (back in 2014, the Western U.S. consisted of 38 relatively independent balancing areas). By adding software, integration and analytics between the system nodes, greater efficiency is possible.

California has invested heavily in renewables and at times, produces more solar or wind power than it consumes. With a unified grid, fossil facilities in Oregon could be throttled down with California handing off its excess power to the Pacific Northwest. Similarly, California could call on natural gas or coal resources outside of the state due to a rapid drop in renewable generation.

"Pacific Power is adding digital controls to make coal more responsive," said Bird. "This will enable operators to fine tune its operating range, double its ramp rate and improve coal economics."

DG investment

Traditional utilities should consider investing in DG assets, such as localized generation of solar and wind, instead of installing

new substations or adding new circuits, said Subbarao Govindaraju, President of SVG Consulting.

"Instead of building transmission lines and substations to bring the power to load areas, establish localized generation at the distribution level, beside or within the load areas," he said.

That means changing power generation from being a one-way flow from the provider to the customer, to being bi-directional. But, in turn, that brings up safety and reliability issues for the electric network that must be addressed.

"Utilities need to be able to monitor, predict and control distributed generation sources," said Govindaraju. "Each type of DG has different parameters."

Such assets installed on the grid will provide additional intelligence to planners, engineers and operators to help them manage the grid more efficiently. This control is feasible through added automation that helps manage the precise orchestration of various assets to manage emerging grid conditions.

Large amounts of data must be processed to make automated decisions or rapidly provide options to the operator on possible next steps. Ultimately, however, many of these decisions need to be automated.

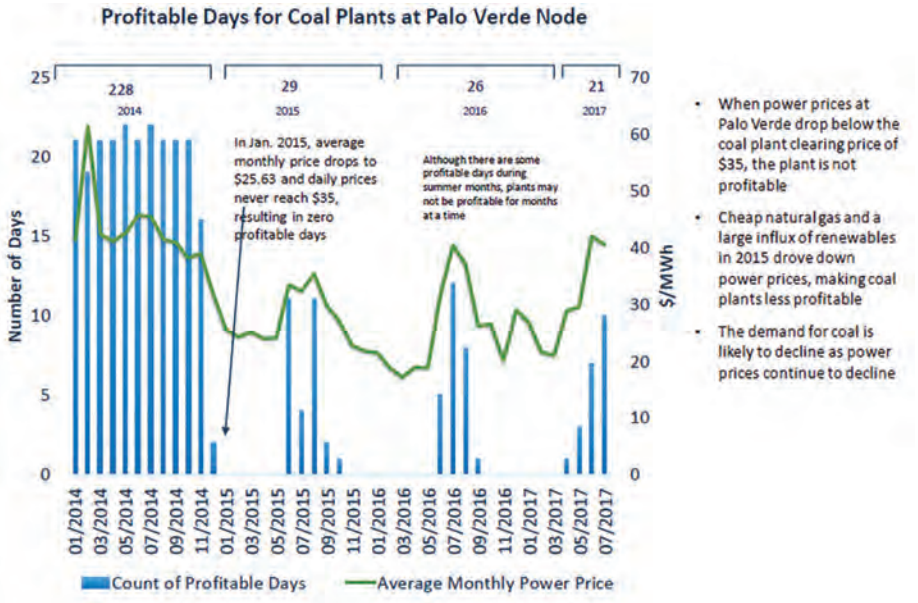
"Data must be collected and communicated to back-office systems in near real time for proactive control," said Govindaraju. "Technology needs to be revamped to accommodate and act on the additional intelligence being obtained from grid assets."

He called for greater investment in planning and operations system, load and DG forecasting, power flow optimization, high-speed communications, cybersecurity, integration of customer and grid technologies, and substation modernization.

The DG theme continued with Kevin Casey, Managing Director at energy consultancy at Beaufort Rosemary. He covered the challenges inherent in expanding the quantity of small distributed energy resources, such as solar, wind, batteries, CHP, hydro, fuel cells, microturbines and the microgrid. They add value that goes beyond the MW they produce: ancillary services, grid independence, and lower or more predictable costs in some cases.

However, traditional large-scale power developers typically do not do well developing resources, such as residential solar. Despite steadily falling prices, existing regulatory constructs and financing options can hamper the expansion of DG.

Take the example of microgrids. Facilities, such as data centers, hospitals, military bases, research labs, and fire stations are among the leaders because they value energy independence, redundancy and reliability.



Back in 2014, the Palo Verde coal plant in Arizona was profitable 228 days of the year. In 2017, that fell to only 21 days.

"They are on the cutting edge as they are willing to pay more for reliability and redundancy," said Casey. "But microgrid reliability may require potentially complex integration and that probably requires utility assistance."

Market shifts

"The American utility industry is in the midst of an energy transition," said Matti Rautkivi, Director of Marketing and Sales at Wärtsilä. "Traditional baseload capacity (coal and nuclear) is being replaced by renewables and flexible gas capacity."

Two-thirds of added capacity last year came from renewables, he said. While that was mainly wind, solar is coming on fast and will probably take the lead. The dominance of renewables should continue as the price per MWh continues to fall.

This is causing havoc with fossil generation, particularly coal. PSEG, for example, has shuttered its last coal plant, said Rautkivi. Similarly, Luminant has recently shut down some of its large coal plants, and the coal plants in Arizona are finding it almost impossible to operate profitably See the figure above.

It boils down to simple economics, as the coal plants are running less and not able to cover their costs. And with renewables becoming "the new baseload," coal plants have to deal with a lot more cycling.

"Even combined cycle gas is struggling," said Rautkivi."

PNM, a utility in New Mexico found the cost of CCGTs would have to be less than $250 per kW to make economic sense. Most CCGTs come in at anywhere from three to four times that.

Wärtsilä, meanwhile, is hoping to gain from these market forces by offering flexible power options using its reciprocating engines, while also expanding into energy storage business via its subsidiary, Greensmith.

Wärtsilä and Tucson Electric Power have agreed on 10 x Wärtsilä 18V50SG natural gas engines to be installed at the H. Wilson Sundt Generating Station in Tucson, AZ. The project will provide 200 MW of flexible capacity to integrate more renewable energy.

The utility is also investing in solar power resources. Greensmith is helping Tucson Electric with the development of a solar plant combined with batteries to produce power at a cost of 4.5 cents per kWh.

"We see ourselves more as an integrator to gain flexibility rather than as a company that is selling engines," said Rautkivi.

Sacramento Municipal Utilities District (SMUD) is also investing in solar and battery power. According to Nancy Bui, Member of the SMUD Board of Directors, it intends to install 75 MW of battery storage over the next ten years as well as more solar resources.

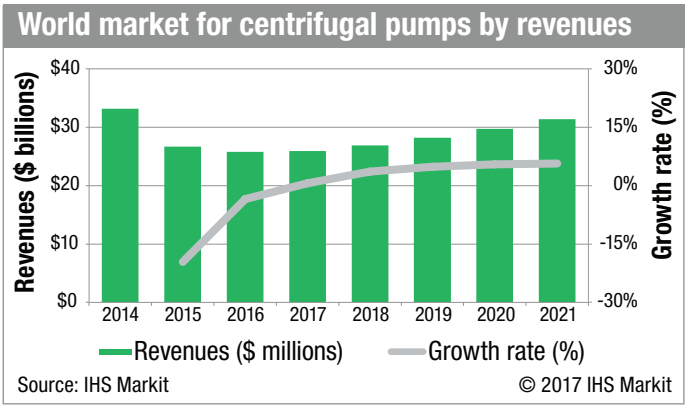
While battery technology still has a way to go in terms of cost, reliability and time of storage, Hydro Quebec believes it has the solution. It is positioning its hydroelectric resources as the battery for the East of Canada and the Northeast U.S.

"We offer a huge reservoir of power which can act as the battery for New England, Ontario and New York," said Gary Sutherland, Director of External Relations, Hydro Quebec. "We are able to provide electricity at a cost of 6 cents per kWh." ■

AFTERMATH OF THE GLOBAL OIL CRISIS

OPPORTUNITIES EMERGE FOR PUMP SUPPLIERS AS THE MARKET STRUGGLES TO RECOVER

BY JOANNE GOH



Centrifugal pump demand from the oil and gas sector has plummeted, but that could soon be changing

The latest Centrifugal Pump Database from IHS Markit shows that the global centrifugal pump market at $25.8 billion in 2016, down 3.4% from 2015. Current revenue is forecast to grow at a 4.1% compound annual growth rate (CAGR) to $32 billion by 2021. The market is not expected to reach 2014 revenue levels until 2021.

The oil and gas industry collapsed towards the end of 2014, which led to revenue declines for several major pump suppliers heavily exposed to the energy sectors. Manufacturers that rely on the commercial and domestic markets gained market share, as these industries outperformed the overall average.

New project announcements for both the upstream and downstream industries dropped 5% from 2015 to 2016, and project-detailed design activity in engineering, procurement, and construction (EPC) firms was low.

With significantly decreased order activity, the average selling prices (ASP) for all types of equipment used in the oil and gas industry declined sharply, including the ASP of centrifugal pumps, estimated to have declined by about 10.7% from 2015 levels.

The centrifugal pump market in oil and gas applications continued to decline in 2017, with revenues down 8% from 2016. Despite a recent recovery in oil prices from a low point in January 2016, IHS Markit expects the OPEC price is unlikely to rise above $60/bbl in 2018.

Investor confidence has not fully recovered; therefore, the demand for centrifugal pumps remains subdued. The forecast is for slight growth of about 1% for centrifugal pump revenues in 2018.

On the other hand, onshore upstream capital expenditure (CapEx) increased by 16% in 2017, leading to stronger upside demand for centrifugal pumps in this application. The centrifugal pump market in onshore upstream applications will have the fastest growth among other oil and gas processes, with revenue growth of 5.1% predicted for 2018.

Urbanization and population growth

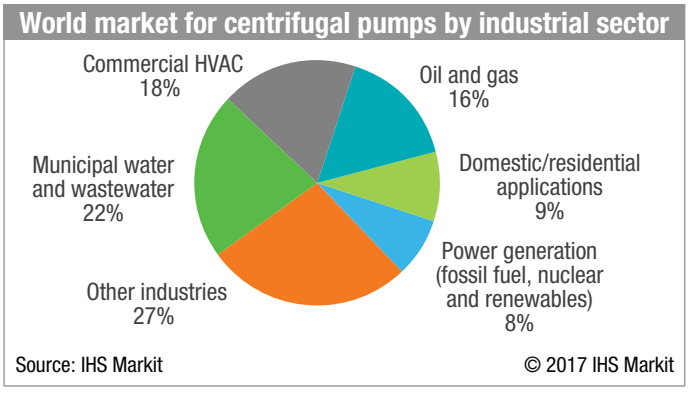
While centrifugal pump demand in many regions and industries declined, high-performing markets, such as commercial HVAC, domestic, and municipal water and wastewater sectors offset the losses in 2016. This acted as a counterbalance against the decline in oil and gas in recent years.

The commercial HVAC market for centrifugal pumps is forecast to expand quicker than other industries. Growth of the centrifugal pump market in this sector will grow the fastest in the Asia-Pacific region. The Philippines and Vietnam are expected to be the fastest growing countries in 2017 and 2018, a result of rapid expansion in technology and manufacturing sectors.

Europe, the Middle East and Africa will experience an increase in commercial building construction, spearheaded by Qatar and its preparations for the upcoming World Cup, as well as an initiative to diversify its economy. Furthermore, rapid urbanization and infrastructure development in the Middle East continue to increase demand for pumping systems.

In the municipal water and waste water section, growth opportunities are mainly in emerging countries, driven by rapid growth in industrialization, despite the lingering financial and global economic crisis in many regions.

The same goes for the centrifugal pump market in the food and beverage sector; developing markets in Asia-Pacific continue to be the backbone of market growth. Urbanization and the growing number of restaurants, restaurant chains, and fast food centers, along with the increased number of food processing facilities, create increased opportunities for centrifugal pumps in food and beverage on a global level.

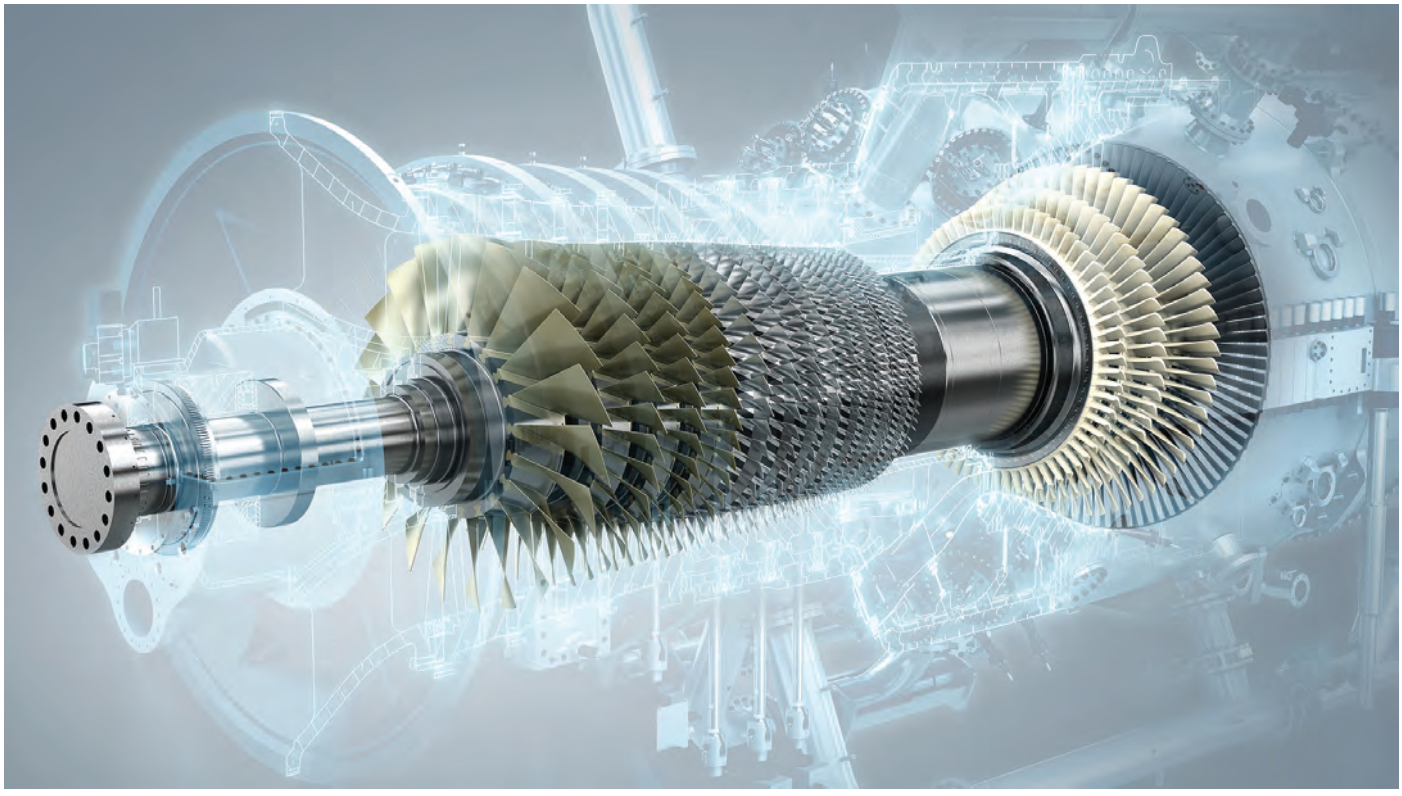


Centrifugal pumps are in highest demand in the water industry, followed by commercial HVAC and oil & gas

Competitive environment

Mergers and acquisitions will increase as larger centrifugal pump companies acquire smaller companies due to strong competition and fluctuating commodity prices. ■

Joanne Goh is a Manufacturing Technology Analyst at IHS Markit, a market intelligence provider for industrial automation equipment, with an expertise in motors and motor controls. For more information on the centrifugal pump market, visit https://technology.ihs.com/582278



VIRTUAL PROTOTYPING

USING 3D MULTIPHYSICS-BASED VIRTUAL PROTOTYPING TO IMPROVE GAS TURBINE EFFICIENCY AND RELIABILITY

BY CHAD CUSTER

Gas turbines (GTs) must be designed to produce energy as efficiently as possible, with components that must sustain reliable operation under extreme conditions. Complex aerodynamic and thermodynamic interactions are a major determinant of a turbine's performance. As such, flow and thermal analysis methods are fundamentally important to the design process.

Some analysis methods rely on 1- and 2-dimensional correlation-based approximations. These approximations limit the accuracy of temperature predictions. 3-dimensional computational fluid dynamics (CFD) simulations can be used to predict complex flow fields and turbine blade metal temperatures accurately. This can be of assistance in improving gas turbine design.

Harsh environments

Turbine blades operate in harsh environments, with temperatures significantly higher than the melting point of the blade metal. Efficient operation relies on cooling provided by air routed through internal passageways.

The goal of cooled turbine blade simulation is to accurately determine metal temperatures throughout the blade. These temperatures and the predicted aerodynamic loads allow for stress predictions to be performed. This helps establish the durability of the blade.

The following analysis methods are used to predict the temperature of a candidate blade design:

LEGACY DESIGN SYSTEM

In this method, internal and external turbine blade flow fields are approximated using 1D correlations obtained from experimental data and simple relations. Results are used as inputs to a 3D finite element analysis (FEA) to predict blade temperatures.

The process begins by specifying the cooling air being delivered to the blade and the aerodynamic conditions the blade will experience (boundary conditions). Additionally, a blade wall temperature is assumed.

These data are used to determine the internal and external flow field. They provide the necessary boundary conditions for a 3D FEA analysis, which will result in a blade surface temperature distribution.

This analysis cycle is repeated until the predicted blade surface temperature agrees with the assumed input (Figure 1). Each iteration is fast due to the simplicity of the models used, but accuracy can suffer.

The correlation methods also rely on engine test data for correlation, meaning that experiments must be performed and only designs like those tested can be considered. Additionally, the analysis process relies on the maintenance of multiple tools, and the transmission of data between tools.

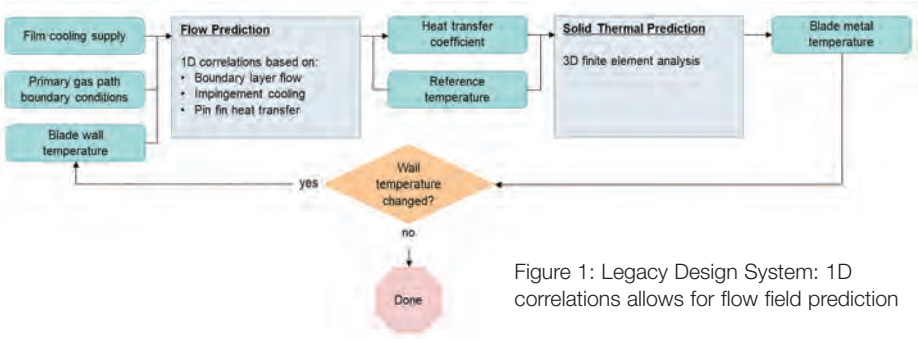


Figure 1: Legacy Design System: 1D correlations allows for flow field prediction

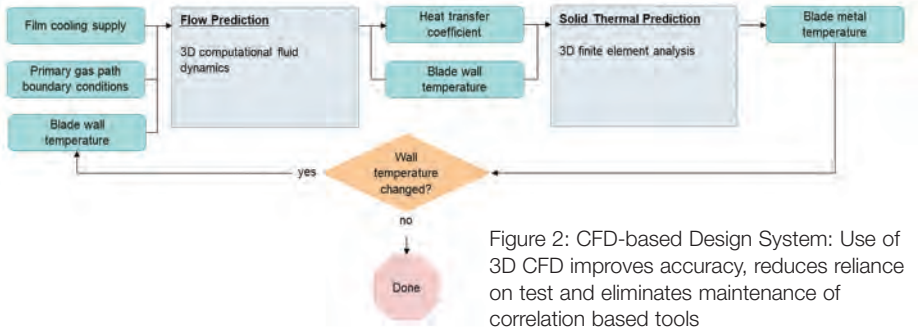


Figure 2: CFD-based Design System: Use of 3D CFD improves accuracy, reduces reliance on test and eliminates maintenance of correlation based tools

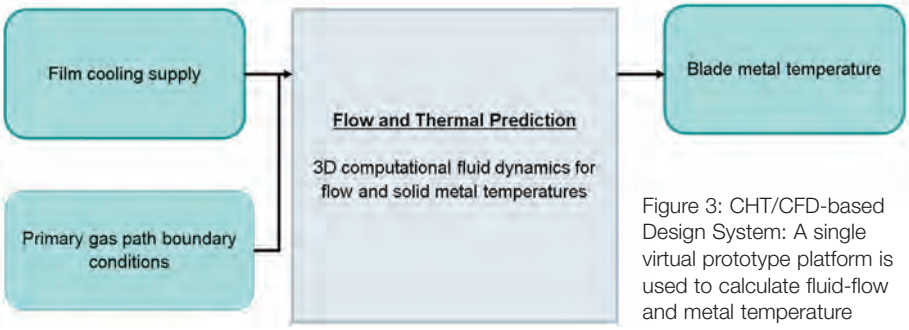


Figure 3: CHT/CFD-based Design System: A single virtual prototype platform is used to calculate fluid-flow and metal temperature

CFD-BASED DESIGN SYSTEM

In this method, correlation-based flow field predictions are replaced by separate 3D CFD simulations of the internal and external blade flow paths. Results are used directly as inputs to 3D FEA analyses to obtain metal temperatures.

The use of CFD allows 3D effects to be captured and accounted for in design iterations, reducing the reliance on prototype testing. The simulations of the internal and external flows can be performed simultaneously, but are not tightly coupled (Figure 2).

The workflow has not changed from the legacy design system. The only change is that the correlation methods used for flow-field prediction have been changed to physics-based CFD models. Accuracy and design capability are improved, but the workflow remains cumbersome and error-prone.

CHT/CFD DESIGN SYSTEM

It is possible to perform the entire analysis within one virtual prototype platform, if the platform can compute the heat transfer between the solid and fluid domains as part of the CFD simulation.

This is commonly referred to as Conjugate Heat Transfer or CHT. This approach provides more accurate results and a simplified workflow. A single 3D multi-physics simulation can model the aerodynamics of the internal and external flow fields, as well as solid conduction. This shortens design time (Figure 3).

Validating the design system

Validation of the CHT/CFD methodology occurs in two stages. Simulations of individual turbine blade features are compared against experiments to determine best practices for subsequent simulations. Further simulation of blade geometry under engine operating conditions use these best practices.

Predictions are compared to experimental data from engine tests to verify accuracy. Tests are done, for example, on single and multi-jet impingement, flow through ducts with ribbed surfaces to promote convective cooling (called turbulated ducts), and pin fins using measurements of the solid blade temperature of an H-class engine's vane 1.

The relative difference between the predicted and observed temperatures has a maximum deviation of 8%. Thus, the integrated CHT/CFD workflow is capable of accurately predicting turbine blade metal temperatures.

The 3D multi-physics-based approach represents a more accurate characterization of the system, enabling engineers to analyze and explore novel concepts beyond the scope of correlation-based methods. ■

Dr. Chad Custer is Product Manager, Gas Turbines, at Siemens PLM Software. For more information, visit www.plm.automation.siemens.com/global/en/

Today's turbines operate under demanding conditions. This places heavy stress on lubricants.

UPGRADING TURBINE LUBRICATION TO REDUCE TCO

THE SELECTION AND MANAGEMENT OF TURBINE OILS IS CRITICAL TO THE AVOIDANCE OF DOWNTIME

BY DR. VOLKER NULL

Today's power generation turbines are working under more demanding conditions than ever — from continuous 24/7 running to frequent stop-start cyclic operation. Turbine oils must be able to cope with difficult requirements, such as heavy stress, the need to reduce downtime, extended oil-drain intervals, hotter temperatures and higher loads.

Greater turbine output power, combined with lubricant reservoirs of the same size or smaller, is also imposing more rapid cycle times on lubricants, resulting in the need for optimized surface properties.

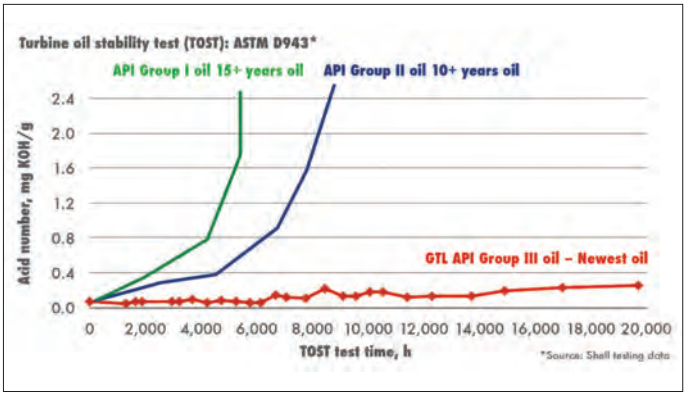
The ratio of megawatt output to oil volume gives a good indication of oil stress. The latest machines are seeing increases of up to 400% in oil stress. This impacts the types of lubricants required by power-generation customers. Whether gas, steam or hydroelectric turbines, the number of rapidly rotating metal surfaces generates high temperatures that can cause protective oils to degrade. This opens the door to metal-to-metal contact and abrasive wear.

The type of turbine, along with operating conditions and lubricant quality, can affect the frequency of oil changes. Steam turbines run under high temperature and moist operating conditions. Gas turbines run under hotter temperatures, but typically without moisture. In the past, different turbine oils were developed for each application.

Lubricant developments

Developments in base oil technology have been achieved with the gas-to-liquid (GTL) process. Production of Shell GTL base oils begins with gasification, where the methane from natural gas reacts with pure oxygen to produce synthesis gas.

The synthesis gas is fed through a reactor and converted to a liquid called syncrude. The liquid is fed into a hydrocracker to



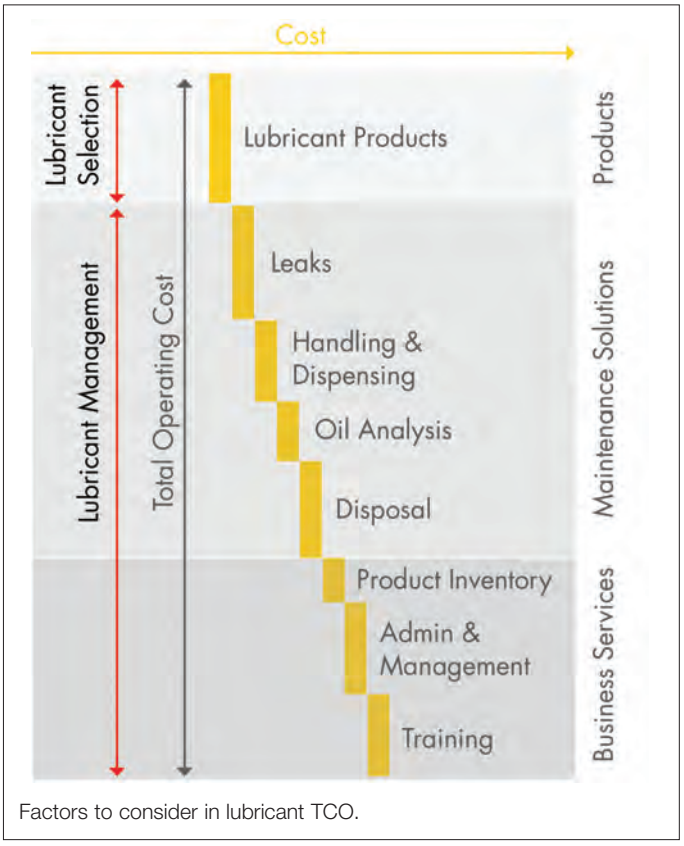
Comparing the oxidative stability of different oils. Turbine Oil Stability Test (TOST) life provides a measure of how quickly different oils degrade under severe conditions. As turbines have developed, oil has improved. Twenty years ago, turbine oil might have been expected to last to around 5,000 hours, whereas today it lasts >10,000 hours.

break down molecules and form new ones and the new molecules are distilled into GTL base oils for use in finished lubricants.

The result? The GTL process transforms natural gas into liquid and solid hydrocarbons with high purity. Pure hydrocarbon base oils are created with a narrow molecular distribution, a high viscosity index and a low level of contaminants (such as nitrogen and sulfur). These GTL base oils respond well to performance additives, enabling the production of turbine oils with good performance even under severe operating conditions.

Compared with conventional mineral oil-based turbine oils, this new class of lubricants slows down the rate of oxidative and thermal degradation. In addition, these oils release air faster, resist foaming and separate water more rapidly.

They also minimize the formation of oil-insoluble degradation products, such as varnish that can deposit on valves and filters and prevent the turbine from starting. GTL-based turbine oils typically exceed original equipment manufacturer (OEM) specifications.



Factors to consider in lubricant TCO.

They can offer high performance, enhanced asset reliability and the potential for turbine life extension. Users report significant Total Cost of Ownership (TCO) savings over the lifetime of the equipment compared to traditional lubricants.

Even with a high-quality GTL oil, however, contamination control remains a vital ingredient. How the lubricant is stored, handled and transported through the site impacts the likelihood of contamination.

Storing drums in a sheltered place and wiping the top clean before it is opened will help limit the risk of contamination by water and particles. Filtration can also help to ensure product cleanliness before oil enters the equipment.

Regular lubricant monitoring and analysis is another way to keep the lubricant functioning well and fit for purpose. It can provide early warning of turbomachinery malfunction, wear or lubricant degradation.

The lubricant can then be changed before issues escalate. Operators are advised to pay attention to lubrication management best practices, including monitoring, analysis and staff training. ■

Dr. Volker Null is Shell Global Product Application Specialist, Turbine Oils. For more information visit www.shell.com/lubricants

RELEVANT POWER SOLUTIONS LAUNCHES MOBILE GENSET

Richard Wolf, President & CEO of Relevant Power Solutions, discusses this new startup venture and the launch of a new 45 MW mobile gas turbine generator product.

Tell us about the formation of Relevant Power Solutions.

Relevant Power Solutions is a privately owned startup with its two shareholders being S&W Energy Solutions and Luther King Capital Management. S&W Energy Solutions began working with Rolls Royce gas turbines during 2012 to provide support and technical assistance for the Trent gas turbine generator set program.

After Siemens acquired the industrial gas turbine business of Rolls Royce, S&W expanded its role by providing balance of plant (BOP) equipment for Trent projects worldwide. In 2017, Relevant Power Solutions was formed to further expand the collaborative arrangement between Siemens and S&W Energy.

How does the arrangement work with Siemens?

Siemens wanted a large mobile gas turbine generator in its product lineup. The SGT-A45 was developed for this purpose. To build the SGT-A45 gensets, Siemens manufactures the gas generator and power turbine hardware in Montreal. The GT is shipped to Relevant Power Solutions in Houston for trailer mounting, package assembly and genset testing prior to shipment. Relevant Power Solutions also provides balance of plant solutions for Siemens' gas turbine business on a project basis.

What can you tell us about the SGT-A45?

The industrial Trent 800 gas generator is a two-shaft gas generator that Siemens uses for the land-based SGT A65 genset rated at 65 MW. However, the weight of a 65 MW trailer mounted genset exceeds the practical limits of highway transportation. We calculated the practical upper limit to be 45 MW.

Siemens engineers figured out that by removing the booster compressor from the Trent 800, the air flow through the gas turbine would be just right for a 45 MW product. This was a match for the existing RB211 power turbine, which was already developed and utilized for power generation and marine service. The entire flow path of blades, vanes and combustors is identical to the ongoing production line with no prototype hardware.

What is the ISO rating of the SGT-A45?

At an ambient temperature of 15°C and sea level elevation, the SGT-A45 is rated at 44.0 MW at the generator terminals with 40.4 % conversion of fuel input (LHV) to 60Hz electricity. For 50Hz applications, the rated output is 41.0 MWe with 39.0% efficiency. The gas turbine is physically identical for 50Hz and 60Hz applications. In addition, all the motors, controls and instruments on the package are dual-rated for 60Hz and 50Hz. To change the product from 50 Hz to 60 Hz or vice versa is a simple software toggle.

Tell us about the electric generator.

The gas turbine drives the electric generator directly with no gearbox. It is the same generator for 50Hz or 60Hz projects. It's a two-pole utility grade air cooled design with brushless excitation. The generator air filter is set directly atop the generator compartment.

How do you plan to differentiate your product?

The SGT-A45 has a much smaller footprint per MW and a lower fuel consumption rate. Power output and fuel efficiency do not fall off at high ambient conditions (mobile gensets are often delivered to job sites with hot ambient temperatures).

Water is generally not available for evaporative cooling, so the electricity that you produce is what the GT can deliver with no boost from external cooling. Even though all units will be capable of operating on natural gas fuel or diesel fuel, most project are forced to run on expensive diesel because natural gas is rarely available in remote areas. In short, fuel efficiency matters when you are operating base load, simple cycle on liquid fuel.

What are its service intervals?

The service interval for the SGT-A45 will be extended to 25,000 hours for liquid or natural gas fuel. This is possible as the gas generator is operating at less than the 65 MW capability of a Trent 800. Reduced firing temperatures associated with its 44 MW output will mean longer hot section life.

The lower firing temperatures also allow the SGT-A45 to avoid a four-hour "restart lockout" often associated with other mobile gas turbine gensets. If the grid goes black and forces the GT to be taken off line, the SGT-A45 can restarted as soon as the grid is re-stabilized.

What is your go-to-market plan?

For those that want to purchase the SGT-A45 mobile genset, contracting will be handled by Siemens. If leasing is desired, Relevant Power Solutions with be involved. For practical purposes, a one-year lease term is the minimum for a mobile genset of this size.

When will it to go into service?

The first SGT-A45 is on the test stand. We will load test every unit before shipment. The product is designed to fit into an air cargo carrier for rapid deployment. Genset #2 is in the advanced stages of manufacturing and packaging. ■

The Atlas Copco TurboBlock fuel gas booster

Fuel gas booster

With an Atlas Copco centrifugal compressor at its core, TurboBlock is a standardized fuel gas booster option. It boosts the fuel gas pressure through single or multiple stages to create the pressure needed in the GT combustion chamber. TurboBlock core seal systems have been upgraded by reducing porting and nitrogen usage, and simplifying the seal support system. Thanks to a compact base frame, a separate oil tank, a single plate and frame oil cooler, piping reductions and simplified components, the booster's footprint is smaller than those of its customizable counterparts.
atlascopco-gap.com

3D printer

GE Additive unveiled the first Beta machine developed as part of Project Additive Technology Large Area System (ATLAS). The laser powder-bed fusion machine provides manufacturers with large 3D printed parts and components.

Suited to industries that require complex metal parts, such as aviation, automotive, space and oil and gas industries, the first models are being evaluated by a small group of customers and will be more available for delivery in 2018. It can scale to components more than 1 meter in length.
ge.com/additive

Degreaser

Madison Chemical has introduced AquaBlue alkaline detergent for removal of dirt, oil, grease, sulfurized cutting oils or metalworking fluids from a wide variety of surfaces. With penetrating and wetting properties, this water-based cleaner and degreaser can be used as a spray, as a soak, and with pressure washers. It provides improved results with less concentration. Safe on ferrous, stainless, aluminum and zinc alloys, it reduces the negative effects of over-use and multiple cleanings.
madchem.com

Axial compressor

MAN Diesel & Turbo has introduced a turbomachinery concept for the fertilizer industry which raises production efficiency of nitric acid. The NAMAX is a type AG-MAX1 axial compressor. While previous concepts used an intermediate gearbox to couple the machines in the train, NAMAX is direct drive and needs no gearbox. This allows efficiency to be boosted by several percentage points and operating costs for HNO3 production to be reduced.

Besides its MAN MAX1 air compressor, the NAMAX concept consists of: a centrifugal compressor for NOx compression, a MAN steam turbine and a MAN axial expander. Grupa Azoty in Poland will use it to expand its fertilizer production in Pulawy, in eastern Poland.
dieselturbo.man.eu

Cybersecurity

Tenable and Siemens are co-developing a new solution for industrial asset discovery and vulnerability management. At a time when the risk of cyberattacks against critical infrastructure has grown exponentially, the partnership is delivering as a service to help companies secure and protect critical assets.

The stakes have never been higher when it comes to cybersecurity for critical infrastructure. The number of cyberattacks worldwide continues to grow, with the industrial sector becoming a growing target, now comprising 30% of all cyberattacks, with a major impact on productivity, uptime, efficiency and safety, according to recent research conducted by Ponemon Institute.
Siemens.com

Emerson Ovation OCC100 controller

New controller

Emerson has launched automation technology for utilities and independent power producers that rely more on renewable energy sources and the fast-growing microgrid market. The modular Ovation OCC100 controller manages the flow of energy from various sources to ensure reliable generation for these emerging industries. Its small footprint is also well-suited to critical water and wastewater applications.

With renewable electricity capacity expected to expand by over 920 GW through 2022, according to a 2017 International Energy Agency report, the OCC100 controller is attractive to power generators that rely on a variety of distributed energy resources.

The OCC100 offers remote monitoring and control capabilities for wind farms spread out over a wide geographic area and the ability to operate in the higher ambient temperatures associated with solar facilities. For microgrids, it provides a single point of control for performance optimization. Similarly, the new controller efficiently monitors and controls remote pump stations critical to collecting, treating, storing and distributing water to homes and businesses.

(Continued on p. 30)

Luneta headline

Luneta, a developer of machinery lubricant inspection technology for machine condition monitoring and reliability, has announced the release of the Bowl. It serves as both a sight glass, and a bottom sediment and water bowl. Made of impact-resistant Tritan, it is stronger than other drain port sight glasses, crystal clear and chemically resistant.

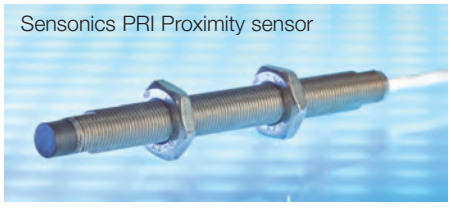
The contour design allows for immediate visual inspection of the oil, along with early detection of potential contamination problems. Its rare earth magnetic drain plug protects machinery by attracting and drawing wear particles to the bottom, preventing machine failure and enabling a drain of contaminants.

luneta.com

Middle East GT filter

Clarcor Industrial Air has released the Clearcurrent PRO SP+ cartridge filter for gas turbines (GTs) in the Middle East. It offers superior dust-holding capacity and pulse-ability, as well as low operating differential pressure (DP). The PRO SP+ filter uses flexible pleats that release dust and debris better than standard filters. The harsh conditions found in the Middle East require a filter that maintains its DP for as long as possible to keep GTs operating normally. The pulse-ability of the PRO SP+ allows it to have lower DP across the life of the filter.

clarcorindustrialair.com



Proximity sensor

Proximity probes play an important role in machine shaft vibration, position and speed measurements, providing operators information on the rotating plant dynamic performance and bearing condition. Sensonics has released the PRI Series of proximity sensors for this market. They use a single probe assembly solution with direct processed outputs, which eliminate the need for a separate driver.

Coaxial connector interfaces are a major failure point on standard proximity probe systems. They are susceptible to the ingress of oil and dirt resulting in intermittent connection through either improper installation or mechanical stresses.

Due to having no external driver and tuned cable assemblies, the PRI series increases sensor reliability. There are no cable length restrictions compared to standard proximity probes which are restricted to typically 5m and 9m systems due to the required tuned circuit between the separate driver and the probe. The PRI series can drive long cable distances (>500m) to the connecting equipment.

sensonics.co.uk

Explosive atmospheres

W. L. Gore & Associates has launched Gore PolyVent Ex+ as part of the Protective Vents Screw-In Series. It is certified according to explosion-proof safety standards, IECEx and ATEX. These certifications enable global integration of the product with fewer certification efforts. Further, the PolyVent Ex+ offers additional protection performance for all non-mining, above-ground applications of combustible gas and dust. The latest membrane, made of ePTFE, delivers pressure-equalization while achieving the highest flammability rating in its category (UL 94 VTM-0).

gore.com

Bearing design tool

The Turbomachinery Laboratory at Texas A&M University has developed a computational design tool for tilting pad thrust bearings. XLTHBR facilitates rapid modeling of thrust bearings over a range of operating conditions, including surface speed, load and fluid types.

It allows the user to design, evaluate and troubleshoot the performance of tilting pad thrust bearings, which control rotor position in rotating machinery. Tilting pad thrust bearings consume less drag power and produce lesser temperature rises in the fluid film and pads when compared to rigid surface fluid film bearings.

Members of the Turbo Lab's Turbomachinery Research Consortium (TRC) have exclusive access to XLTRC software, a suite of codes for executing complete lateral and torsional rotordynamic analyses of rotating machinery. Until recently, the XLTRC software suite was missing a thrust bearing element.

XLTHBR offers a thermohydrodynamic model that couples a generalized Reynolds equation for the film pressure, including cross-film viscosity variation, a 3D thermal energy transport equation for the film temperature, and a heat conduction equation for the pads' temperatures.

Predictions are benchmarked against archival test data for a six-pad tilting pad thrust bearing (228 mm outside diameter) operating under a specific load of 0.5 to 2.0 megapascals (MPa) and with a shaft speed of 1.5 to 3.0 krpm (36 m/s maximum surface speed).

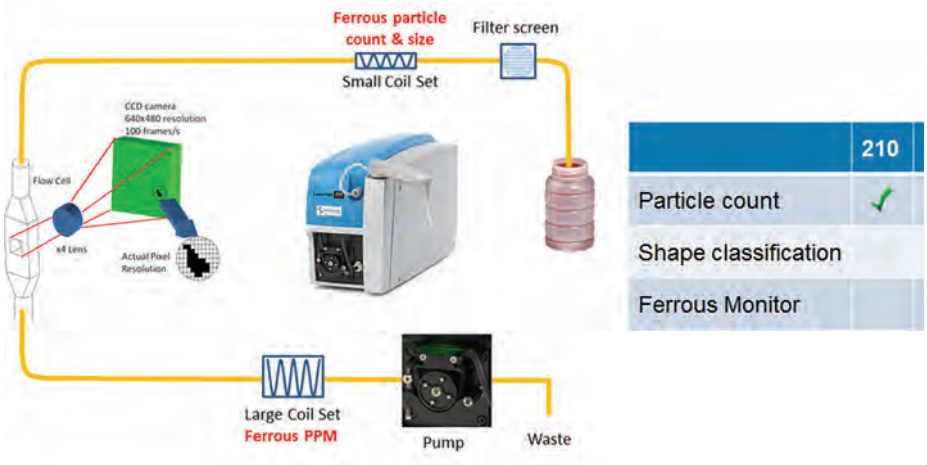
The predictions agree with the test data with a maximum difference of eight percent for the peak pressure, 17% in maximum pad temperature, 20% in minimum film thickness, and 8% in drag power loss. XLTHBR delivers bearing performance predictions and displays 2D and 3D plots. Predictions include for a given set of axial loads and shaft speeds:

- Drag power loss and torque
- Required supply flow rate
- Peak pressure and maximum pad temperature
- Fluid film thickness and pad tilt angles
- Axial stiffness and damping coefficients
- Pivot elastic deflection

turbolab.tamu.edu/trc

Particle analyzer

The new version of the LaserNet 200 Comprehensive Particle Analyzer Series from Spectro Scientific provides analysis of particles in lubricating and hydraulic fluids. Compared to earlier releases, it increases particle counting range up to 10 million particles/ml without dilution, and



Spectro Scientific's new particle analyzer

includes a new set of ferrous particle measurements that gives users new insights into the progress of machine wear.

The analyzer employs LaserNet Fines laser imaging technology and dual magnetometers that characterize ferrous particles larger than 25 microns as well as total ferrous particles. The new software enables LaserNet to report ferrous concentration in part per millions (ppm) for ferrous particles larger than 25 microns in diameter.

Together with total ferrous content in ppm, new measurements such as larger ferrous particle percentage and ferrous wear severity index can be derived, providing a more simplified view of machine wear from a single in-service oil test.
Spectrosci.com

Fluid couplings

Whether assembly instructions, information about nominal fill volumes, tutorials for fill level checks, or scheduling overviews for maintenance planning, the TurboGuide online platform developed by Voith simplifies management and operation of fluid couplings.

The online tool offers a central database from which all important information and technical data regarding a coupling can be accessed. It makes it possible to schedule upcoming maintenance work. Apart from basic data such as serial number, size, type, and fill volume of the coupling, TurboGuide also offers the option to safely document and access drive-related data, such as output, speed, installation location and date of commissioning. It uses this information to calculate the current technical condition of the coupling and displays it by means of a traffic light system in green, yellow and red. TurboGuide also features a notification function that sends out an automated email as a reminder for upcoming appointments.
turboguide.voith.com

Voltage stablizer

Ametek Solidstate Controls, a manufacturer of industrial power inverters and uninterruptible power supplies (UPS), has introduced a Digital Voltage Stabilizer (DVS) power conditioner designed to work in the most-extreme environmental conditions and capable of single- or three-phase conditioning to conserve energy.

DVS accommodates a variety of incoming AC line voltages, while regulating and conditioning the AC output to preset limits. In a typical distribution system, the rated input voltage usually operates at voltages slightly higher or lower than the actual rating, affecting sensitive downstream loads. DVS fixes that issue in both single- and three-phase applications.
Solidstatecontrolsinc.com

Ametek Solidstate Controls DVS Power Conditioner

LV-45 sensor from Alliance Sensors

Linear position sensor

Alliance Sensors Group has released its LV-45 series inductive, contactless linear position sensor using LVIT Technology. It is designed for measuring applications requiring rugged devices, whether measuring position of steam turbine valves, mounted in a paper mill head box or calendar roll stand, or outdoors fastened to a building, bridge or structure.

It can withstand the high vibration and severe shock environment found in steel, aluminum and paper mills, as well as extremes of temperature and humidity found in most outdoor applications where many other types of linear position sensors cannot survive.

The LV-45 uses inductive technology that allows it to replace traditional DC-LVDTs in most applications. Its coil design permits the sensor to be both shorter and more rugged than its counterpart while operating over a wider temperature range. It is available with optional mounting flanges, rod eye ends, connector or cable terminations, and a captive connecting rod assembly that cannot break loose.
Alliancesensors.com

Fireproofing

Carboline has released Thermo-Sorb 263 and Thermo-Sorb E, which are VOC-compliant intumescent coatings. They provide a durable fire protection for commercial and industrial applications. Thermo-Sorb 263 provides up to four hours of cellulosic fire protection for interior structural steel. Thermo-Sorb E provides up to three hours of cellulosic fire protection for exterior structural steel.
carboline.com

Health monitoring

Windrock, a Dover Energy Automation company, has launched the Spotlight Monitoring System. It leverages Industrial Internet of Things (IoT) principles to deliver insights into the health and performance of critical assets. It acquires high-speed rotating data which is sent to a Microsoft Azure cloud. Data visualization software provides actionable insights and uncovers trends concerning the health of the entire fleet of assets.
Iot.windrok.com/spotlight

Microturbine filtration

Capstone Turbine has launched a cleanable severe environment air filtration system for its line of microturbine products. It recently received an order for three C65 microturbines utilizing this new filtration system for a flare gas reduction project in Oman.

During sand and dust storms common to most hot arid desert areas, particulate concentrations close to the ground can reach levels 20,000 times those in typical U.S. cities. Even at an elevation of above grade, particulate concentrations about 1,000 times U.S. urban averages are frequently observed during sandstorms and dust storms. Such dust and dirt loads can cripple conventional air filtration systems, cause massive maintenance expenditures and allow excessive dust concentrations to be ingested by the turbine.

The filters are a scaled down version of the filters used in much larger industrial and aero-derivative gas turbines and allow operation for prolonged time periods in desert environments like the Middle East. Pipeline Supply, Capstone's distributor for Oman and Qatar, secured the order for multiple C65 cleanable severe environment units. The microturbines will be fueled by the associated gas that is a natural byproduct of the oil extraction process. This gas, which can be of poor quality, is normally vented or flared into the atmosphere because it is not of the quality to be put into natural gas

pipelines. Additionally, oil and gas operations are typically in remote areas, which means there is no infrastructure available to clean and capture the gas and bring it to market. *Capstoneturbine.com*

Temporary maintenance hall

Enerpac Heavy Lifting Technology offers a self-erecting facility hall (SEFH) for power generation plants that lack an on-site workshop, and manufacturing sites that need additional capacity. It is hydraulically activated, 12.7 meters high and features a heavy-lift strand jack as well as an ancillary crane. It is ideal for power plants servicing rotors that are 12 meters long and three meters in diameter weighing up to 70 MT, or sites where space restrictions close to the turbine hall rule out access for large cranes.

The Enerpac SEFH provides a temporary facility to conduct maintenance. It can be assembled on-site, and it contains a strand jack for lifting and up-ending the rotor, as well as a 10-tonne overhead crane to change rotor blades and lift ancillaries. *Enerpac.com* ■

AD INDEX

RENTECH Boiler Systems delivers complete, engineered solutions

RENTECH Boiler Systems of Abilene, Texas, is an international provider of high-quality, engineered industrial boiler systems. RENTECH designs and manufactures its products in state-of-the-art plants spanning nearly 70 acres. RENTECH boilers are custom designed and built for each unique application. RENTECH delivers complete, integrated, engineered solutions with packaged watertube boilers, modular, heat recovery steam generators (HRSGs), wasteheat boilers and other specialty boilers.

Our boiler manufacturing experience and passion for customer service have made a significant difference to the largest independent power producers, refining, petrochemical and industrial companies in North America. We specialize in and are the largest supplier of HRSGs for today's high-efficiency gas turbines that operate in the 3–40 MW size range. Our expertise in high-fired applications incorporates full optimization of the duct-burner performance while utilizing catalytic oxidation and SCR for control of emissions from the entire system.

Our packaged boiler design often has been specified for critical industrial processes, turbine warm-up and auxiliary boiler applications because of its rugged design and proven reliability. Our 100 percent membrane wall construction eliminates the need for refractory and enables quick start-up to achieve full steam capacity of the boiler in less time than it takes with older designs.

We achieve lower emissions with optimization of the boiler design. RENTECH's knowledge of low emissions burner and catalytic reduction technologies enables our company to supply systems that fully comply with all performance criteria and are backed by single-source guarantees.

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GAS TURBINES VERSUS GAS ENGINES: WHICH ARE BETTER?

BY KLAUS BRUN & RAINER KURZ

When following press releases from the recent past we find frequent discussions about the future of fossil-fueled engines. There is public debate about the viability of gas engines in automotive transportation as well as other applications.

In our myth-buster column we usually do not write about automotive issues. But we care about fossil-fueled engines for oil & gas and power generation applications, which currently face similar public discussion and scrutiny from environmental regulatory agencies.

In this context, it is important to understand the fundamental principles of the oil & gas industry's two primary fossil fuel burning drivers: gas engines and gas turbines. Specifically, we want to highlight the technical and operational differences of gas turbines and gas engines that impact their performance for industrial applications.

Both systems are basic thermodynamic heat engines and work by compressing the working fluid air, adding and burning fuel for heat input, and extracting useful work by expanding the hot exhaust gas resulting from the combustion of air and fuel.

The difference lies in the fact that a reciprocating engine performs combustion intermittently, while a gas turbine performs it as a continuous process. This means that a gas turbine runs at significantly higher speeds, thus achieving a higher power density. For example, a 10,000 hp gas turbine weighs less than a 1,000 hp gas engine.

Continuous combustion allows for better control of the combustion process, which results in lower exhaust emissions of all criteria pollutants such as Nitrous Oxides (NOx), Carbon Monoxide (CO), Unburned Hydrocarbons (UHC), and Particulate Matter (PM). A gas turbine's combustion system further allows for a complete separation of the combustion process from the engine's lubrication system.

Therefore, the combustion process cannot contaminate the lube oil, nor can the lube oil participate in combustion. This not only avoids frequent oil changes or the need to replenish oil that is consumed, but it also prevents hydrocarbon soot emissions from burned lube oil.

In a gas turbine, all parts of the turbomachinery train rotate rather than oscillate as they do in a reciprocating gas engine. This results in a significantly lower vibration load introduced to the machine's foundation.

Particularly for offshore applications, this can lead to a reduction in the amount of structural steel required. But even onshore, there is a difference in the complexity of the required foundations between gas engines and gas turbines. Finally, the difference in the level of vibrations and the number of moving parts also impacts the reliability of these machines.

One of the key ingredients of emission reduction is the improvement of operational efficiency. This includes the efficiency of components like the driver and the driven compressor of a system.

Arguably, the biggest efficiency enhancements come from the capability for smart operation. This requires optimal matching of the compressors and their drivers with the pipeline system, gas storage system, or any other compression operation system.

Here, fast adaptability of the machinery system is a key requirement. There is a noticeable difference between gas engines and gas turbines. For compatibility reasons, gas turbines are usually matched to centrifugal compressors, while gas engines are typically the drivers of reciprocating compressors.

So, while gas engines offer attractive levels of driver-only efficiency, this advantage is reduced when the efficiency level of the overall package (i.e., the compressor and its driver) are compared, especially for pipeline applications, or if options with waste heat recovery are compared. Also, hydrocarbon leakage is lower for centrifugal compressors compared to reciprocating compressors.

And yes, size matters. For low-power applications, reciprocating systems have advantages regarding cost and efficiency. The bigger the systems become, the more the advantage turns to gas turbine systems with lower maintenance cost and higher achieved availability.

Furthermore, because gas turbines have much higher mass flows than gas engines, they are better suited for waste heat recovery applications. Finally, gas turbine noise emissions are easier to control since they create noise in a much narrower frequency band, and avoid low frequency noise.

So yes, there are differences between gas turbines and gas engines. Each have their advantages and disadvantages, depending on the application. Regardless, when deciding between gas turbines and gas engines one should always look at the whole system performance, including total system efficiency, reliability, availability, maintenance, emissions, footprint, weight, modularity, noise, and so forth, rather than simply and singularly the driver's efficiency. ■

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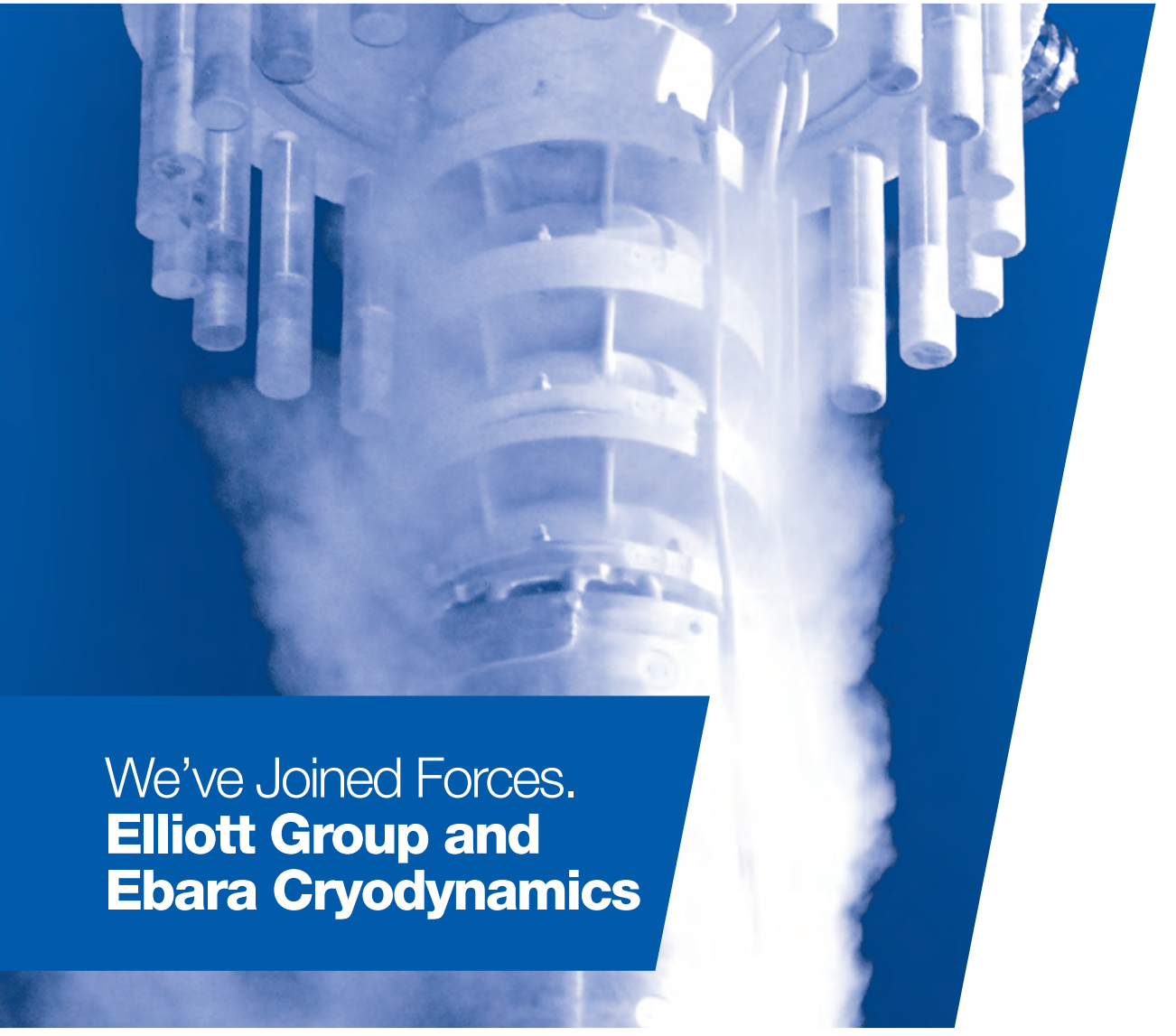

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