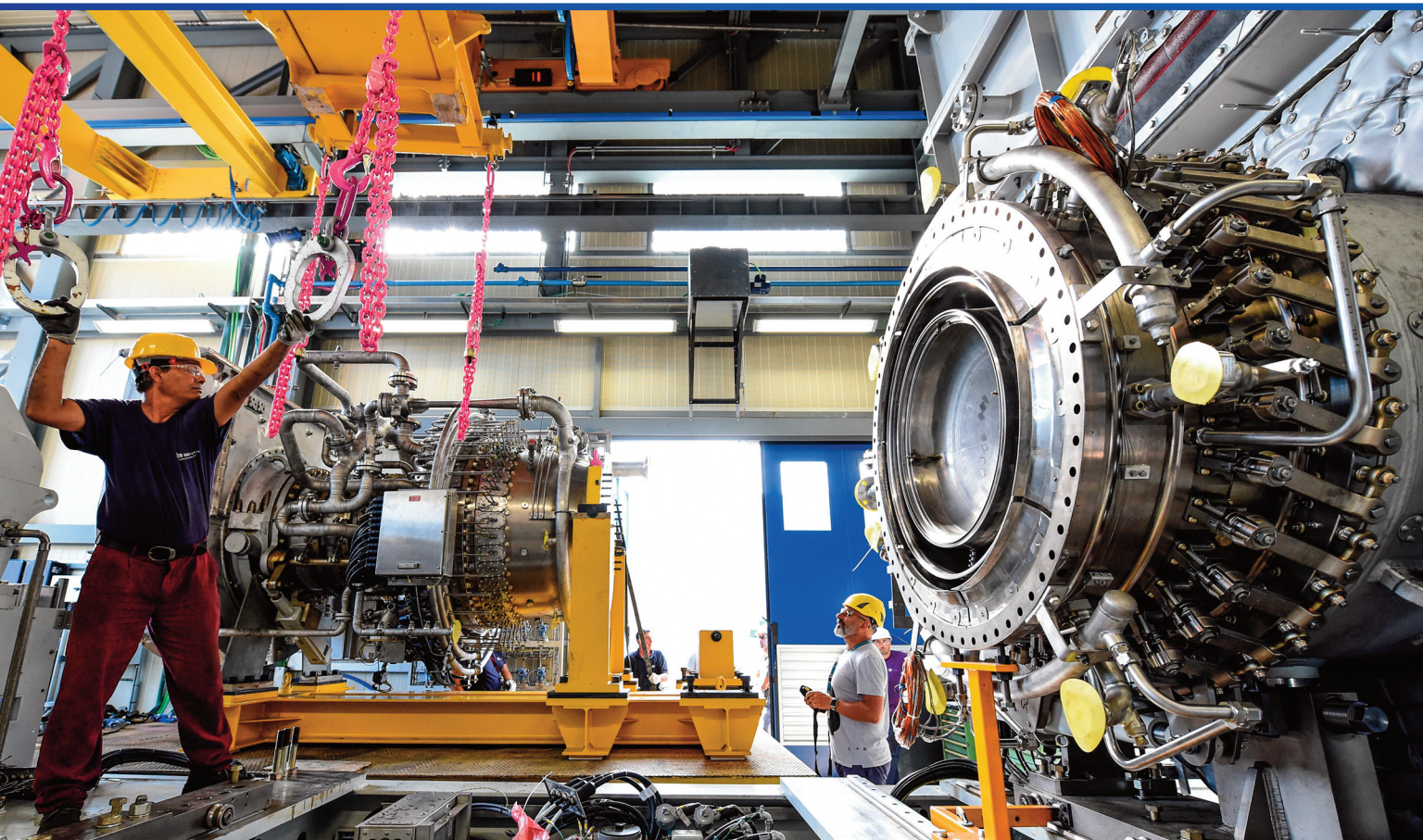


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# Turbomachinery<sup>INTERNATIONAL</sup>

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## A BRIGHTER OUTLOOK FOR OIL & GAS

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COVER STORY

## 18 A BRIGHTER OUTLOOK FOR OIL & GAS

The oil & gas industry has had a tough couple of years following the collapse in oil prices. But the January Annual Meeting of Baker Hughes, a GE company (BHGE), in Florence, Italy sounded a more positive note. This two-day event brings together more than 1,000 senior oil & gas leaders and government leaders from companies, such as Shell, Maersk Oil, SKF, Nvidia, Saipem, BP and Novatek. They outlined key trends, including digitization, environmental constraints, lower spending than in the past, increased asset utilization and the importance of 3D printing.

*Drew Robb*

Cover photo: The GE NovalT 16 gas turbine



OIL & GAS

## 22 COMPRESSOR FOULING

The Cracked Gas Compressor (CGC) is one of the most critical pieces of rotating equipment present in modern ethylene plants. Fouling is one of the typical causes for reduced capacity or performance deterioration in CGC operation.

*Pallavi Baddam*

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A critical fastening application is any bolted joint that requires accurate and uniform bolt loading. In the early years of turbomachinery, it was common practice to tighten a nut and bolt through thermal expansion. But better methods have evolved.

*Pat McCormack*

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*Garry Brown*



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## 33 DRY GAS SEALS, COUPLINGS, FILTRATION AND INDUSTRY TRENDS

John Crane provides turbomachinery related technology, supplying products and services for rotating equipment in mission-critical operations. Its portfolio includes dry gas seals and seal-support systems, filtration systems and couplings. It has eight turbomachinery service centers and more than 300 engineers worldwide. Paul Hosking, Senior Product Manager at John Crane, discusses his company's turbomachinery related products and services as well as ongoing trends



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#### 6 GT ORDERS ARE STRUGGLING

Worldwide GT orders in MW were down 29.4% in 2017 and unit orders were down 17.6%. Since 2012, MW orders are down 45% and unit orders are down 60%. Worldwide aeroderivative MW orders were down 19%, and unit orders down 28% in 2017. U.S aeroderivative MW orders were down 48% in 2017. The industry needs to find a way to reverse these trends by establishing its new position and remaining relevant in the evolving energy mix.

*Drew Robb*

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Boiler Feedwater (BFW) pumps are high-pressure centrifugal pumps used to pump purified BFW at high pressures to boilers to produce steam. They are usually high-speed, high-power units with specific requirements for each service, material selection and pump design.

*Amin Almasi*

### MYTH BUSTERS

#### 36 ENERGY STORAGE TECHNOLOGIES WILL SOLVE GRID PROBLEMS

Energy storage is important for the future. But dynamic imbalance created by wind and solar can be addressed by natural gas power plants, the pipeline system, and natural gas storage capacity. This can be done at a much lower cost than adding hundreds of gigawatts of electric storage systems.

*Rainer Kurz & Klaus Brun*



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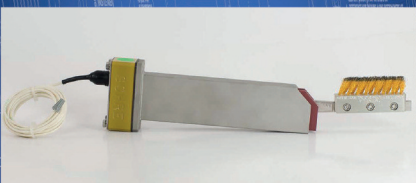
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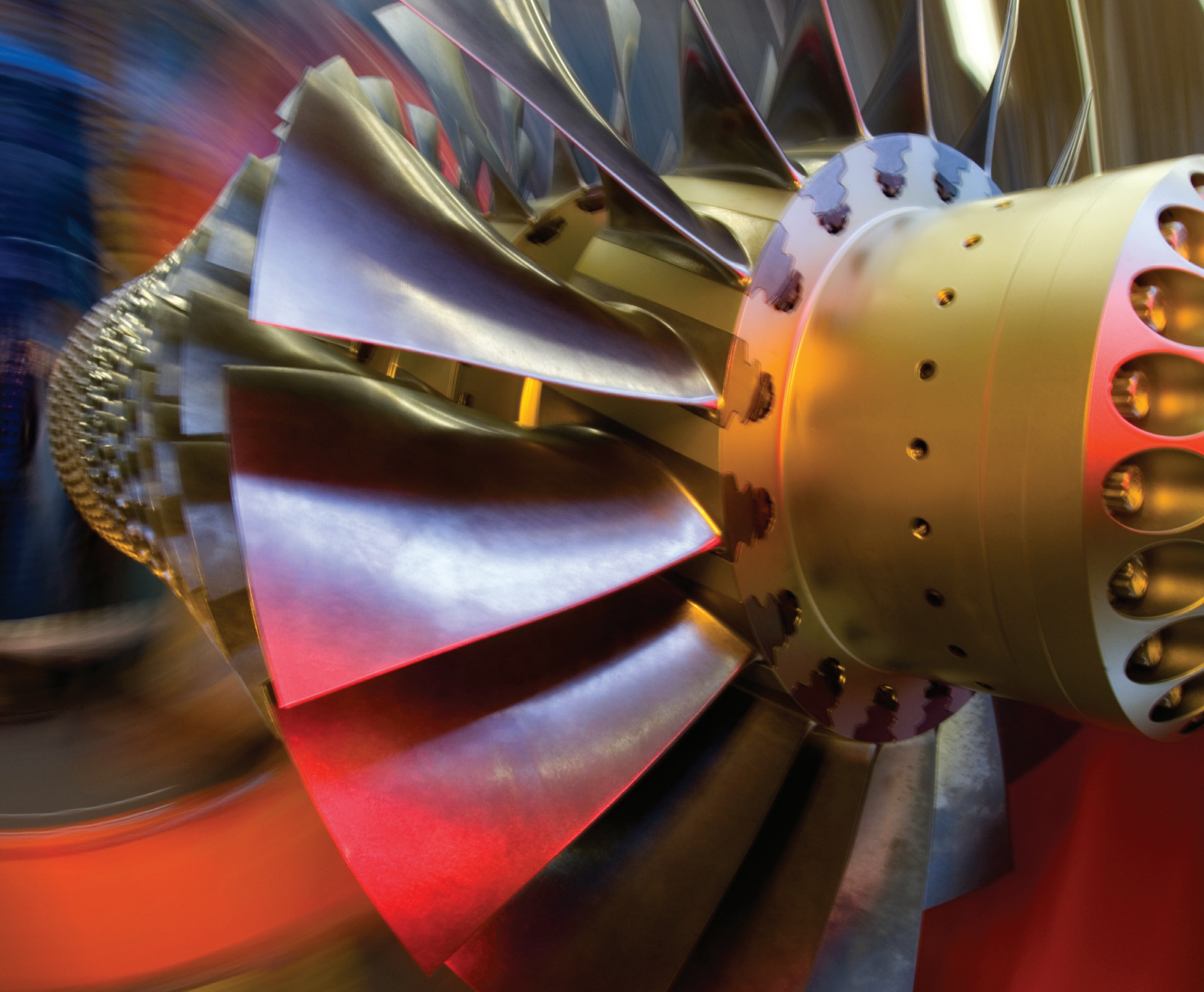
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# GT ORDERS ARE STRUGGLING

**T**he gas turbine industry is hurting. I just attended a presentation on turbine trends at the Western Turbine Users Inc. (WTUI) conference in Palm Springs. Given by Mark Axford of Axford Consulting and Tony Brough of Dora Partners, it will be the subject of a feature article in the next issue (along with a WTUI show report).

Here are some of the facts from that WTUI session:

- Worldwide GT orders in MW were down 29.4% in 2017 and unit orders were down 17.6%.

- Since 2012, MW orders are down 45% and unit orders are down 60%

- Worldwide aeroderivative turbine MW orders were down 19%, and unit orders down 28% in 2017

- U.S aeroderivative MW orders down 48% in 2017

- Massive layoffs in the power section from the big turbine OEMs.

Our *Turbomachinery Handbook 2018* cited the following statistics from Forecast International and Industrial Info Resources:

- Forecast's current analysis expects \$112.1 billion in GT revenues over the next decade. Five years back, it anticipated \$152.9 billion in the coming decade

• For the next three years, this means the annual turbine sales forecast has dropped from \$15 billion to \$10 billion

• The number of units to be sold over the next decade shrunk from 12,521 in the 2012 ten-year prediction, to 4,719 in this year's forecast

• Models in the 0.2 to 3.0 MW grouping have fallen from 19% of unit sales in the 2012 report to less than 2% this year.

Axford noted renewable subsidies would continue through 2020 and were a significant reason behind the decline. But flooding the grid with renewables is

already creating problems in states like California and Texas, as well as countries such as Germany.

Driving into Palm Springs to the WTUI conference, I saw thousands of wind turbines and only about 2% spinning. If Southern California Edison and other utilities in that region continue to be forced to retire their fossil assets due to state and federal policy, the Golden State could be in for a rude awakening.

Perhaps in twenty years, industrialized nations will be able to keep running 24/7/365 without traditional power sources existing. But that's wishful thinking based on the hoped-for maturity of battery technology and fuel cells. Regardless of policy, we do have a place in the world. We need to define it and own it.

After all, a small recip company from Finland known as Wärtsilä has carved out quite a market for itself by providing engines and power plants in the 20 MW to 200 MW range. They package them to provide fast ramp power for CHP, combined cycle and simple cycle — whatever the customer wants. And they are in demand. Complacency at the low end of the market has enabled this company to occupy a space that was once dominated by GTs.

I do see some light at the end of the tunnel. At WTUI, the new head of GE's aeroderivative turbine business said the company would invest \$180 million in aeroderivatives and offered some fighting words about the strength of the market. Similarly, at the Baker Hughes GE (BHGE) conference in January, the company noted that its NovalT line of GTs was selling well and that they were developing more models (it serves the 5 MW to 16 MW market). These are clearly examples of products the market needs and wants. We need more examples like these.

But what should be done? I'm happy to take an article from any GT OEM on what they are doing to reverse our fortunes. I'd also like to hear from some readers. A request, though: The time has come and gone to complain about renewable subsidies or politics. The nation is committed on a path towards renewables and clean energy. That clock is unlikely to ever turn back. What we need to do is come to terms with how things are: and figure out how to stay relevant and create a sustainable model for the future that WILL keep the lights on. Any suggestions? ■

**“ We need to figure out how to stay relevant and create a sustainable model for the future that will keep the lights on”**

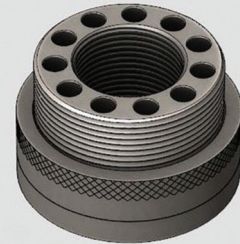


*Drew Robb*

DREW ROBB  
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## MHPS digest

A large-scale gas turbine (GT) for use in power generation under development by Mitsubishi Hitachi Power Systems (MHPS) has passed a firing test using a 30% hydrogen fuel mix. The test results confirmed that by using MHPS's burner (developed to burn hydrogen), stable combustion can be attained when hydrogen is mixed with natural gas.

Using a 30% hydrogen mixture, a reduction in carbon dioxide (CO<sub>2</sub>) emissions of 10% was achieved, compared to natural gas-fired power generation. The test was carried out at MHPS's Takasago Works using actual-pressure combustion testing facilities.

Test conditions called for a turbine inlet temperature of 1,600°C, equivalent to 700 MW of output, using the premix combustor of the J-Series GT. The combustor's fuel nozzle creates a rotational airflow enabling a more uniform premixed gas, leading to low NOx. Other than the combustor, the equipment currently in place can be used without modification.

MHPS has received the first order for its pressurized hybrid power generation sys-



The MHPS combustion testing facility

tem, integrating solid oxide fuel cell (SOFC) stacks with micro gas turbines (MGT). Launched for the commercial and industrial market, this system is being installed in the Marunouchi Building in Tokyo, owned and operated by Mitsubishi Estate Co.

The 250 kW hybrid is scheduled to start generating in 2019. It uses city gas as fuel, generating electricity with both ceramic SOFC stacks that operate at around 900°C, and MGTs. The GT and the cogeneration

system bring the combined efficiency to more than 73%. Carbon emissions are said to be down by 47% compared to conventional power generation systems.

The MHPS M501 JAC GT has been selected for the Vale Azul II Project in Brazil. The plant, which will have an output of 466 MW in combined cycle, will provide base load power commencing in 2023. It will use the MHPS-TOMONI digital cloud information infrastructure, as well as data analytics and machine learning to leverage data generated during plant operations.

MHPS has received a full-turnkey order for the engineering, procurement, construction and commissioning (EPC) of a 5,300 MW natural gas-fired power plant project planned by a joint venture between Gulf Energy Development, one of Thailand's largest independent power producers (IPP) and Mitsui & Co. A long-term service agreement (LTSA) was concluded. Plans call for two 2,650 MW combined cycle power plant (CCPP) incorporating eight M701JAC GTs for plants near Bangkok. Commercial operation is due to begin in 2021 and 2023.

## New plants

Construction of the Lordstown Energy Center has been completed. This 940 MW CCPP is located 80 km southeast of Cleveland, in the village of Lordstown, Ohio. The main developer of the project is Clean Energy Future.

Commercial operations are expected to begin by mid-2018. Engineering and procurement has already been completed along with the installation of all major equipment. The plant will use natural gas from the Utica and Marellus shales.

The produced power will be delivered to PJM Interconnection's regional transmission network. The CCPP has two Siemens SGT6-8000H GTs and one SST6-5000 steam turbine (ST). It includes two air-cooled SGen6-1200A generators, one hydrogen-cooled SGen6-2000H steam generator, and two NEM Heat Recovery Steam Generators (HRSGs).

The electrical equipment being installed at the plant features the SPPA-T3000 instrumentation control system. The Low Emission Combustor (LEC) will be installed with emission control equipment, including dry low NOx burners, two catalytic oxidation systems, two selective catalytic reduction systems, and a high-efficiency drift elimi-

nator. Clean-Ramp technology will help main stack emissions at 2ppm NOx and 2ppm CO during loading up.

CB&I has broken ground for the Lake Charles Power Station, a new natural gas-fired CCPP for Entergy Corporation subsidiary Entergy Louisiana, in Lake Charles, LA. CB&I's scope of work on the project includes EPC for the 994 MW plant. The two MHPS GTs (air-cooled versions of G-class) at the plant will become operational in 2020.

E-J Electric is partnering with Skanska, Burns & McDonnell and ECCO III to provide design-assist services for the installation of the fast-track 680 MW power plant at the new CPV Valley Energy Center in Middletown, NY. The scope of services includes the installation of an underground duct bank, grounding, above ground cable tray, isophase bus duct, modular power control building and MV cables and terminations.

Advanced Power has announced commercial operation has begun at its 700 MW Carroll County Energy natural gas CCPP in northeastern OH. Bechtel acted as the general contractor. The facility features two GE 7F.05 GTs and a D602 ST. Ethos Energy is operating the facility.

State-owned Coal Power Generation Company Bangladesh has broken ground on a 1.2 GW Matarbari power plant in

Cox's Bazar District, Bangladesh. The plant will comprise two 600 MW ultra-supercritical coal-fired units, pulverized-coal-fired boilers, STs and generators. A coal storage and jetty will be constructed for importing sub-bituminous coal. The EPC will be handled by a consortium made up of Sumitomo, Toshiba and IHI. A deep-sea port will be constructed.

The Reppie waste-to-energy project has come online. This plant converts 1,400 MTs of waste every day, nearly 80% of Addis Ababa's landfill generation in Ethiopia. The waste is burned to run an ST. The 110 MW plant is preceded by a waste-sorting process that helps in recycling.

Platinum Equity has signed an agreement to acquire GenOn's Hunterstown power generation facility and related assets in a transaction valued at about \$520 million. GenOn, a unit of NRG Energy, filed for bankruptcy protection in June 2017. Located in Gettysburg, PA, Hunterstown is a CCPP that provides 810 MW to the PJM grid.

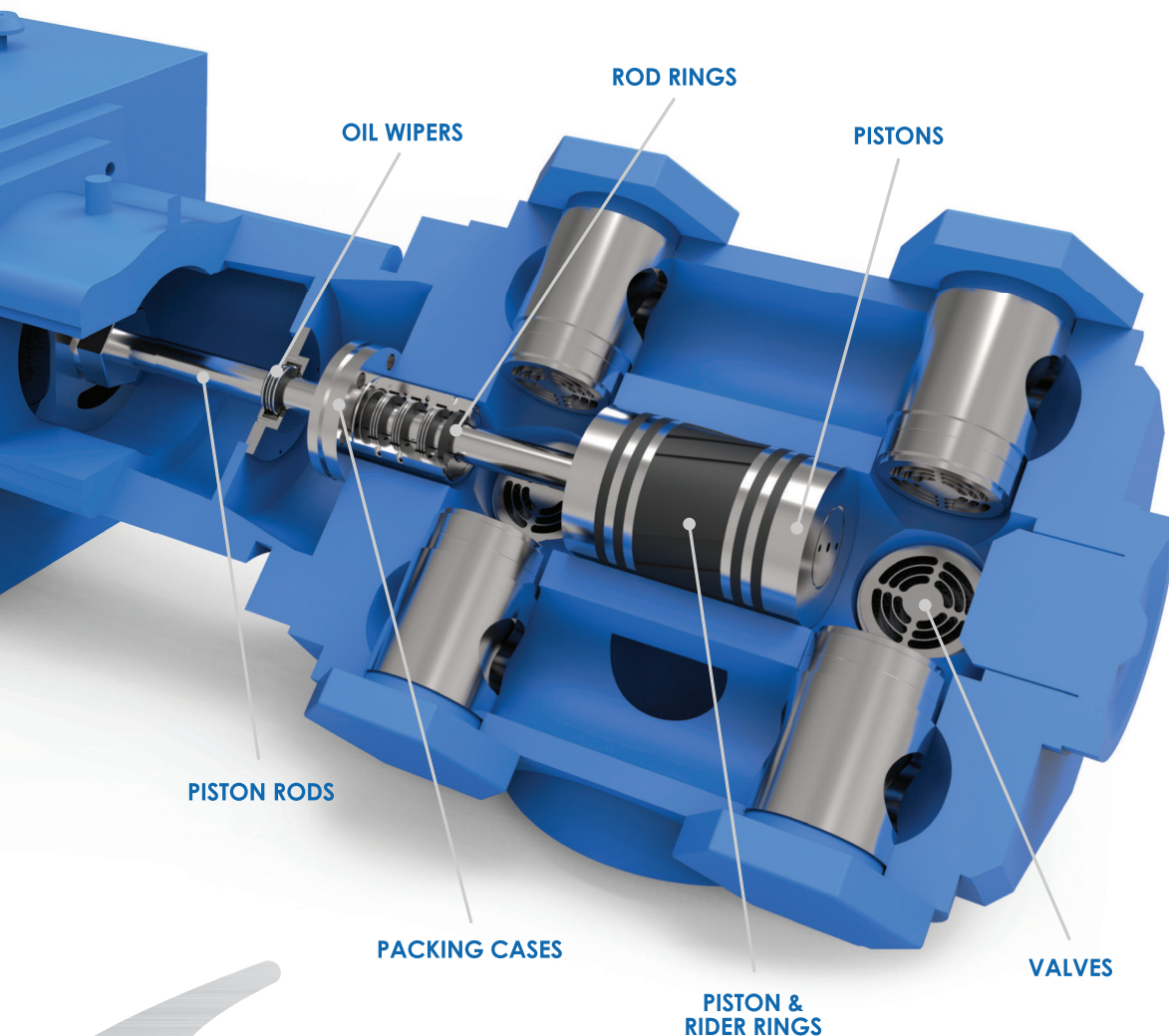
Exergy has added a new geothermal project to its 370 MW portfolio. It signed a contract in Turkey with GLC ND ENERJI in the Manisa region. The plant will exploit a medium enthalpy resource at ap-

*(Continued on p. 10)*



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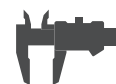
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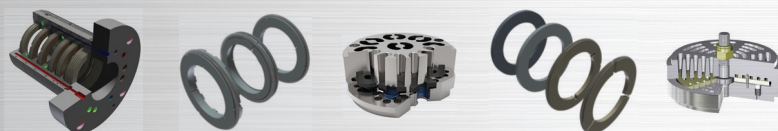
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proximately 150°C to generate 12.6 MW of electricity from an ORC system equipped with radial outflow turbine technology and using an air-cooled condensing system.

## Westinghouse Electric acquisition

A subsidiary of Canada's Brookfield Asset Management plans to acquire Westinghouse Electric, the bankrupt nuclear services company owned by Toshiba. The buyers are also assuming Westinghouse's underfunded pension plan.

One of Westinghouse's unfinished U.S. projects, known as Vogtle in Georgia, will continue with Southern Co. replacing the company as the project manager. Westinghouse has joined a consortium bidding to provide nuclear power in Saudi Arabia, one of the biggest new markets in the world. Bringing Westinghouse out of bankruptcy could help close a proposed deal for six of the company's new AP1000 reactors in India.

## Atlas Copco Compressors president

Atlas Copco Compressors appointed



Robert Eshelman

Robert Eshelman as President and General Manager. He succeeds John Brookshire, who will retire. Eshelman will oversee Atlas Copco Compressors' customer center in the U.S. and will be responsible for sales,

marketing and service operations. He was previously the General Manager of Scales Industrial Technologies, part of the Atlas Copco Group. He completed his undergraduate studies in engineering at the Georgia Institute of Technology and his master's degree in business administration at Georgia State University.

## Honeywell cryogenics

Honeywell's UOP Russell business will provide a third cryogenic gas processing plant to Brazos Midstream. The high-recovery 200 million cubic foot per day (MMcf/d) plant, called Comanche III, will extract natural gas liquids (NGLs) from natural gas produced in the Southern Delaware Basin in TX.

Honeywell will provide engineering, fabrication and supply of a modular cryogenic NGL recovery unit. This new plant follows two earlier plants that also were customized to handle the gas composition in the Basin.

Cryogenic gas processing plants cool the gas in a demethanizer column until the NGLs precipitate into a liquid. These heav-

ier components can be used as fuels, fuel blending components and other petrochemicals.

## Control systems market growth

A report "Power Plant Control System Market – Global Forecast to 2022," published by MarketsandMarkets, predicts that the control system market will grow from an estimated \$4.70 billion in 2017 to \$6.22 billion by 2022, or 5.78% per year during the forecast period. This is primarily due to the increasing emphasis on alternative energy production, the traditional power sector undergoing digitization, as well as government initiatives toward the adoption of industrial automation.

The turbine and auxiliaries control segment is projected to dominate the market during the forecast period. It is the largest application vertical in the report, comprising control systems for turbine governing, vacuum, condensate, feedwater, cooling water and lube oil. These systems are used in coal-based thermal power plants, nuclear power plants, oil-fired steam turbine power plants, gas-fired CCGTs, wind power plants, and concentrated solar power plants.

The turbine and auxiliaries control segment is the largest cost component in a power plant control system. The increased global capacity from wind farms and large investments in thermal power plants in the Asia Pacific are driving this segment.

Within the segment (which includes SCADA, PLC and DCS), SCADA is expected to constitute the fastest growing market from 2017 to 2022. The market is primarily driven by increasing investments in large-scale renewable power projects where SCADA investments in renewable energy are expected to boost installations in the region.

## EthosEnergy contract

EthosEnergy has been awarded a modernization contract by ENEA Wytwarzanie for work at its power Station in Kozienice, Poland. The contract is for the modernization of a unit 8 generator stator including manufacturing stator bars, testing and inspecting the core with EL-CID method and rewinding the stator with new modernized bars.

## BHGE support

Blackstone Industrial Services (Blackstone), a Canadian rotating equipment services company, has expanded its role in support of Baker Hughes, a GE company (BHGE, formerly GE Oil & Gas). As an authorized service and sales channel, Blackstone's scope has expanded to support parts, service and repairs for legacy products, such as its Allis-Chalmers compressor and Rotoflow turboexpander for

all of Canada.

Blackstone also will handle distribution and sales for Lufkin power transmission services in Western Canadian. Lufkin's gearing solutions transmit power from engines, electric motors, turbines and compressors.

Allis-Chalmers' compressor lines manage critical processes in industrial, mining and oil and gas applications. Rotoflow is a pioneer in the use of turboexpanders in the natural gas processing industry. Rotoflow's turboexpanders support cryogenic natural gas processing through dew point control, NGL recovery, ethane recovery and LNG production.



Ansaldo Energia's Guido Rivolta and Giuseppe Zampini

## Ansaldo digest

The first GT36-S5 model GT, produced at Ansaldo Energia's Genoa production facility, was presented to an audience, including Italian Defense Minister Roberta Pinotti, Mayor of Genoa Marco Bucci and Edoardo Rixi, Liguria Regional Administration Economic Development Council.

Following the acquisition of the former assets of Alstom in February 2016, Ansaldo Energia has invested over €65 million to bring production of these machines to Italy. The GT36, the most powerful engine built by Ansaldo Energia, generates 538 MW (50Hz) and 760 MW in a CCGT with an efficiency of 62.6%. With the support of Ansaldo Energia's Chinese partner, Shanghai Electric Group, the first GT36 maxi gas turbines will be installed in two power generation plants in the Shanghai area.

Ansaldo Energia Managing Director Giuseppe Zampini has resigned as Chair-



man, a position taken over by Guido Rivolta, Managing Director and General Manager of CDP Equity and an Ansaldo Energia Board Director since 2014. Zampini served as Managing Director of the company from 2001 to 2016, when he led the recovery, relaunch and internationalization of Ansaldo Energia.

Guido Rivolta will help define the company's strategy in liaison with the Managing Director. Rivolta has worked in CDP Group since 2012 and has a decade of experience in industry, having previously served in Pirelli, Piaggio and Valeo Group. Rivolta is also a Board Director of several companies in the CDP Equity portfolio, including Valvitalia, Inalca, Open Fiber and Bonifiche Ferraresi.

### GE Digest

GE expects the overall global market for new GT orders in 2017 to be less than 35 GW. Orders are expected to be down to 30 GW for 2018. The OEM expects to maintain a 50% share in global orders. GE cited McCoy Reports, stating that the industry could be heading for the lowest gigawatt year since 2002.

"We announced a 12,000-person reduction and a commitment to right-size our global manufacturing footprint," said GE

in its 2017 fourth-quarter financial report. "We are working to accelerate additional restructuring efforts in 2018 to support a market that could be as low as 30 GW."

GE sales have been suffering. In 2017, orders of \$10.2 billion were down 25%, with equipment down 24% and services down 26%. Revenues of \$9.4 billion were down 15%. In the fourth quarter, GT orders were up 1 unit at 24 versus 23 units in prior year, with the increase driven by nine H units versus eight in the prior year.

GT orders in 2017 were 75 units, down 9 versus prior year. Total year GT shipments was at 102 in 2017. The company expects 2018 shipments to be in the range of 60 to 70 units, with about 15 H units sold.

Aligning with Mexico's Ministry of Energy's National Electric System Development Program (PRODESEN) 2017-2030 plan, GE Power has signed long-term agreements, which include two fully integrated contracts, plus an Operation and Maintenance (O&M) agreement and a Contractual Service Agreement (CSA). These will provide 25 years of plant services solutions for the 907 MW Norte III power plant, in Chihuahua, Mexico. GE will use its Fleet360 platform for the Norte III plant, which operates on four GE 7F.04 GTs, as well as two Toshiba STs. Fleet360

also provides digital solutions and plant improvement services, regardless of the OEM. GE's Predix-based Asset Performance Management and Operations Optimization software will apply data analytics to predict and eliminate unplanned downtime and improve productivity.

Harbin Electric (HE) has awarded GE Power an order for two 9F.05 GTs for the State Power Investment Corporation's Langfang CCPP project. HE will provide the STs, generators and auxiliary systems. Langfang will generate about 800 MW at 60% combined cycle efficiency, and will be commissioned in 2019. As a CHP facility, it will provide power and heating.

Shipbuilder Huntington Ingalls Industries will construct a destroyer with U.S. Navy Flight III upgrades incorporated. Each destroyer features four GE LM2500 marine GTs in a COmbined Gas turbine And Gas turbine (COGAG) configuration.

GE's Power Services business has announced that its largest ever flange-to-flange (F2F) replacement project in Japan was successfully completed on time at Block 7 and Block 8 of TEPCO Fuel & Power's (TEPCO) Yokohama power plant in Japan. In a flange-to-flange replacement, the entire engine from inlet flange to ex-

*(Continued on p. 12)*



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**Nicholas Leaf**  
Product Manager  
for Fuel Gas Boosting  
Atlas Copco Gas and Process, USA

**Dr. Henning Struck**  
Technical Development Manager  
Atlas Copco Gas and Process, USA

#### Moderator

**Drew Robb**  
Editor-in-Chief  
Turbomachinery

For questions contact Kristen Moore at [kristen.moore@ubm.com](mailto:kristen.moore@ubm.com)

### Who Should Attend

- Technology managers, technical managers/directors, plant managers/directors, maintenance managers, rotating equipment managers, procurement department representatives, EPC representatives, design institutes representatives

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- How fuel gas booster standardization saves you money and time

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haust flange is replaced as one piece.

This project, expected to save about \$71 million in annual fuel costs, includes eight GTs ranging from 9FA.01 to 9FA.03 models. Upgrades will improve performance and reduce lifecycle cost. Total plant output has been increased by 216 MW. Efficiency has increased by 1.7% and emissions have been lowered.

GE successfully completed the world's first 9EMax four-stage GT at TEPCO's Futtsu power plant in Chiba, Japan. The upgrade is the first of six 9EMax upgrades to be implemented at the plant and is expected to increase output, improve thermal efficiency from 47.2% to 51.4%, and reduce emissions.

GE Power has announced commercial operation for China Huaneng Group's Huaneng Guilin Gas Distributed Energy Project using three GE 6F.01 GTs. This combined cooling, heating and power (CCHP) configuration takes advantage of materials and technologies adopted from GE's H- and F-class GTs.

GE Power and Marinus Energy have formed a pilot project in Ghana to capture flared isopentane gas and use it as a fuel to generate electricity. The Atuabo Waste to Power Independent Power Project (Atuabo) will be the first TM2500 power plant in Sub-Saharan Africa to use isopentane gas as a fuel source. In the first phase, Atuabo will convert the isopentane fuel into up to 25 MW of power. As additional gas is brought onshore, the plant is expected to reach a capacity of 100 MW.

GE is leveraging Ansys Pervasive Engineering Simulation to accelerate product development and analysis, improve product quality and reduce testing time in aviation and power generation applications. The agreement provides GE access to Ansys engineering simulation software and experts, to enable multi-physics solutions in ground-based and on-wing GT engines.

## Air compressor market

The air compressor market is likely to surpass \$40 billion by 2024, according to a research report by Global Market Insights. Increasing industrial activities will propel the market owing to extensive use in manufacturing, oil & gas, electronics, food & beverages, and other industries. Air compressors have gradually developed to become lighter and more compact in design, offering lower gas emissions, lower noise, and better efficiency.

The Asia Pacific region is undergoing rapid industrial development. Automotive and manufacturing are witnessing sharp growth owing to an abundance of raw materials and easy availability of labor. Increased manufacturing will fuel air com-

pressor demand in this region.

The oil-free air compressor market will also see rapid growth, owing to food security and oil contamination concerns. Oil-free products also will find extensive application in healthcare for respiratory support systems and air ventilators.

The air compressor market is segmented into stationary and portable segments. The stationary segment accounts for the bulk of the market and will surpass \$29 billion by the end of the forecast period. Centrifugal compressors will surpass \$35 billion by the end of 2024, to capture close to 40% of the entire air compressor market. They offer high capacity and large discharge rates as well as low maintenance.

## Siemens digest

Siemens has rebranded its subsidiary, NEM Energy, into Siemens Heat Transfer Technology (HTT). All other company details and legal structures remain unchanged. Martin Alf and Daniela Schwarz-Krause continue as CEO and CFO.

As part of the Siemens Power and Gas Division, Siemens HTT designs, engineers and sells components for power plants: HRSGs, Waste Heat Recovery Units (WHRUs), exhaust & diverter systems and related equipment. Headquartered in the Netherlands, Siemens HTT has branches in Germany, the U.S., Egypt and the United Arab Emirates.

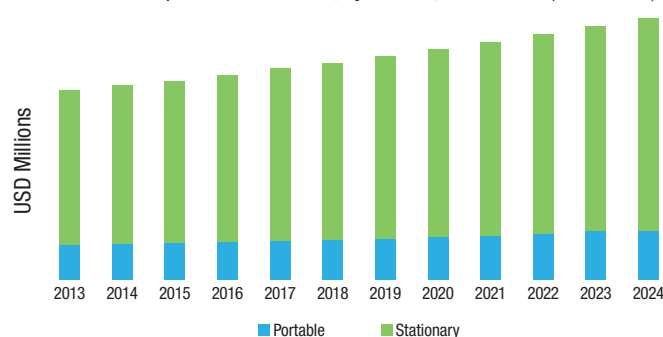
Siemens received an order from North American pipeline operator, Nova Gas Transmission Ltd. (NGTL), a subsidiary of TransCanada, to supply a GT-driven compressor train for the Winchell Lake Compressor Station in Alberta, Canada.

The turbo-compressor train will be part of the NGTL pipeline expansion to transport natural gas to export markets. Commercial operation is expected to begin the fourth quarter of 2019.

Winchell Lake Compressor Station pressurizes natural gas along the Western Alberta System Mainline. It exports natural gas into Washington, Oregon, California, and Nevada. The scope of supply includes an RFBB36 pipeline compressor driven by Siemens aeroderivative SGT-A35 GT (Industrial RB211) and auxiliary systems.

Siemens has been awarded a contract from Statoil to supply a compressor train for a floating production, storage and of-

U.S. Air Compressor Market Size, by Product, 2013–2024 (USD Million)



floating (FPSO) vessel in the Johan Castberg oilfield in the Barents Sea, northwest of Finland. The compressor train comprises a 41 MW SGT-750 GT that will drive two Datum compressors in tandem.

This marks the first use of an SGT-750 in an offshore application. A waste heat recovery unit will distribute turbine exhaust heat to prevent ice build-up. Equipment delivery is set for mid-2019 with first oil production planned for 2022.

## Cybersecurity

Siemens, Airbus, Allianz, Daimler Group, IBM, NXP, SGS and Deutsche Telekom have signed a joint charter for greater cybersecurity. It calls for:

- Binding rules and standards to build trust in cybersecurity and further advance digitization
- Cybersecurity responsibility to be assumed at the highest levels of government and business, with the introduction of a ministry in governments and a chief information security officer at companies
- Companies to establish mandatory, third-party certification for critical infrastructure and solutions, such as autonomous vehicles or robots.

Cybersecurity attacks caused more than €560 billion damage worldwide in 2016, according to the *Threat Landscape Report* from the European Union Agency for Network and Information Security (ENISA). For some European countries, the damage was equivalent to 1.6% of GDP.

The threats to cybersecurity are steadily growing: according to Gartner, 8.4 billion networked devices were in use in 2017, a 31% increase over 2016. By 2020, the figure is expected to reach 20.4 billion.

## Pump acquisition

Duechtung Pumpen Maschinenfabrik (Witten, Germany), a specialist for the development and production of high-performance centrifugal pumps took over Habermann Mineral Systems (HMS). HMS is a specialist in the design and manufac-

ture of suction dredgers and solids pumps for the sand and gravel industry.

In 2015, Duechting adopted a single-stage centrifugal pump program and incorporated suction dredger pumps into its wear-resistant WRX series for abrasive conveyed goods.

### Curtiss-Wright gets D-R assets

Curtiss-Wright Corp. is acquiring assets of the Dresser-Rand (D-R) Government Business, part of Siemens. The acquired business will operate within Curtiss-Wright's Power segment.

D-R reciprocating compressors, STs and steam system valves support Nimitz-class and Ford-class aircraft carriers, Virginia-class and Columbia-class submarines, as well as most major U.S. Navy shipbuilding programs.

D-R was the sole supplier of steam turbines and main engine guard valves on all aircraft carrier programs. Through its three service centers, it is also a major provider of ship repair and maintenance for the U.S. Navy's Atlantic and Pacific fleets.

Curtiss-Wright supplies products to every nuclear submarine and aircraft carrier commissioned by the U.S. Navy. It is the preferred supplier of pumps and valves used in the nuclear propulsion system.

### New Turbo Lab director

The Turbomachinery Laboratory, a center of the Texas A&M Engineering Experiment Station (TEES) and part of The Texas A&M University System, has a new director. Dr. Eric Petersen, the Nelson-Jackson Professor in the Department of Mechanical



Dr. Eric Petersen

Engineering at Texas A&M University, is a 10-year veteran of the Turbo Lab.

Petersen has authored more than 400 journal and conference papers on gas dynamics, propulsion, combustion, shock waves, chemical kinetics, optical diagnostics and spectroscopy, laminar and turbulent flames, and rocket combustion. He is vice-president of the Institute for Dynamics of Explosions and Reactive Systems (IDERS) and an associate editor of the *Journal of Engineering for Gas Turbines and Power* and the *Journal of Propulsion and Power*.

Petersen holds three degrees in mechanical engineering: a bachelor's from the University of Central Florida (1988), a master's from the University of Florida (1990) and

a doctorate from Stanford University (1998).

Before coming to Texas A&M, he taught at the University of Central Florida. Prior to becoming a professor, he was an analytical engineer in the combustion group at Pratt & Whitney and a research scientist in the propulsion science group at the Aerospace Corporation.

As director of the Turbo Lab, he will oversee all operations of the Lab and Symposia Office, including industry- and government-sponsored research, education and workforce development initiatives, including courses and symposia. He assumes the post held for three decades by Dr. Dara W. Childs, who retired in January.

### Siemens in Pakistan

Siemens has signed an LTSA with Punjab Thermal Power to provide maintenance, parts and repair services for Punjab Power Plant Jhang in Pakistan for the next 12 years. The agreement includes Siemens' Power Diagnostics, part of the company's "Digital Services for Energy" portfolio. The plant is expected to add 1.3 GW. The LTSA for this CCPP includes Siemens' SGT5-8000H GTs, generators, related auxiliaries as well as the supply of spare parts and field services. Siemens' Power Diag-

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nostics use data analytics to help predict and eliminate unplanned downtime, and improve power plant productivity by identifying operational challenges in advance. It will also allow the power plant's team to manage outages more efficiently.

Siemens has also signed an LTSA with the Sudanese Thermal Power Generating Company (STPGC) to provide service and maintenance for the power generating assets and related components operating at the 337 megawatt MW Port Sudan and 502 MW Garri power plants. Siemens will provide Operation and Maintenance (O&M) advisory services for both plants.

This will include both classroom and hands-on training for STPGC personnel at Siemens GT plant in Berlin as well as at STPGC's training facility in Sudan. The Port Sudan plant is equipped with two SGT5-2000E GTs, while the Garri plant, scheduled to begin commercial operation in May 2018, will be equipped with three SGT5-2000E GTs. Both plants feature Siemens' SPPA-T3000 controls system.

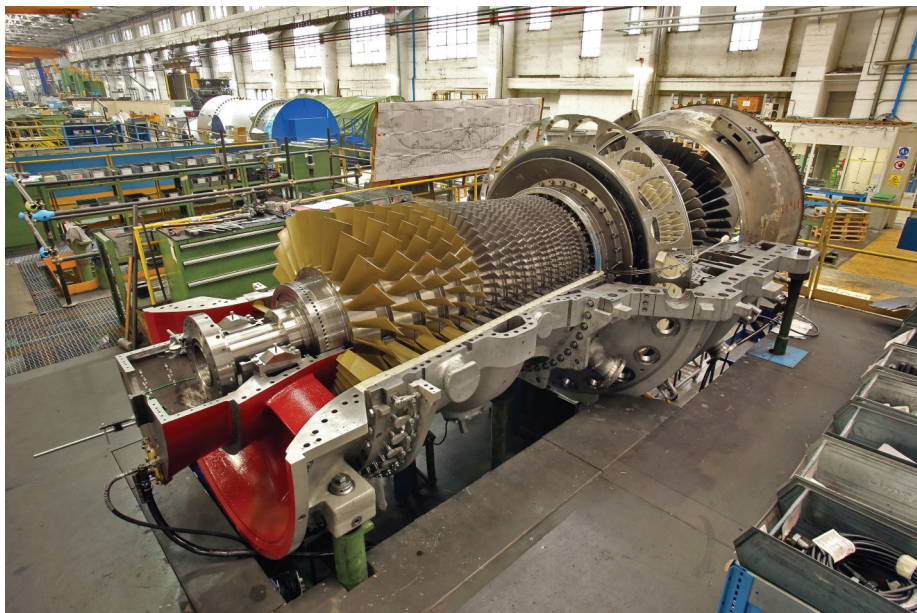
## New EthosEnergy workshop

EthosEnergy's new workshop opened in the New Industrial Area of Doha. The shop, which is 2,000 square meters, offers extended manufacturing capabilities for rotating equipment parts in the oil & gas and industrial markets, as well as repairs services for large pumps, compressors and STs. It consists of two bays and features two overhead cranes. It offers a range of services including low speed balancing, pressure testing up to 10,000 psi, flange facing machines for in-situ work.

## Recycling GTs

GTs contain finite metals and various precious alloys, which would be lost without efficient recycling when scrapped. Cronimet, a supplier of stainless steel scrap, ferroalloys and primary metals, has been successfully scrapping and recycling air-

Ansaldo Energia's AE 64.3A gas turbine



craft turbines for years and has now recycled two GTs. Based in Karlsruhe, Germany, the company dismantles the turbines, documents the destruction of the individual parts and returns the secondary raw materials according to their alloys to the environmental cycle.

## Atlas acquires Walker Filtration

Atlas Copco has acquired Walker Filtration, a British manufacturer of equipment for the treatment of compressed air, gas and vacuum. The company has around 220 employees worldwide and sales offices in Europe, U.S., Australia and Japan.

## Turbine report

Research And Markets's *Steam and Gas Turbine Report 2018* predicts that the turbine market will grow at an annual rate of 4.4%, due to the continued increase in coal-fired and gas-fired power capacity,

industrial expansion in the developing world and tightening air quality controls. China and India are pruning back on new coal-fired plants, but they are not stopping. Turkey, Indonesia and Bangladesh are going large on coal, and the United States is upgrading large chunks of its big coal-fired fleet to supercritical technology. This activity means more, advanced class STs. The report noted that China produces over half the world's STs, with Shanghai Electric, Dongfang and Harbin Electric the global leaders.

## Ansaldo contract

Ansaldo Energia has been awarded a contract by Shanghai Electric to supply GTs and generators for the Pancevo Combined Cycle Power Plant in Serbia. The 200 MW Pancevo combined cycle power plant is owned by TE-TO Pancevo, and Shanghai Electric Group will be responsible for EPC on a turnkey basis. The plant will produce power and heat using natural gas. Ansaldo Energia will supply two AE64.3A GTs, WY18Z air-cooled generators and auxiliary systems.

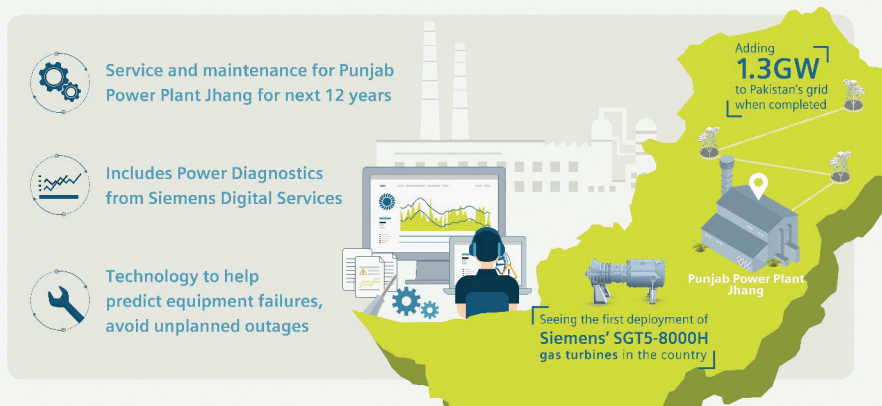
## Micro LNG

Siemens' Dresser-Rand business recently commissioned an LNGo-HP (high-pressure) micro-scale natural gas liquefaction system for Altagas in Dawson Creek, British Columbia, Canada. The Dawson Creek facility, with a capacity of approximately 30,000 gallons of LNG per day, commenced production at the start of 2018. The LNGo-HP system allows consumers to convert from diesel and other fuels to natural gas. The system consists

(Continued on p. 16)

## Siemens secures major service contract for Pakistan power plant

With the fifth-largest population in the world, Pakistan is working to strengthen the country's energy system





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The Sao Vang and Dai Nguyet gas fields will use MAN compressors

of two Siemens gas engines, two Dresser-Rand MOS reciprocating compressors, three Siemens MV motors, Siemens variable frequency drives, and associated auxiliaries.

### Filtration and flow control

Orbital UK has been awarded four contracts by a UK-based EPC. It involves filtration, flow control, fiscal metering, supervisory PLC metering, gas quality measurement, electric heat exchangers-control and specialist lube oil to fuel gas heat exchangers providing pre-heated natural gas to the Solar GTs. Orbital UK will provide high-pressure temperature measurements using its VE Technology Thermowells together with its GasPT Integrated Calorific Value Determination analyzers to reduce response times while eliminating sample blending.

### Offshore gas

PTSC Mechanical & Construction has commissioned MAN Diesel & Turbo to supply two compressor trains for the Sao Vang and Dai Nguyet gas fields' development project in Vietnam.

The compressor trains export the gas from the offshore platform to the onshore receiving terminal. The gas fields are located 500 km south of Vietnam's largest city Ho Chi Minh City. Japanese petroleum company Idemitsu Kosan is the customer and operator of the new platform. The order comprises two booster + export gas compression trains, each consisting of two RB35 barrel-type compressors, driven by a 13 MW gas turbine from

Solar Turbines. The compressors dry gas seal system will use technology features of MAN's standardized U-Pac solution system. MAN will manufacture the systems in Zurich, Switzerland. Both trains will be string tested in Oberhausen, Germany. After delivery in spring 2019, the installation and commissioning works in Vietnam will be the responsibility of the company's regional hub in Kuala Lumpur.

### Mexican pipelines

Siemens recently delivered five GT-driven compressor trains to Fermaca for two pipeline stations in Mexico. The pipeline projects, which also include an LTSA, are part of the Comision Federal de Electricidad de Mexico's (CFE) ongoing energy reform program intended to increase the availability of low-cost energy and stimulate the country's economic growth.

Both stations plan to begin commissioning in 2018, and the entire 500 km pipeline is expected to begin commercial operation in 2019. The five compressor trains, packaged at Siemens facility in Houston, TX, each consist of a SGT-400 GT driving a STC-SV single-shaft pipeline compressor.

The GT trains will provide compression power for a kilometer pipeline that will transport natural gas from northern Mexico to the center of the country. Two of the trains will be installed at a pipeline station in La Laguna, Coahuila, Mexico. The other three units will be part of a pipeline compressor station in Villa de Reyes, San Luis Potosi, Mexico. ■

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# SPECIFYING AND MAINTAINING BOILER FEEDWATER CENTRIFUGAL PUMPS

AMIN ALMASI

**B**oiler feedwater (BFW) pumps are a special class of high-pressure centrifugal pumps used to pump purified BFW at high pressures to boilers to produce steam. They are usually high-speed, high-power units with specific requirements for each service, material selection and pump design.

Steam turbine-driven BFW pumps are often used in steam generation systems. Properly designed steam turbine drivers are typically more reliable than electric motors for high-speed BFW pump applications. As they consume steam generated in the boiler, they are usually more efficient, and easier to control.

However, electric motor-driven BFW pumps are still needed for start-up, back-up and standby. Electrical motor drivers can be started faster, making them a better option for standby and spare pump trains.

The same model of BFW pump is generally used in both electric-driven and steam-driven BFW pumps to encourage commonality, and ease of operation and maintenance.

In a steam generation system, a steam-turbine-driven BFW pump is provided for normal operation. 2 x 100% electric motor-driven pumps are provided for start-up, backup and standby. Overall, 300% of the installed capacity is provided. As the required availability is 100%, such an expensive solution is needed.

In a critical, large steam generation system, 2 x 50% steam-turbine-driven BFW pumps (total 100%) are provided for normal operation and 3 x 50% electric-motor-driven pumps (overall 150%) are furnished for backup and standby.

A 30% electric-motor-driven BFW pump is also provided for start-up of the large unit. In this case, installed BFW pumps amount to 280% of the required capacity, and provide 180% of spare and standby capacity. In addition, a 10% to 15% flow margin should also be considered for each BFW pump.

## Components and sub-systems

Casings for BFW pumps should be designed to withstand their maximum working pressures. This should be assessed during extreme conditions such as: the shutoff point at maximum speed (when the discharge valve is closed); failure of the discharge non-return valve (check valve); obstruction of flow in the suction piping; or a combination of these, with hot water, cold water and other possible thermal shocks.

**"Casings for boiler feedwater pumps should be designed to withstand their maximum working pressures."**

The pump casing should enable the removal of the internal assembly without disturbing the piping. Therefore, casing design, fabrication and assembly need great care as many considerations are involved.

Many pumps usually use flange connection at both suction and discharge for connection to the piping. However, for many BFW pumps, discharge flanges have been a source of leakage and trouble.

In small or medium BFW pumps, flanges of one or two pressure ratings above the calculated rating should be used to provide a margin and prevent leakage. However, this is expensive.

For high-pressure and large BFW pumps, flange connections at the discharge

may not be feasible, particularly if pressure and temperature are high. The connection between the pump casing and BFW at the discharge nozzle (and sometimes both the suction and discharge) is usually welded.

Corrosion and erosion, major issues for BFW pumps, require careful material selection. All areas subject to possible erosion should be protected by linings or alternative methods. BFW pump shafts should be machined from high-quality forgings of a carefully selected grade of stainless or alloy steels. They should be heat treated. Additionally, the rotor assembly must be properly designed, fabricated, tested and balanced.

Impellers should be of the shrouded type and fitted to the rotor shaft in such a manner as to be readily removable, and to ensure freedom from thermal distortion, due to high operating speeds and loadings. High speed, speed variations and high head place them under considerable stress, requiring careful stress analysis and fatigue calculations.

All stage impellers should have a useful lifetime of more than 140,000 hours. Each impeller and each rotating part should be individually balanced. In addition, the rotor assembly should be dynamically balanced and the assembled rotor checked for concentricity.

Tilting-pad journal bearings are often used for BFW pumps. However, small BFW pumps might use rolling-element bearings. Provision should be made to permit vertical and horizontal adjustment of each bearing by shim manipulation. The return oil flow from each bearing should be visible and the oil should remain at local temperature.

In addition, sensors are needed for flow, temperature and pressure of the lubrication oil system (both supply and return), as well as measurement of vibration and temperature. Duplex thermocouples should be installed in the white metal of each journal bearing and within each pad of thrust bearings. Bearings should be arranged so they are readily accessible for examination and replacement without removal of the rotor assembly from the pump. ■





Lorenzo Simonelli

# A BRIGHTER OUTLOOK FOR OIL & GAS

**KEY TRENDS INCLUDE DIGITIZATION, ENVIRONMENTAL CONSTRAINTS, LOWER SPEND THAN IN THE PAST, INCREASED ASSET USE AND 3D PRINTING**

BY DREW ROBB

**T**he oil & gas industry has had a tough couple of years following the collapse in oil prices. But the January Annual Meeting of Baker Hughes, a GE company (BHGE), in Florence, Italy sounded a more positive note.

This two-day event brings together more than 1,000 senior oil & gas leaders and government leaders from companies, such as Shell, Maersk Oil, SKF, Nvidia, Saipem, BP and Novatek. They outlined key trends, including digitization, environmental constraints, lower spending than in the past, increased asset utilization and the importance of 3D printing (also known as Additive Manufacturing or AM).

Most speakers saw a brighter future — but only for those that embraced a new way

of operating — one that involved the latest technology and digitization of their assets, while keeping operating costs low.

## Opening keynote

During his opening keynote, Lorenzo Simonelli, Chairman and CEO of BHGE, offered a positive outlook on the oil and gas market.

“We began 2017 with a bearish outlook, but as we enter 2018, it looks a lot brighter,” he said. “People are optimistic, and they are starting to spend again.”

Simonelli outlined several mega-trends impacting the industry. The foremost one, a growing need to keep pace with the digital revolution that has seen the industrial world adopt many consumer market tech-

nologies. The result is that business processes are moving at a pace we have never seen before.

In turn, this has generated a raft of new players coming onto the scene. Google and others are now looking to play a part in the energy sector. For some, this is a threat, for others an opportunity.

The environmental challenge was next. The oil & gas industry has been viewed in the past as a pollution generator. In this low-carbon regulatory environment, oil and gas needed to change. For BHGE, and others in the sector, this means moving to cleaner energy sources, such as natural gas and alternative production methods.

A further trend is lower spending. “It’s no longer the oil price that matters alone;

it is the need to reduce CAPEX and OPEX,” said Simonelli. “There is a strong drive toward efficiency to remain competitive. We cannot go back to the way things were before the oil price crash.”

The recent merger of Baker Hughes and GE Oil & Gas, he said, is one way to meet these goals and respond to those trends. This is enabling the company to increase asset utilization and lower the total cost of ownership by 50%.

“The future of competitiveness in energy will be defined by radical improvements in project economics, significant shifts in the way we do business, and the ability to balance energy demand and environmental responsibilities,” said Simonelli.

A recent order will supply the turbine to Vietsovpetro to be deployed offshore in Vietnam. The NovaLT16 will be combined with the gas compression platform’s existing gas engine-driven reciprocating compressors to expand gas compression capacity at Block 09-1. Its mechanical drive capabilities will enhance the facility’s gas compression performance, with 89% or higher compressor efficiency.

Khuram Majeed, APAC Vice President for Turbomachinery & Process Solutions at BHGE, explained that GE’s heritage has been in large GTs. Until the NovaLT, it has never participated in the below 20 MW segment.

This sets up an interesting scenario whereby oil & gas specialist BHGE is sell-

Across APAC, he said, needs vary widely. China is currently engaged in a distributed power initiative. It is looking for many units in the 10 MW to 30 MW range to promote general manufacturing and smaller industrial parks.

In Malaysia, palm oil and paper customers predominate. One NovaLT16 customer, for example, makes rubber gloves. They use the turbine to power a geothermal heat recovery system.

“These buyers prefer the NovaLT as they can use it continuously for four years,” said Majeed.

Beyond the NovaLT, he said the strongest market segment for BHGE turbomachinery is in Liquefied Natural Gas (LNG). Most of that market is also in Asia or Australia. Some LNG plants use large frame machines and others use aeroderivatives.

Gorgon and Woodside LNG both use Frame 7s. Large LNG facilities gravitate towards turbines that produce 100 MW or more for power generation and driving a compressor for liquefaction.

The GE LM6000 PF is used at Wheatstone LNG. The plant is upgrading its LM6000 PFs to PF+, he said, which add 10 MW more power. In addition, the new 65 MW LM9000 should be in production by the end of next year. It targets a range of driver that BHGE believes will be in the sweet spot for more LNG projects over next few years.

Turbines deployed in LNG are getting smaller. While large reservoirs required big drivers, new fields tend to offer lower reserves (in the 1 to 3 million tons per annum range), Majeed said. Smaller turbines fit better for that range.

## BHGE partnerships

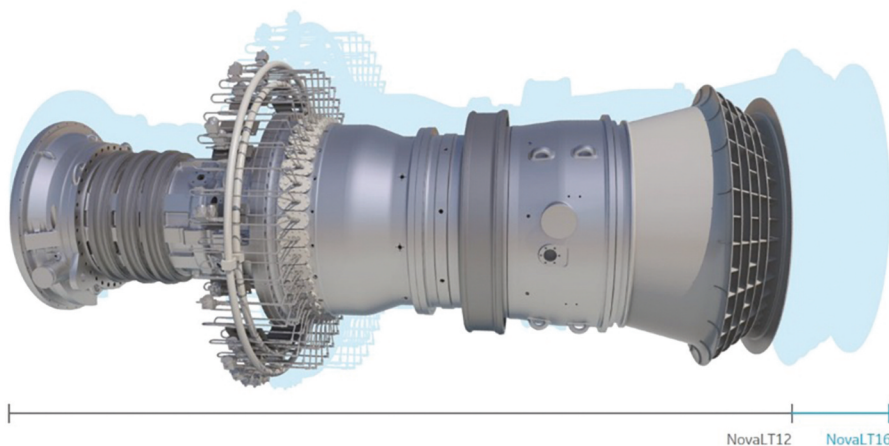
New digital technologies are changing the way BHGE works. This has spurred closer partnerships with others in the industry.

For example, a contract with Maersk Oil will see BHGE deliver an integrated scope of turbomachinery equipment for the topside production facility of the Tyra field redevelopment project in the Danish North Sea, including: seven compression trains featuring BCL centrifugal compressors driven by GE Power high-speed electric motors; three gas turbine generator sets; and two turbo expanders.

The compressors use an active magnetic bearing (AMB) solution for both driver and driven equipment, and BHGE will supply AMB applications through a license-based partnership with SKF.

Adopting an AMB and high-speed electric motor configuration allows Maersk to eliminate lubricants and reduce the weight, footprint and maintenance costs for the

*(Continued on p. 20)*



The new BHGE NovaLT12 gas turbine compared to the existing NovaLT16 (light blue shadow)

## NovaLT turbines

BHGE is accelerating the use of 3D printed parts implemented within its NovaLT gas turbine series. The company was targeting oil and gas with this machine but found a great deal of interest in the power industry.

Initially conceived for the mechanical drive market, BHGE is seeing sales for power generation due to the unit’s light weight and small footprint for areas needing power in the 5 MW to 16 MW range.

Developed and built in Florence, Italy, the turbine can operate for up to 35,000 hours between maintenance intervals. It has been configured to ensure servicing activities can be completed quickly and efficiently, thereby reducing downtime, resulting in high levels of reliability, availability and efficiency, with reduced operating costs for the customer.

The Asia Pacific (APAC) region has proved to be a strong market for the NovaLT16, with 12 turbines sold to customers in 2017. Vietnam, for example, continues to have significant levels of oil & gas development both onshore and offshore, with increasing demand from power plants, refineries and petrochemical plants.

ing a power generation unit that GE Power cannot offer. The NovaLT competes with Solar, Siemens and Kawasaki turbines.

“We saw a market, invested \$100 million in the NovaLT line, and make these machines in Florence,” he said.

The company has sold 12 NovaLTs in Asia Pacific, he added, by far the strongest area for sales of this new machine: five 16 MW units and seven 5 MW units. In this region, the company expected primarily oil & gas orders. However, it has also taken off as a power generation machine. Out of 12 sales, only three have been in mechanical drive.

“By offering the NovaLT as an industrial turbine, we are no longer tied to price of oil for sales,” said Majeed.

High GDP growth in Asia is generating demand for power generation units below 20 MW. Rubber plantations, paper mills, cement factories and beverage producers are among those that have purchased NovaLTs to provide electricity to power their processes. In some cases, it is configured for combined cycle with exhaust heat used for steam production (three units are used this way).





Harry Brekelmans



Carlo Calenda speaking at a panel discussion

equipment on the platform's topside.

BHGE has jointly developed Jewel-Suite with Royal Dutch Shell, to enable better execution of field development planning by integrating data and workflows from seismic interpretation all the way through to geological modelling. This allows Shell to reduce uncertainties on well placement, reserves estimation and production planning.

"Digital technologies have been an important feature in our industry for years but now the pace of change is increasing dramatically," said Harry Brekelmans, Director of Shell Projects and Technology. "What used to take years or months to be developed and deployed, can now take a few weeks."

We are at the beginning of a renaissance, he said, as the industry adjusts to new concepts of digitalization, capital efficiency and operational excellence.

Shell's Stones project, said to be the deepest oil & gas project in world, uses a floating production, storage and offloading (FPSO) vessel. The initial wells for this project took only 60 days to drill, about half the time they would traditionally take. The Appomattox deep water project had brought operational costs down 20% and capital costs down 25% using 3D printing, digitalization and analytics.

"Shell is targeting a 20% reduction in its carbon footprint for ourselves and our customers by 2035 and a 50% reduction by 2050," said Brekelmans.

Other speakers also detailed how the old ways were being replaced by a new reality.

Dr. Dawood Nassif, Advisor to the Bahrain Oil Minister, Board Director of the Bahrain Petroleum Company and Board Director of Gulf Air, began with his view on the price of oil.

With OPEC and Russia forming a partnership that controls half of worldwide oil production, he foresees the price of oil being

pushed up further. But looking to the future, he predicted that the gasoline-fueled car is going away. The electric car and autonomous car (also known as a driverless car, self-driving car, robotic car) are coming, along with the end of individual vehicle acquisition.

"80% of the time, a vehicle is parked at home or at the office," said Nassif. "We will all be using providers instead of vehicle ownership in the future."

Carlo Calenda, Italian Minister of Economic Development, offered a similar message. He said Italy has many old vehicles, and government policy was aimed at changing the paradigm of car ownership. This is part of a national energy strategy, which also encompasses natural gas as being the most important transition fuel between a fossil and a renewable economy.

"We are pushing for more natural gas supply sources," said Calenda. "Right now, a lot of supply comes through Russia and Ukraine. We need to diversify our supply."

## Digitization emphasis



Binu Mathew

Binu Mathew, Senior Vice President & Global Head, Digital Products at BHGE, said the modern oil & gas company is as much in the data business as it is in the hydrocarbon business. To gain market share, they need to harness sensor, geolocation, weather, drilling and seismic data to derive organizational insight. A typical offshore rig generates 50 terabytes of data per year. A shocking 1% is used in analysis.

Accordingly, BHGE has formed a partnership with chip maker Nvidia to bring what is called "Deep Learning" to oil & gas. The companies are co-developing artificial intelligence (AI) technology which includes Nvidia-powered computing and BHGE's analytics and digital twins.

"A new generation of intelligent operations can dramatically improve efficiency and productivity for energy producers," said Jim McHugh, Vice President and General Manager for Enterprise Systems at Nvidia.

The Graphics Processing Unit (GPU) was originally deployed in 3D game rendering. But people soon realized that it could accelerate computational workloads in oil & gas, finance, simulation and other fields.

The GPU takes vast amounts data and does the same thing repeatedly at great speed. It is this focus on one type of task that boosts overall computational velocity. BHGE is pairing the Nvidia GPU and the Nvidia DGX computing platform with its Predix cloud-based industrial platform to unify this data and break down isolated information silos.

This enables engineers to gain analysis results in hours that previously could take months, opening the door to more intelligent machines and systems that can reduce the cost of discovering and extracting oil and natural gas.

Another touted benefit is greater accuracy in predicting machinery failure. This new generation of systems helps operators to visualize production and sensor data flooding in from equipment throughout a facility. Pressures, flow rates, temperatures and other parameters can be unified to draw accurate, automated conclusions. In addition, rapid number crunching helps explorers to identify optimum rock formations and predict reservoir location.

## Plenty of oil

Shale gas means more oil from recoverable resources than we need for next 30 years by a large margin. So said Bernard Looney, Chief Executive for Upstream at BP. He added that China, Algeria and other countries may have more oil than the U.S. Due

to this surfeit of supply and pressure from electric vehicles (EVs) and renewables, some of these resources will not be needed.

"Competitiveness is the way forward: you have to be ready to compete efficiently and that demands different market responses," said Looney.

BP's response is to strategically grow its natural gas business, which he said was the fastest growing non-renewable segment. The company is also focusing on what it called "advantaged oil" — sources where there is resilience to a range of prices.

Looney was yet another advocate of digitization, which he termed a game changer. "We use an algorithm to hear the sound of the type of rock, and whether liquid, gas or solids are present, so you can change the well speed, adjust pressure, and change drilling direction," he said. "We now have miles of fiber optic cable in our wells."

BP employs a system known as BHGE Plant Operations Advisor in its Gulf of Mexico Atlantis facility. It can run 40 million calculations on 40 pieces of equipment in one day. This enables the company to fix issues in turbines, compressors and other systems before they happen. The plan is to deploy this on all BP assets within the next two years.

Additionally, digital analysis helped BP discover that it had 200 million more barrels of oil in one Gulf field than expected. Looney said the calculations involved would have taken 1,000 years to complete in 1999. They can now be done in two weeks.

Looney ended with a shift in how gas turbines are being sold. He gave the example of a turbine BHGE is supplying to a BP site in Trinidad.

"Rather than buying it, we will pay for power by the hour," said Looney. "As we pay for reliability rather than a piece of equipment, BHGE has an incentive to make it more reliable. In turn, it provides them with a predictable revenue source over decades rather than at one point in time."

Saipem, too, has a strong relationship with BHGE for oil and gas. Stephano Cao, CEO of Saipem, said years of cost cutting is not enough. He is preparing the company for the digital world to be able to take advantage of big data, the Internet of Things (IoT) and analytics.

He is also focused on developing local skills in the various markets where the company is active in conjunction with universities and local authorities to train more people on digital technology.

"Together with the digital revolution, we must develop a different way of dealing with clients, the countries in which we operate and our stakeholders," said Cao. "We need to be more collaborative rather than operating in opposition."

## European pipeline

Reinhard Ontyd, Chief Commercial Officer, Nord Stream 2 pipeline, spoke about bringing Russian gas to Europe through the Baltic Sea from Finland, Sweden and into Germany. This will be operational by 2019.

Nord Stream 2 will close Europe's natural gas import gap due to lower LNG availability, and increase security of supply. A market study by the University of Cologne predicted the pipeline could save European consumers 8 billion euros every year.

The Nord Stream 2 pipeline will deliver gas from the Bovanenkovo gas field in Russia's Yamal Peninsula, which holds 4.9 trillion cubic meters of gas reserves. The pipeline runs from the Baltic shore west of St. Petersburg to the German Baltic coast near Greifswald. It will also require compressors to keep gas moving to the European coast.

Mark Gyetvay, CFO and Deputy Chairman of the Management Board at Novatek, followed with an in-depth briefing on Yamal LNG. This project is one of most challenging in the world, but the reward potential is high — 1.4 tcm of natural gas reserves.

Train 1 entailed the drilling of 38,000 pylons due to the permafrost surface. Heat exchangers are used to manage the permafrost to keep the ground stable. Special ships navigate and crush through ice of up to two meters thick to keep supply lines flowing. Some 208 wells are being drilled at 19 well drilling pads.

The liquefaction plant consisting of three production trains of 5.5 mmt of annual capacity per train. The first train began production at the end of 2017.

After the gas is brought out of the ground, initial separation removes mechanical impurities, water and methanol. Separated gas is supplied to the liquefaction trains.

The process involves removal of acid gas and methanol, dehydration, mercury removal, as well as extraction of liquefied petroleum gas and a propane cooling loop before the LNG is stored in cryogenic tanks.

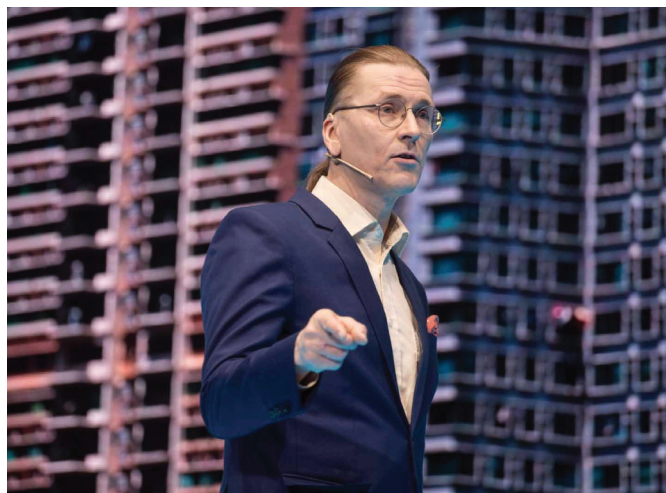
A power plant is also present with a capacity of 376 MW. Turboexpanders in-

crease gas treatment efficiency. Yamal LNG's second and third trains will be operational in 2018 and 2019, respectively.

With the experience gained at Yamal LNG, the company has launched Arctic LNG 2 about 70 km away. Once fully operational Arctic LNG 2 will have a production capacity of 18 million tons compared to Yamal LNG's 16.5 million tons. Novatek is selecting Italy's Saipem to build offshore platforms for Arctic LNG 2.

As it is built on solid rock, Arctic LNG 2 should save 30% compared to the Yamal LNG project, Gyetvay said. The Kamchatka Transshipment Complex is being established in the region to provide 20 million tons of LNG per year of planned capacity.

Construction begins this year. This will enable the company to deliver LNG to the China market in 18 days, halving the time it previously took. BHGE is partnering with Novatek on both these projects to provide a wide range of turbomachinery equipment and services.



Mikko Hyppönen

## Data is the new oil

Mikko Hyppönen, Chief Research Officer of computer security firm F-Secure, delivered a lecture on the growing importance of cybersecurity. While he applauded the move to bring Operational Technology (OT) and Information Technology (IT) together, he delivered a warning to those engaged in the digitization of their systems.

"Whenever a device is called smart, it is vulnerable," said Hyppönen. "However, the upside of using digital technologies outweighs the downside of potential attacks."

Security, he added, is a process, not a technology product. He urged the audience to make computer security a board-level subject. Only by doing so, can digitization become a true enabler of organizational goals. ■





Figure 1. Cracked gas compressor fouling: CGC LP casing after operation (left), and HP casing (right). As a result of fouling, the accumulation of polymers on the internal surfaces adversely affects overall performance. Changes in feedstock or cracking severity can change or shift the dominant fouling mechanism.

# COMPRESSOR FOULING

## CRACKED GAS COMPRESSOR FOULING AND ANTI-FOULING TECHNOLOGIES

BY PALLAVI BADDAM

**E**thylene plant capacities in recent decades have increased well beyond 1.5 MMTPY (million metric tons per year) and are now around 2.0 MMTPY. The Cracked Gas Compressor (CGC) is one of the most critical pieces of rotating equipment present in modern ethylene plants.

The purpose of the CGC is to compress gases from the cracker for separation in downstream units within the process plant. The compressor handles process gas, which is a complex mixture of cracked gases containing substantial quantities of high molecular weight hydrocarbons, such as  $C_4$ s,  $C_5$ s and  $C_6$ s.

Therefore, any reduced capacity or unscheduled downtime of the CGC negatively impacts overall production and plant economics. Fouling is one of the typical causes for reduced capacity or performance deterioration in CGC operation.

Typically, a CGC train consists of two or three bodies of multistage compressors

driven by steam turbines (STs). Fouling that occurs in a single multistage cracked gas compressor has a crippling effect on the overall performance of the train.

Fouling is caused mainly by three different mechanisms: free radical polymerization, condensation and thermal degradation to coke. Polymerization occurs when two or more unsaturated monomers with reactive double bonds (or consisting of the same elements in the same proportions by weight but differing in molecular weight) react to form another compound having higher molecular weight and different physical properties.

Compounds, such as ethylene ( $C_2H_4$ ), Propylene ( $C_3H_6$ ), and Butene ( $C_4H_8$ ) within the gas stream may react with heavier molecular weight (i.e.,  $C_6$ ,  $C_7$ ,  $C_8$  hydrocarbon compounds) resulting in polymer formations. These polymer formations and fouling rates tend to increase exponentially with temperature.

As such, the polymer chain grows, and the molecular weight of the polymer increases

until it becomes insoluble and clings to the metal surface. With time, these polymer deposits reduce to a coke-like substance on internal parts of the compressor (Figure 1).

### Fouling and performance

Surface roughness has a major impact on compressor performance. Impeller and diffuser performance depends on the presence of a smooth surface finish. Fouling aggravates the degree of surface roughness and affects the component efficiencies at individual and collective levels. Additionally, this fouling reduces the fixed volume of the internal components, ultimately decreasing the gas-pass area within the impeller (Figure 2).

In a two-stage impeller compressor the performance of the first-stage impeller has a significant effect on the performance of the second-stage impeller. Decreased flow area due to fouling, lowers the efficiency and discharge pressure of the first impeller (Figure 3).

Therefore, the predicted suction pres-

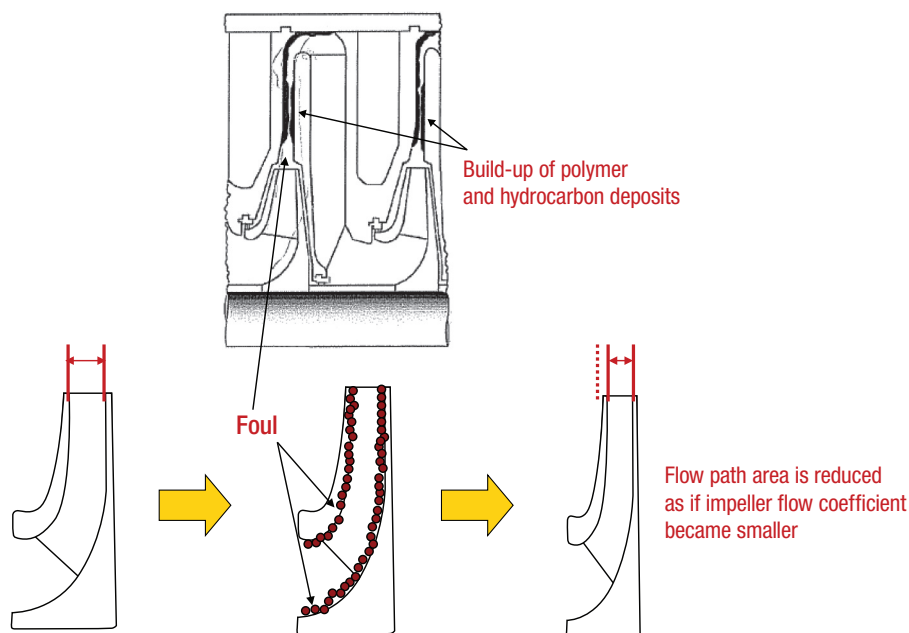


Figure 2. Volume reduction due to narrow passage within the impeller as a result of fouling. This is equivalent to using an impeller with a smaller flow coefficient. As a result, the efficiency of the impeller decreases.

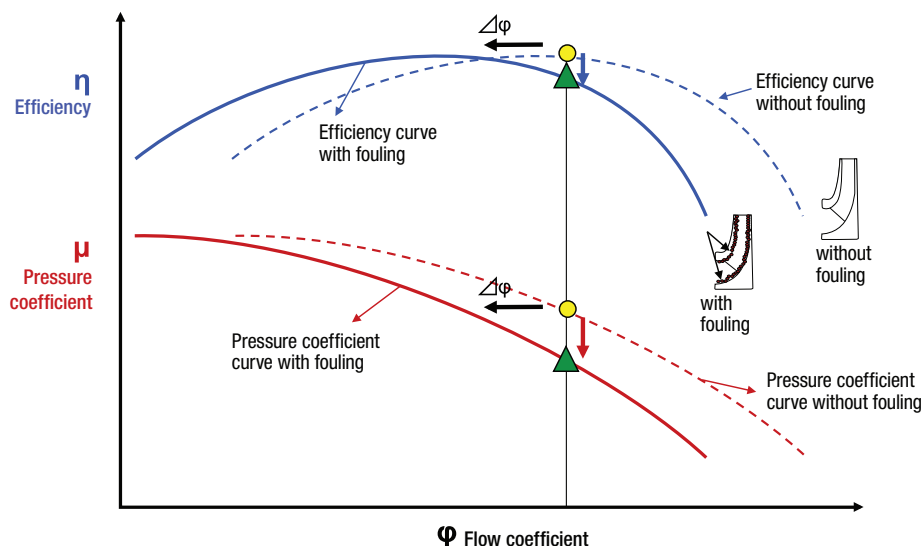


Figure 3. Stage 1 Aerodynamic performance with and without fouling. As can be seen, fouling causes a reduction in the gas passage area which impedes the impeller. As the impeller design was optimized for a particular flow coefficient, fouling means a drop in impeller efficiency.



Figure 4. A rough surface inside a compressor due to fouling

sure of the second impeller is no longer the same as the actual suction pressure. As a result, the pressure, temperature and flow to the second stage also change, thereby lowering second-stage efficiency.

This also leads to high temperatures within the compressor internals. To meet the predicted discharge pressure, then, the compressor has to work harder. As a result, the speed and power of the compressor increases. This rise in power results in higher than expected operating expenses

As mentioned earlier, surface roughness contributes to compressor performance. The effects of surface roughness within the gas passage due to fouling can be estimated using ICAAMC Reynolds Number correction formulas.

If surface roughness is worse than the impeller design condition, losses can be expected at the impeller surface resulting in a lower pressure coefficient. Therefore, a shift in the operating point from the design point brings about a change of predicted polytropic head, flow coefficient and impeller efficiency (Figure 4).

## Anti-fouling technologies

A certain amount of fouling is inevitable; however, it can be controlled. Several anti-fouling mechanisms have been used by operators. As the fouling mechanism changes, the effectiveness of the mitigation method may also shift. It is usual for process licensors and end users to dictate the type of anti-fouling mechanism needed.

Anti-fouling technologies can broadly be divided between conventional and unconventional techniques. One example of an unconventional approach involves the use of chemical treatments or anti-foulants within the process gas.

Its main function is to prevent fouling by inhibiting chemical reactions. These formulations contain an inhibitor and antioxidant. The inhibitor reacts with monomers before they can form insoluble polymers. The anti-oxidant reduces oxidative polymerization. Researchers are constantly coming up with anti-foulant formulations that can prevent polymerization at its initial phase.

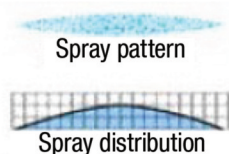
Conventional anti-fouling technologies used by ethylene producers include:

## CGC COMPRESSOR COATINGS

Compressor internals are coated to avoid corrosion and foulant deposition on the surfaces. Use of coatings has a minimal efficiency decrement. They are generally applied to diaphragms, inlet guide vane (IGV) and rotor assemblies (Figure 5). Process licensors, purchasers and OEMs mutually agree upon the compressor components that need coating based on the type of serv-



Figure 5. Water injection nozzles are located on the casing in order to be able to inject the water spray into the compressor stages.



ice and the process gas used.

Mitsubishi Heavy Industries Compressor Cooperation (MCO) uses SermaLon coatings if requested, typically a three-layer coating. The foundation is a tightly adherent layer of sacrificial aluminum-filled ceramic.

This galvanic coating prevents corrosion of structural hardware. The intermediate layer in a SermaLon is an organic coating containing metalo-compounds, which prevent corrosion by modifying the chemistry of environmental corrodants. The outermost layer is an organic material containing PTFE. It acts as a barrier against corrodants in the environment and limits fouling. This incurs a nominal drop of compressor efficiency.

## CGC COMPRESSOR WATER INJECTION

Ethylene producers typically add water to the process gas compressor to lower the gas discharge temperature. Water vaporizes in the compressor stage, absorbing some heat of compression and lowering stage discharge temperatures.

As fouling increases at high discharge temperatures, water injection is used in applications for more precise temperature control. It can either be continuous or intermittent. Typically, the water quantity is around 1% of the total process flow. When wash nozzles are requested, the purchaser or the process licensor should provide discharge temperature limits to calculate the water flow rate.

Experience with this method had

demonstrated significant decrease in temperature ( $\sim 10^{\circ}\text{C}$ ) due to water injection (Figure 6).

## CGC COMPRESSOR WASH OIL INJECTION

To prevent efficiency losses due to fouling during long-term operation, wash oil is injected at regular intervals in CGCs (Figure 7). Wash oil injection nozzles are usually installed on the suction piping as well as the return bend on each stage.

Wash oil injection ensures that polymer deposits do not adhere to internal surfaces. Oil quality is important and should be free of impurities. Some of the best wash oils have aromatic contents greater than 60 % and boiling points higher than  $300^{\circ}\text{C}$ . This ensures that the oil remains liquid, allowing

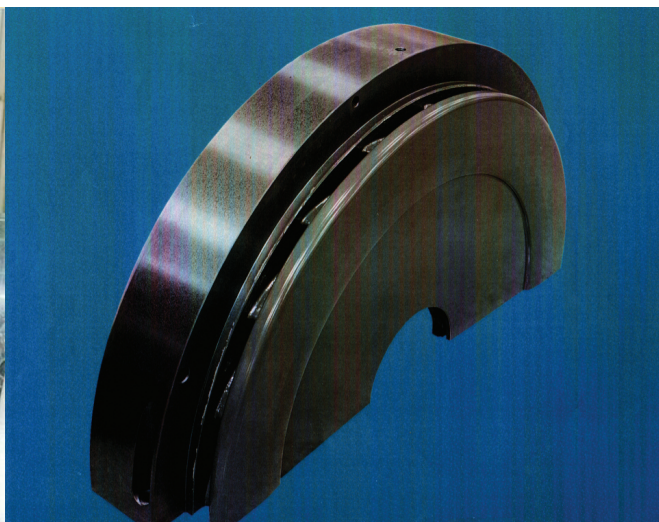


Figure 6. SermaLon coating of internal components

it to dissolve and scour polymer from the metal surfaces and minimize deposition.

OEMs have the responsibility to ensure that the droplet size is maintained to avoid erosion due to water or oil injection. The location of injection nozzles should be optimized to improve wash efficiency. CFD analyses should be used to determine the optimum oil injection location

The effectiveness of water and oil injection cannot be estimated by an OEM alone since the operating history and usage pattern is unknown. To resolve a fouling problem, collaboration is required. ■



**Pallavi Baddam is the Proposal Manager for Mitsubishi Heavy Industries Compressor International (MCO). She has a Master's Degree in Mechanical**

**Engineering. MCO is currently working with an operator to evaluate the optimum wash area and oil quantity, as well as how to mitigate erosion potential. The results will be presented in a follow-up article. For more information, visit [www.mhicompressor.com/en](http://www.mhicompressor.com/en)**

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## HYDRAULIC BOLT FASTENING

### BEST PRACTICES FOR CRITICAL FASTENING APPLICATION ON GAS TURBINES

BY PAT MCCORMACK

**A**dvancements in engineering design and analysis tools have allowed many new products to be developed for maintaining and operating gas turbines. They are not only safer, but they also allow for faster and easier operation as well as cost savings. Some of these enhancements have become best practices in the industry.

One specific area of improvement is seen in critical fastening applications. A

critical fastening application is any bolted joint that requires accurate and uniform bolt loading.

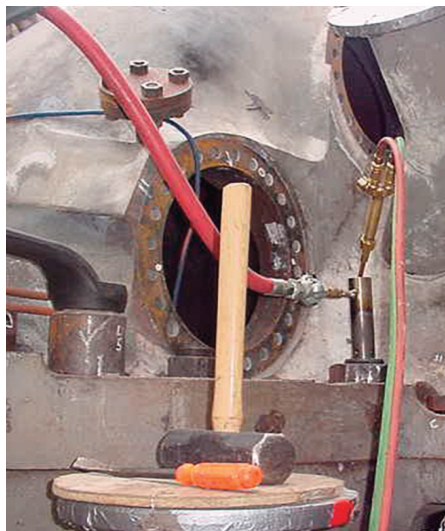
In the early years of turbomachinery, it was common practice to tighten a nut and bolt through thermal expansion. This process, sometimes referred to as “heat and beat,” was done by heating the stud or bolt to cause the material to expand in length. You then tighten the nut with a slug wrench and a large hammer. When the stud cools down, it contracts and creates the clamping force. Drawbacks to this method are the inconsistency in obtaining an accurate clamping force, and safety concern surrounding

the use of high heat and a large hammer.

Another method used to tighten fasteners is to apply torque. It is common to see stud sizes well above one inch in diameter; a mechanical torque wrench used by a single person cannot supply enough torque.

To achieve high torque values on studs of larger size, the hydraulic torque wrench was developed. Using hydraulic pressure, it transmits far more torque than a mechanical torque wrench. This enables better bolt loading of large studs.

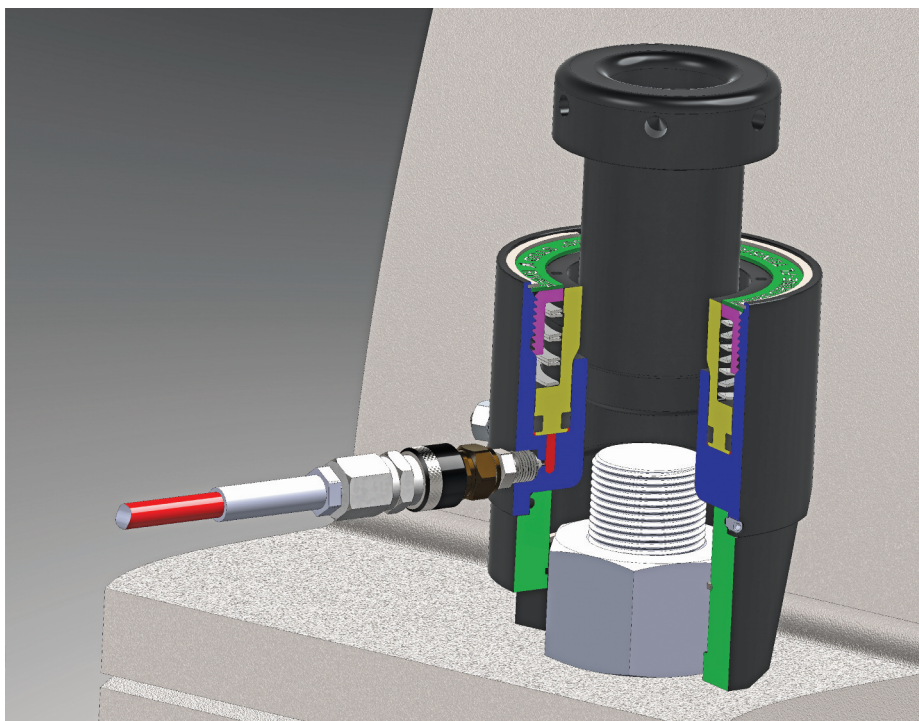
An alternative to stud heating and hydraulic torque wrenches that has become accepted as a best practice is hydraulic bolt



Stud heater and slug wrench



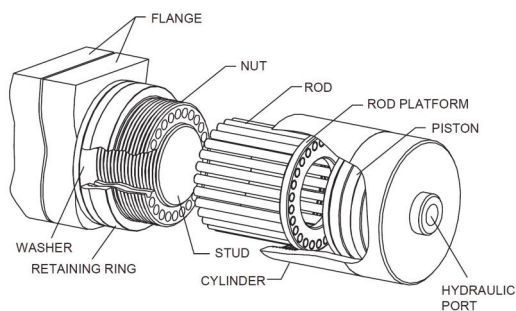
Hydraulic Torque Wrench



A standard hydraulic bolt tensioner fits over the stud and nut. Its threaded adapter grips the exposed threads above the nut. Using hydraulics, the stud is stretched, and the nut can be freely turned down to the flange face.



The hydraulic rod tensioner needs a foot print no bigger than that of the original heavy hex nut. This kind of tensioner allows the studs to be as close as possible to one another, which is often the case with many of today's flange designs.



Hydraulic rod tensioner

tensioning. Benefits include repeatability and accuracy, as opposed to the high variance in pre-load that exists with the heat and slug wrench method, as well as the bolt torque method.

The problem of friction between threads is another area that is resolved by bolt tensioning. Friction develops in the threads of the nut and bolt, as well as when the nut is being tightened onto the flange itself. This tends to gall the material. As a result, the nut can stick and needs to be cut off.

Even if the nut does not gall and stick, friction remains a problem. The amount of friction can vary from bolt to bolt which leads to preload variation. Friction also tends to cause the bolt to wind up, which relaxes over time and loses its initial clamping force. Hydraulic bolt tensioning eliminates this issue.

For applications that do not have enough spacing between the studs for a tensioner, or there are not enough threads exposed above the nut for a standard tensioner to grip onto, a hydraulic rod tensioner can be used. The hydraulic rod tensioner was developed for applications with a very tight radial footprint.

The standard hydraulic bolt tensioner needs space to fit around the nut. The hydraulic rod tensioner, on the other hand, uses a perforated nut to allow the tensioner to use rods to push through the nut and tension the stud.

This perforated nut makes it possible to tension studs that were originally done with torque and therefore did not have the stud length to allow proper thread exposure above the nut for the standard tensioner to grip onto.

There are many different types of hydraulic bolt tensioner available on the market. Various suppliers have developed tools which can be used in different situations. As well as off-the-shelf items, specialty designs are available. ■



**Pat McCormack, Director of Business Development at Riverhawk Company.** For more information visit, [www.riverhawk.com](http://www.riverhawk.com),

call 315/768-4855 ext. 144 or email [pat.mccormack@riverhawk.com](mailto:pat.mccormack@riverhawk.com)

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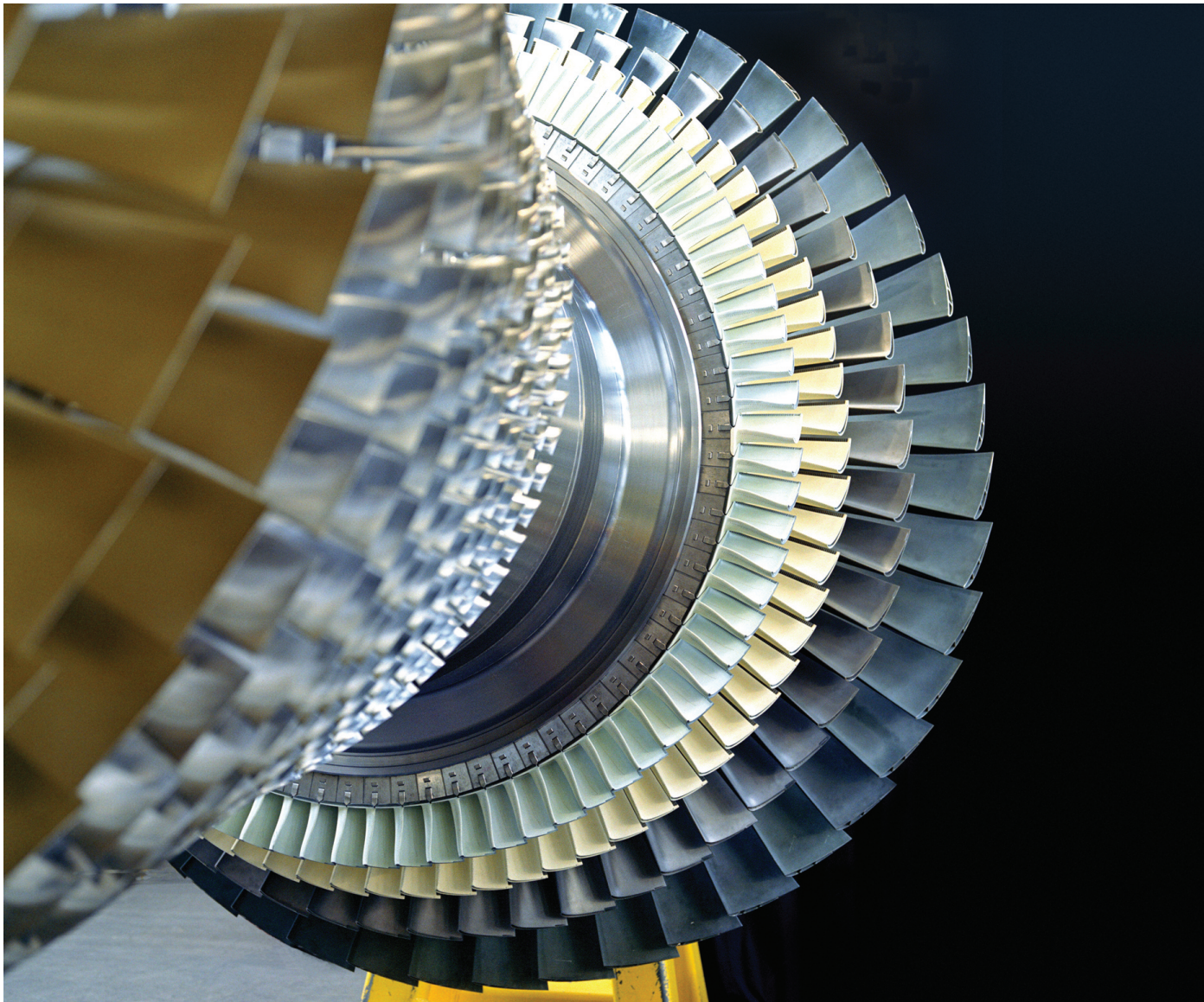


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## VANQUISHING VARNISH

### HOW TO PROTECT GAS TURBINE EQUIPMENT AGAINST DOWNTIME

BY GARRY BROWN

**I**n an effort to gain greater production, operators are pushing their gas turbine equipment harder than ever before. Those with older equipment seek more output, while those investing in more advanced turbines are looking for greater efficiency. In both instances, this leads to more demanding operating conditions, such as higher operating temperatures, that place greater stress on the lubricating oil.

This, in turn, accelerates varnish formation. According to an ExxonMobil survey of 192 gas turbine power plants, approximately 40% of turbine operators reported either current or historical issues with varnish within six years of servicing their oil.

Treating the symptoms of varnish with mitigation technologies can help. However, reliable operation of turbine equipment de-

pends on preventing or slowing the formation of varnish. It begins with a clean system and the right approach to lubrication.

#### **Varnish formation**

Varnish, also referred to as oil deposits, is the hard, oil-insoluble organic residue not easily removed from mechanical components by wiping it away. On equipment, varnish appears as distinct cloudy particles





or blemishes. Excess varnish can strain equipment and increase the threat of component failure.

There are three main mechanisms of varnish formation:

- **Thermal degradation of oil:** Occurs at temperatures above 300°C. These high temperatures are not common in most power generation applications
- **Oxidation:** The chemical process that acts to decompose the oil, creating sludge
- **Oil contamination:** Happens when external and internal contaminants become mixed in with oil. The equipment's quality of performance can be drastically affected.

The best defense against varnish formation is using a well-formulated lubricant designed to perform in the high temperature environments common to today's power generation operations. Such lubricants consist of a mix of base oils and additives to help deliver longer oil life, better equipment protection, and increased productivity.

Lubricants for gas turbine applications should be able to control deposits, limit sludge and provide oxidation stability. Oxidation occurs when an oil is exposed to oxygen at high temperatures. It causes viscosity to increase. Since gas turbines and

engines are often exposed to temperatures above 120°C, lubricants in these systems should have advanced base stocks, carefully selected additives and antioxidants appropriate for this environment.

In oils with poor air release performance, entrapped air can compress in bearings or hydraulics and cause varnish to form. Operators, therefore, should look for oils with good air release and foam control performance.

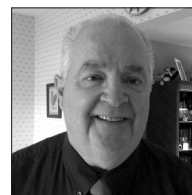
Filterability is another vital characteristic. It measures an oil's ability to pass through a filter without inflicting a pressure change. Oils with poor filterability often pollute filters faster than normal and cause varnish formation. Rust and corrosion, too, can also contribute to oxidation and varnish formation. Look for oils with good filterability, and that include additives capable of preventing rust and corrosion.

Wear on components such as high-pressure hydraulics, accessory gear drive, and generator reduction and turning gears can also act as oxidation catalysts and result in varnish formation. Some oils are available that contain antioxidants and inhibitors to help reduce wear.

Dynegy Midwest Generation upgraded the lubricants used in its two Siemens Westinghouse 501 FD gas turbines in its

Pennsylvania cogeneration facility. After the switch, the company monitored performance for a period of 11 years and more than 48,000 hours of service. There had been no system trips or unscheduled outages related to lubricant condition. During a scheduled shutdown, maintenance personnel inspected the unit and confirmed that journal bearings remained clean and thrust bearings had avoided varnish buildup.

Lubrication, then, can help operators better tackle varnish and reduce unscheduled downtime. At the same time, it protects, and helps equipment run more reliably and productively. ■



**Garry Brown, Senior Field Engineer CLS, at ExxonMobil.** For more information on ExxonMobil lubricants for turbomachinery such as Mobil DTE 732 and Mobil DTE 932 GT,

visit [mobil.com/industrial](http://mobil.com/industrial)





Dag Calafell, chairman ATPS Technical Advisory Committee, addresses a conference session

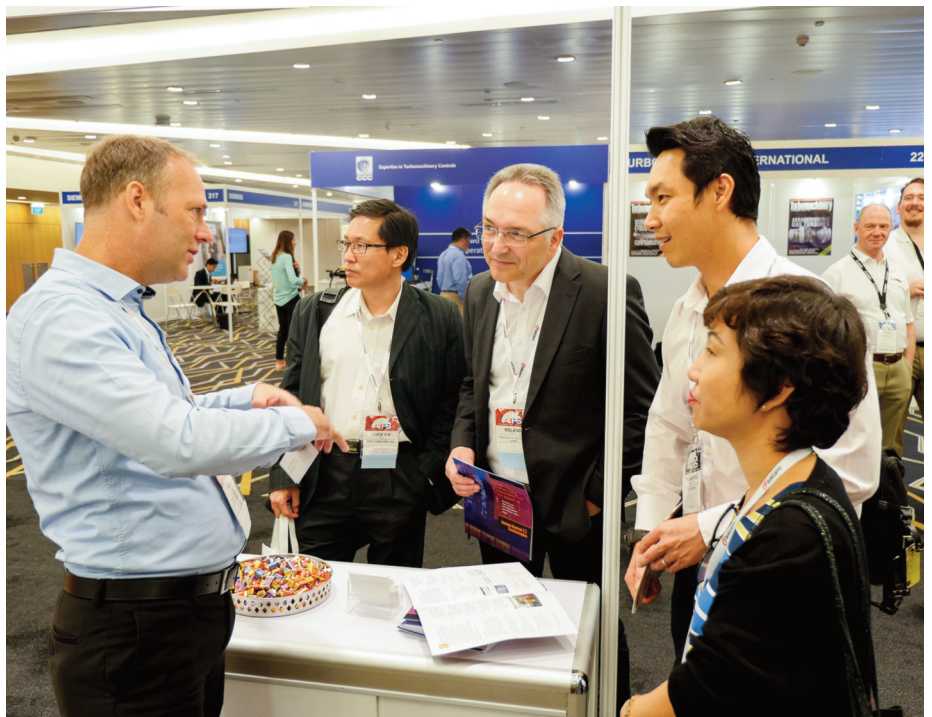
## ASIA TURBOMACHINERY & PUMP SYMPOSIUM RETURNS TO SINGAPORE

**AFTER THREE YEARS OF ENTRENCHMENT, THE ASIA PACIFIC OIL & GAS, AND POWER INDUSTRIES ARE SHOWING SIGNS OF RECOVERY**

**T**he Asia Turbomachinery & Pump Symposium (ATPS) opened in Singapore in March with a familiar face at the keynote podium. Dr. Dara Childs, retired director of Texas A&M's Turbomachinery Laboratory, welcomed attendees and exhibitors and treated them to a story from his early days as an engineer. It concerned trouble with a high-pressure fuel turbopump that created instability problems for NASA and Rocketdyne.

"Resolving those problems and moving forward to develop a better base of understanding of the causes led to far-reaching changes in rotordynamics for both aerospace and commercial turbomachinery," Dr. Childs said. "Those changes continue to improve our industries."

This second biennial ATPS was curated by an advisory committee comprised of field-experienced and R&D engineers. It featured a technical program representing the Southeast Asia region and the rest of the world, on par with the legacy of the annual Turbomachinery & Pump Symposia (TPS). "I am very pleased with the quality of the program and the traffic," said Dag



30 companies from around the world exhibited at ATPS. This included Rochem, Flowserve, Elliott Group, Concepts NREC, Compressor Controls Corp. and Graphite Metallizing Corp.



Calafell, II, Chairman, ATPS Technical Advisory Committee.

"The oil & gas, and power industries in Asia have been hard hit with three years of entrenchment when CAPEX has been constrained," said Calafell. "The great news is that everything is looking up. All the signs are there." Market intelligence companies, such as Dun & Bradstreet and Rigzone, concur, predicting increases in head count, and OPEX and CAPEX spending.

The ATPS advisory committee is counting on this news to carry momentum to the next meeting. "The region is telling us more networking, more lessons learned and more case histories," said Calafell. "We want the ATPS to be more focused on their needs."

For that reason, ATPS will vary slightly from TPS. ATPS had 39 case studies versus 16 to 18 at TPS. "We will continue with technical briefs — case studies without verification of the results," said Calafell. "We may also include a weekend day so students from local universities are more available. And we will augment our outreach program due to its success."

Exhibitors, such as Rochem, Flowserve and Elliott Group were happy to attend the show. "At ATPS, we see the right people," said Martin Howarth, Managing Director of Rochem Technical Services. "After ten years of pessimism, we are cautiously optimistic, a common theme everywhere in Asia." Rochem has a thriving business in Indonesia, with further potential in Malaysia.

Supplying OEMs for years, Rochem is now breaking into the end-user market for process gas compressors. "We have new methods for cleaning compressors and improving their performance," said Howarth.

Flowserve is exhibiting at ATPS to gain feedback on our products and the market outlook in the Asia Pacific Region, said Torsten Bernicke, Flowserve Product Manager, Compressor Seals & Systems. "China and India are doing better than in the last two years," he said. "We also see an uptick in oil & gas and petrochemicals, driven by a local demand for goods."

Flowserve introduced its Ampliflow G-Boost Seal Gas Booster at the show. It delivers a continuous supply of clean seal gas to compressor gas seals, eliminating a source of contamination and equipment downtime, said Bernicke.



Flowserve Seal Gas Booster

Driven by an electric motor, the booster improves operational reliability during periods of low differential pressure across the compressor when

the available seal gas supply is insufficient.

"Our goal at ATPS is to get in touch with local industry in Southeast Asia that want to do their own turbomachinery design work," said Nitin Jain, Managing Director, Concepts NREC. "We are looking for people who are doing 5X machining of turbomachinery impellers."

Concepts is also working with local academic communities teaching fundamentals of turbomachinery design. "We are concentrating on Vietnam, Malaysia, Singapore and Indonesia," said Jain. "These countries want to be self-sufficient and develop their own technology, especially in aerospace and defense."

Concepts NREC recently released its new Agile Engineering Design System for high-fidelity CFD, through a partnership with Numeca.

ATPS Sponsor, Elliott Group, owned by the Ebara Corporation, has its regional sales and global service office in Singapore, from

High Speed 3D Printing  
SLM | Concept | Arcam | EOS | TRUMPF

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## SHOWREPORT



670 event delegates from 31 countries enjoyed 110 technical sessions covering a broad range of turbomachinery and pump topics. The program also included a series of case studies.

where it sells products and services to China, India, Malaysia, Indonesia and Japan.

Ebara is transferring its cryogenic pump and expander business to the Elliott Group to market along with Elliott's refrigeration compressors. These products are used primarily with liquefied gas transfers from ships and docks that require cryogenic technology.

"Elliott is building a new test stand for cryogenic pumps at his headquarters in Jeannette, PA," said Christiann Bash, corporate communication manager. "It will be completed in two years."

Compressor Controls Corporation (CCC) also has an office in Singapore. We are exhibiting at ATPS to solve customer problems and to improve their efficiency using CCC hardware and controls, said Mohammed Abousalem, Regional Commercial Leader Asia Pacific.

Exhibitor Graphite Metallizing Corporation has recently expanded its worldwide bearing business with the addition of Exalto.



Exalto water-lubricated bearings

In 2016, the company purchased Exalto UK, a manufacturer and worldwide supplier of water-lubricated bearings, from Exalto BV, its Dutch owners.

"We can now offer a wide range of bearing solutions for almost any application," said Eric

Ford, Vice President Sales & Marketing. Graphite Metallizing specializes in bearings and products manufactured using Graphalloy, a novel graphite and metal alloy suitable for use in the toughest conditions.

ATPS will return to Singapore in March of 2020. The annual TPS show will take place in Houston in September. ■

# DRY GAS SEALS, COUPLINGS, FILTRATION AND INDUSTRY TRENDS



*Paul Hosking, Senior Product Manager at John Crane, discusses his company's turbomachinery related products and services as well as ongoing trends.*

## Tell us about John Crane.

John Crane provides turbomachinery related technology, supplying products and services for rotating equipment in mission-critical operations. Our portfolio includes dry gas seals and seal-support systems, filtration systems and couplings. We have eight turbomachinery service centers and more than 300 engineers worldwide. In addition to technical support, we provide maintenance and repair services, asset management services and reliability programs.

## What do you do with dry gas seals?

Decades of reliable operation have made dry gas seals the standard technology for sealing centrifugal gas compressors. Since the introduction of gas seal technology by John Crane in the mid-1980s, the industry has progressively adopted gas seals as the preferred design standard for new equipment. At this time, it is estimated that 99%+ of new centrifugal compressors are delivered with gas seal technology.

Aura, our most advanced range of gas seals, builds upon experience drawn from a large installed base. The seal range utilizes a common rotor design paired with performance-specific stators delivering robust performance and reduced lifecycle costs.

Its unidirectional and bidirectional range will be expanded later this year to include Aura 120NS for compressor applications with small cross section cavities. Development activities are underway to expand Aura to address the challenges of the high pressure reinjection market and deliver API 692 compliant gas panel solutions.

## What trends do you see developing with regards to seals?

Later this year, we should see the introduction of API 692, a standard for *Dry Gas Sealing Systems for Axial, Centrifugal, Ro-*

*tary Screw Compressors and Expanders*. It replaces the former Part 4 of API 614, which will no longer exist in its upcoming edition. This reflects progress in gas seal technology in recent years and sets out the minimum dry gas sealing system requirements to increase reliability and gas seal longevity.

API 692 should increase standardization across OEMs and end-users, particularly in the design of gas seal systems, but also in the specification of gas seals to be used. Contaminated seal gas is one of the leading causes of premature failure for dry gas seals. API 692 places additional emphasis on dry gas seal systems and seal gas conditioning.

## How about methane emissions?

Another significant trend is that centrifugal compressors equipped with oil-seal technology are a leading source of methane emissions. As the principal constituent of natural gas, methane is a greenhouse gas. Recent estimates suggest that routine losses from current infrastructure and practices emit natural gas valued at \$30 billion annually. Existing fleets contain a mix of compressors with oil seals and gas seals. Depending on region, installed fleets of old compressors will become liable to methane reduction regulations and may be forced to upgrade.

## How about trends in couplings?

As smaller turbines with the same power output are produced, couplings with increased power rating, efficiency and reliability have followed. Additionally, constant demands for lower-weight, lower-maintenance designs stimulate further product advances.

John Crane H-ME couplings offer low overhung moments and additional shrouding of flexible elements and bolts. They are suitable for most medium-speed and high-speed compressor drives. Their transmission membranes optimize torque, while minimizing reaction forces due to misalignment.

## How about filtration systems?

Seal gas contamination negatively impacts operations, resulting in increased maintenance, reduced production time and unplanned costs. Since seal gas filters are not part of a recycling system, filter performance testing used in liquid filtration (in accordance with ISO 16889) is inadequate since those are based on a multi-

pass test procedure.

For proper seal gas filter performance testing, ISO 12500 standard *Filters for Compressed Air* provides a more adequate test performance, and this will be adopted in the new API 692 industry standard. ISO 12500-1 provides oil aerosols coalescing efficiency performance and pressure drop in compressed gas with a resulting oil carry-over measured in mg/m<sup>3</sup>.

ISO 12500-3 is providing a test standard for filtering particulates from a compressed air flow. Dry gas seals cannot be properly selected unless the characteristics of the gas supplies are known for all operating conditions. Filters must be able to remove particles smaller than the range of operating clearances of seal components.

API 692 will require the specification to be 1 µm spherical particle size with 99.9% removal efficiency for seal gas and separation gas for contacting separation seals, and a rating of 10 µm spherical particle size with 99.9% removal efficiency for secondary seal gas and non-contacting separation seals. John Crane filtration systems are designed around the requirements of API 692.

## What turbomachinery services do you provide?

John Crane has a global support infrastructure consisting of service centres and test rigs. Customers can witness real-time testing data remotely, thereby speeding delivery and reducing average lead times for returning repaired components. The time from when a part fails to when it is fixed is critical. We strive to increase uptime by maintaining rapid service response. Maintenance services are available on a contract or as-needed basis. By scheduling timed, frequent health care checks, customers can uncover potential problems early on.

## How has your service business evolved over recent years?

As rotating equipment has evolved in complexity, the importance of mission-critical applications has created a demand for performance-based service offers. Our asset management programs deliver improved maintenance processes and increase asset efficiency by providing the systems and data needed to reduce maintenance costs and keep people and equipment safe. ■





Enerpac bolt tensioners for power generation

## Bolt tensioners

Enerpac's new portfolio includes three power generation bolt tensioners for fastening applications. They are designed for harsh environments. The PGT-Series Double Deck and Single-Stage Bolt Tensioners provide high performance in tight spaces found in wind and gas turbines (GTs).

Key features including auto-retract pistons, over-stroke protection and auto-engage nut rundown. FTR-Series Foundation Bolt Tensioners are for wind tower foundations bolts. Long stroke models enable applications to be completed in a single pull. FTE-Series Elliptical Foundation Bolt Tensioners are for foundation applications where limited space between the stud and wall prevent the use of standard tools.

[Enerpac.com](http://Enerpac.com)

## Multiphase wet gas compression

Featuring hybrid rotor geometry with innovative cooling, Hicor compressors can accommodate wet and dry gas. The wet gas compression system eliminates liquid separation at the wellhead. Instead, a multiphase stream is pumped to a central facility for separation and processing, resulting in the elimination of fugitive emissions and leaving a smaller wellhead footprint.

[Hicor.com](http://Hicor.com)

## Asset health

Windrock has launched its Industrial Internet of Things (IIoT) Spotlight Monitoring System. This automated solution analyzes asset performance and health data. It uses four magnet-mounted PUCs (Peripheral Universal Connection) to acquire



Windrock Spotlight

high-speed rotating data. PUCs are connected to the controller via a single cable. The controller sends the data to the cloud where Windrock software provides insights and uncovers fleet trends.

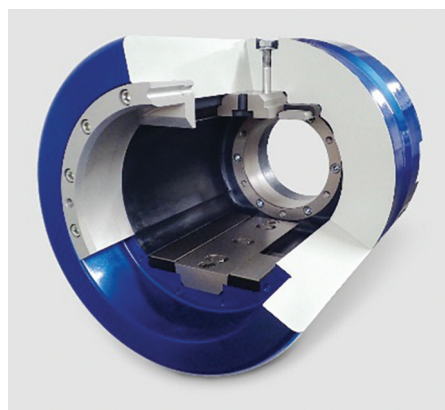
[Windrock.com](http://Windrock.com)

## Gas expander

The Regi U.S. RadMax Two-Phase Gas Expander (TPX) and the Two-Phase Expander Generator (TPXG) can extract 10-20% of the available pressure-volume energy normally lost in throttling operations. Under testing, it produced predicted torque and power generation at all speeds.

The torque produced by the expander was used to generate electric power through a belt-driven alternator connected to an adjustable electrical load. This was sufficient torque to self-start the unit and the alternator. RadMax's sliding axial-vane technology has been undergoing enhancements. It can operate in gas and gas-liquid states. Targeted applications are commercial markets for air conditioning, refrigeration and natural gas distribution.

[Radmaxtech.com](http://Radmaxtech.com)



Voith FlexPad helps to increase operational life of hubs through intelligent wear protection. In this case the system uses four FlexPads to decrease wear.

## Shaft couplings

Voith has introduced intelligent wear protection for joint shaft couplings. The Voith FlexPad Roll End Hub (REH) design increases hub body operational life by reducing wear (estimated operational and maintenance cost reduced by 20%). FlexPad eliminates metal-to-metal contact, reduces wear and ensures a longer hub lifetime. It allows an area contact to the roll neck by slight flexibility of the roll neck contact partner. The line contact is transferred into area contact, which decreases stress on local hotspots. Prevention of overload on the hub surface protects, increases clearance and lowers breakage risk.

[Voith.com](http://Voith.com)



Sensonics proximity probe holders

## Eddy currents

Sensonics has introduced the ECPHS Eddy Current Probe Holder, designed for use with its range of API 670 compliant XPR04 Proximity Probes. These probes measure relative shaft vibration, eccentricity, axial position, thrust pad wear, shaft speed and overspeed. The Eddy Current Probe Holder allows probe and extension cable access externally to the machine, enabling gap adjustment, or retracting the probe for replacement.

[Sensonics.co.uk](http://Sensonics.co.uk)

## Online vibration monitoring

GTI Predictive Technology's VibePro 24/7 conducts continuous online vibration and temperature monitoring for rotating equipment and bearing health. VibePro wirelessly provides predictive tools on an iPad platform.

[GTIpredictive.com](http://GTIpredictive.com)

## Cavity pump

Netzsch Pumps North America has added the NEMO to its line of FSIP (full service-in-place) progressive cavity pumps. NEMO provides full access to all rotating parts for wear-intensive applications. NEMO FSIP is available in six sizes for flow rates up to 700 gpm, and differential pressures up to 180 psi. The NEMO's rotor-stator unit can be lifted out after opening the new inspection cover on the pump housing. All wearing parts can easily be replaced when opening the pump.

[Netzsch-Pumps.com](http://Netzsch-Pumps.com)

## Microturbine

The A400 microturbine from Finland-based Aurelia Turbines offers 400 kW and efficiencies above 40% at part load (170 kW). This makes it competitive with small reciprocating engines. Unlike a conventional microturbine that comes with a recuperator to increase efficiency, the A400

is a twin-shaft machine with the Low Pressure (LP) compressor driving an LP turbine and a High Pressure (HP) compressor driving an HP turbine. The 2-spool turbine features a recuperator as well as an intercooler between the LP and HP compressor to boost efficiency further. The turbine is based on R&D by Lappeenranta University.

[AureliaTurbines.com](http://AureliaTurbines.com)



The Vibscanner 2 high-speed data collector

### Data collector

The Pruftechnik Vibscanner 2 increases the efficiency of vibration-based condition monitoring. It uses parallel data acquisition to collect health information up to four times shorter. It measures parameters, spectra and time waveforms on three axes.

[Pruftechnik.com](http://Pruftechnik.com)

### Solar combined cycle

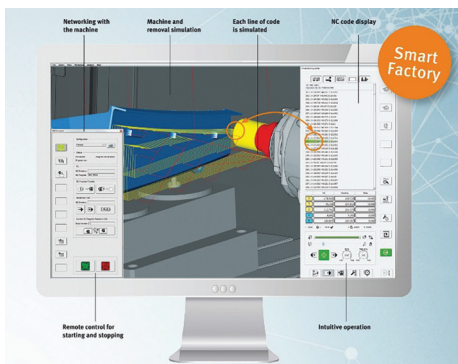
Pintail Power has combined solar and conventional power generation with molten salt thermal energy storage to deliver low-carbon dispatchable power. The result is the production of more than ten times as much solar energy as in previous Integrated Solar Combined Cycle power plants.

The new Dispatchable Solar Combined Cycle (DSCC) technology reduces fossil fuel use and greenhouse gases 30% below the world's most fuel efficient combined cycle power plant. It also provides cost-effective energy storage, and permits fast startup and more responsive load following. A non-reheat steam cycle and a simpler Heat Recovery Steam Generator permits flexible load following.

[PintailPower.com](http://PintailPower.com)

### Virtual machining CAM

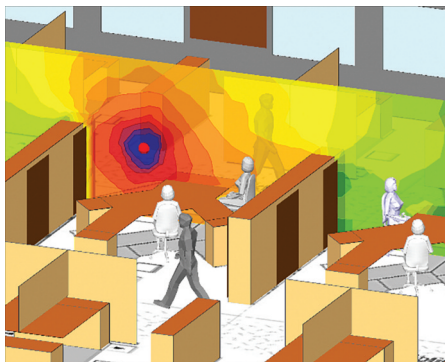
Open Mind Technologies has introduced *hyperMILL* 2018.1, a new version of its CAM software. New features include greater blending capabilities, 3D-optimized roughing, global fitting, rotational abilities for CAD electrode applications and virtual machining simulation. A soft overlap feature is used for blending machining marks found between steep and flat areas or located at the boundaries of rest machining regions. Virtual machining simulation enables constant real time bi-directional communication between the



Open Mind has added virtual machining simulation to its CAM software

machine tool controller and a remote simulation to improve manufacturing workflow. Machining operations can be reliably evaluated, checked and optimized before running a job using process networking and virtual mapping.

[OpenMind-Tech.com](http://OpenMind-Tech.com)



Simulation of noise levels in a facility

### Noise mapping

Noise mapping software specialists SoundPLAN have added new modules and enhancements to the latest version of its SoundPLANnoise software. It models levels and dispersion of noise, including accurate estimates of the movement of sound around corners. It calculates sound propagation through the use of sound particles, helping those wishing to address and mitigate nuisance noise.

[SoundPlan.com](http://SoundPlan.com)

### New controller

Emerson has launched automation technology for utilities and independent power producers that have renewable energy sources and serve the microgrid market. The Ovation OCC100 controller manages the flow of energy from various sources to ensure continuous, reliable generation. It is also well-suited to critical water and wastewater applications. With renewable electricity capacity expected to expand by over 920 GW (an increase of 43%) through 2022, according to the International Energy

Agency, 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. In addition to operating independently, the new controller can be merged into a larger Ovation distributed control system offering greater visibility into plant-wide operations.

[Emerson.com](http://Emerson.com)



Force measurement from Starrett

### Force testing

L.S. Starrett Company has introduced a comprehensive line of computer-based force testing solutions for applications ranging from load limit and distance testing to break limit, time average, cyclic count and duration testing, constant hold and more. Optimized for production and quality control testing, the architecture of the L1 system is designed for reliable, fast, repeatable and easy operation.

The Starrett L1 line of force solutions consists of systems for computer-controlled force measurement, digital force gages, motorized test stands for the company's FMM digital force tester, manual test stands and load cell sensors. Six models are available in standard and extended travels with testing capacities of 110 lbf, 330 lbf and 550 lbf. The Starrett Series DFC and DFG digital force gages, for example, can be used as a fast, affordable handheld-testing solution for basic applications, or via the DFC gage, as a force sensor and controller when used with the FMM Series of motorized stands or the MTL and MTH manual stands.

[Starrett.com](http://Starrett.com) ■



## MYTH: ENERGY STORAGE TECHNOLOGIES WILL SOLVE GRID PROBLEMS

**T**here always seems to be something to hype in the energy industry. This time it's energy storage. Having been actively engaged in the industry for many years (no, I'm not giving away my age), I have learned to be suspicious of hype.

Remember IGCC, LNG import, clean coal, the hydrogen economy, gas to liquids, and biomass gas, as a few examples from the last two decades?

Reputable sources are forecasting the installation of hundreds of gigawatts of electrical energy storage systems over the next few years. A study presented by McKinsey predicts the installation of 200 GW by 2025 and over 1,000 GW by 2040.

That's a lot of batteries! This is all based on the need to provide flexible capacity for intermittently available alternative energy electricity, primarily solar photovoltaics and wind turbines.

Most everyone by now has heard about the California duck curve, a graphic representation of the mismatch of electric supply versus demand in a state that has a large installed base of renewables. To address this mismatch, large storage systems are being proposed to temporarily hold any oversupply of energy and release this electricity at times of demand. It's a good idea, but public discussion is ignoring conventional energy storage that's proven, efficient, flexible, and has been around for over half a century.

Basic economics are being overlooked in forecasts for storage demand. Power from renewable sources remains more expensive than power from gas turbine combined cycle plants on a basis of dollar per kilowatt-hour produced (not on a misleading metric like kilowatts installed).

Once one adds the cost of storage to this, including the roundtrip efficiencies of storage systems, electricity from alternative energy sources becomes rather expensive. Several recent studies showed that giving away the surplus electricity or even paying a "tipping fee" for it when there is too much available is still cheaper than storing it due to the expense of storage systems.

There are several small- to large-scale storage technologies available including many different types of batteries (some of which have been commercially available for many years), compressed air energy storage, pumped heat electric storage, ther-

mal storage, hydrogen fuel cells in conjunction with electrolytic hydrogen generation, pumped hydro storage, and flywheels.

These range from several thousand to several hundred dollars per kilowatt-hour installed, and with roundtrip efficiencies from below 40% to near 90%. Each has advantages and disadvantages. They are applicable to some, but not all grid storage applications.

**"We need to take advantage of an existing energy storage technology that has most of the necessary infrastructure already built. It's called the natural gas pipeline system."**

Nonetheless, they all add cost: Dollars per kilowatt-hour of electricity stored. Although this cost has gone down over the years, it is currently still well over \$200 per kilowatt-hour in capital costs. This number can be integrated into basic leveled cost of electricity calculations and usually adds somewhere between 3 to 11 cents per kilowatt-hour to the electric bill.

One should remember that in most states the average electricity cost to produce electric power (not the consumer price) is somewhere between 3 to 4 cents per kilowatt-hour. Therefore, storage costs will more than double the cost of providing electricity.

As well as looking into newer and more expensive storage technologies, we need to take advantage of an existing commercial energy storage technology that is currently available and has most of the necessary infrastructure already built.

It's called the natural gas pipeline system and associated storage facilities. The U.S. alone has over 300,000 miles of interstate and intrastate pipelines. Hydrocarbons such as natural gas "store" energy and can make it available when needed in thermal power plants through the combustion process.

There is a huge amount of capacity in the pipeline system that is flexible. Any system deficits can be compensated by fresh gas from thousands of natural gas wells.

But it is not just the cost of storage facilities but also the cost of additional grid or

pipeline capacity that must be considered and compared. A study published by the Northwest Gas Association showed that both the installed cost and the energy cost delivered on an equivalent dollar per kilowatt-hour is approximately 60% lower for a natural gas pipeline than an electric transmission line.

Consequently, most of the time it is cheaper to place a natural gas storage facility locally or at a strategic energy demand intersection than placing electric energy storage onto the grid.

The U.S. alone already has about 370 active natural gas storage facilities with a design capacity of over 4,600 billion cubic feet of gas. This infrastructure is often not fully used. Before new large-scale electric storage is implemented, these facilities could provide flexible energy capacity upon demand.

Energy storage is certainly important for the future. But a lot of the dynamic imbalance in the electric supply system created by wind and solar can be addressed by natural gas power plants, the pipeline system, and natural gas storage capacity.

This can be done at a much lower cost than adding hundreds of gigawatts of electric storage systems. Yes, we will see electric storage added to our energy system. But the current hype about batteries is unrealistic.



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