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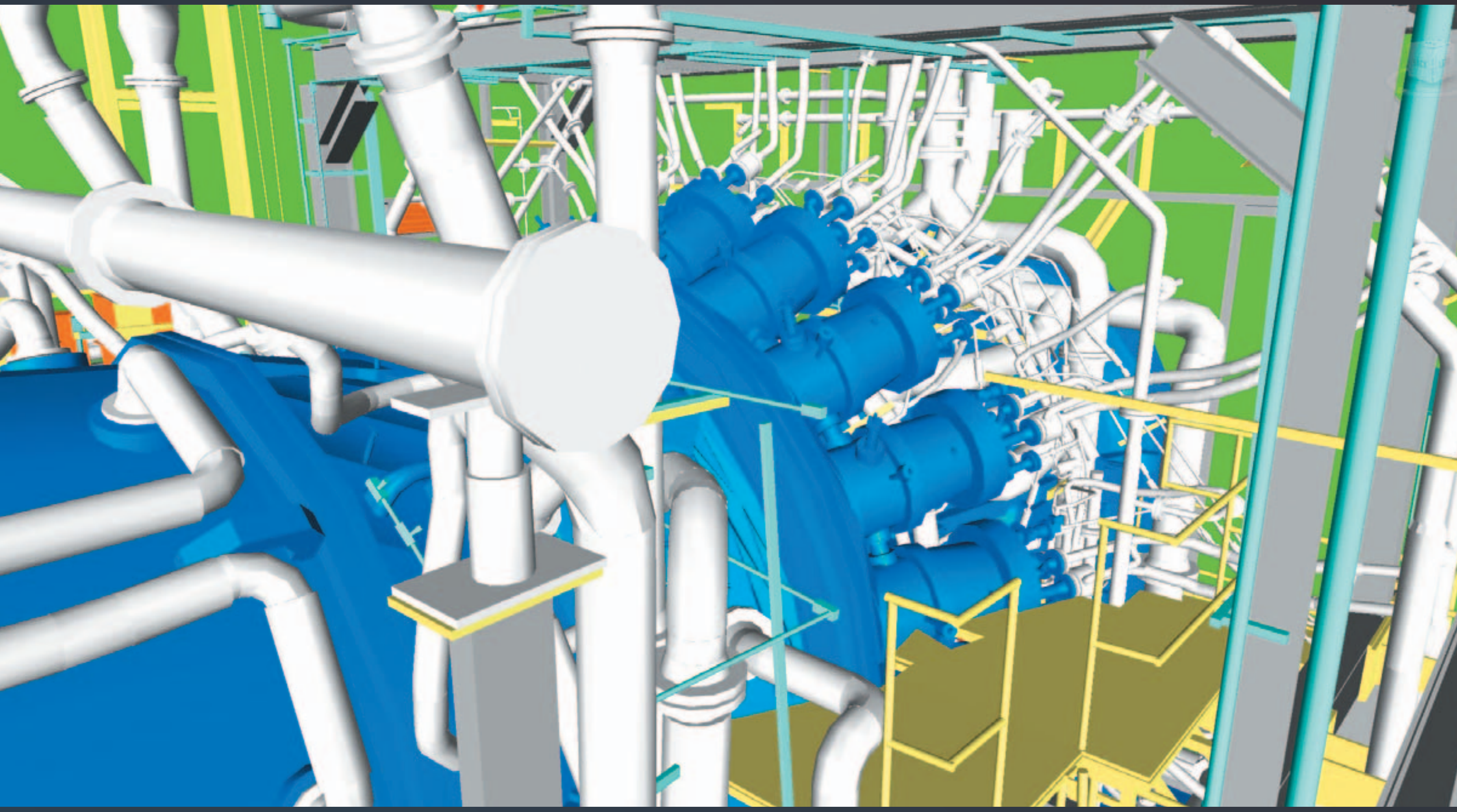
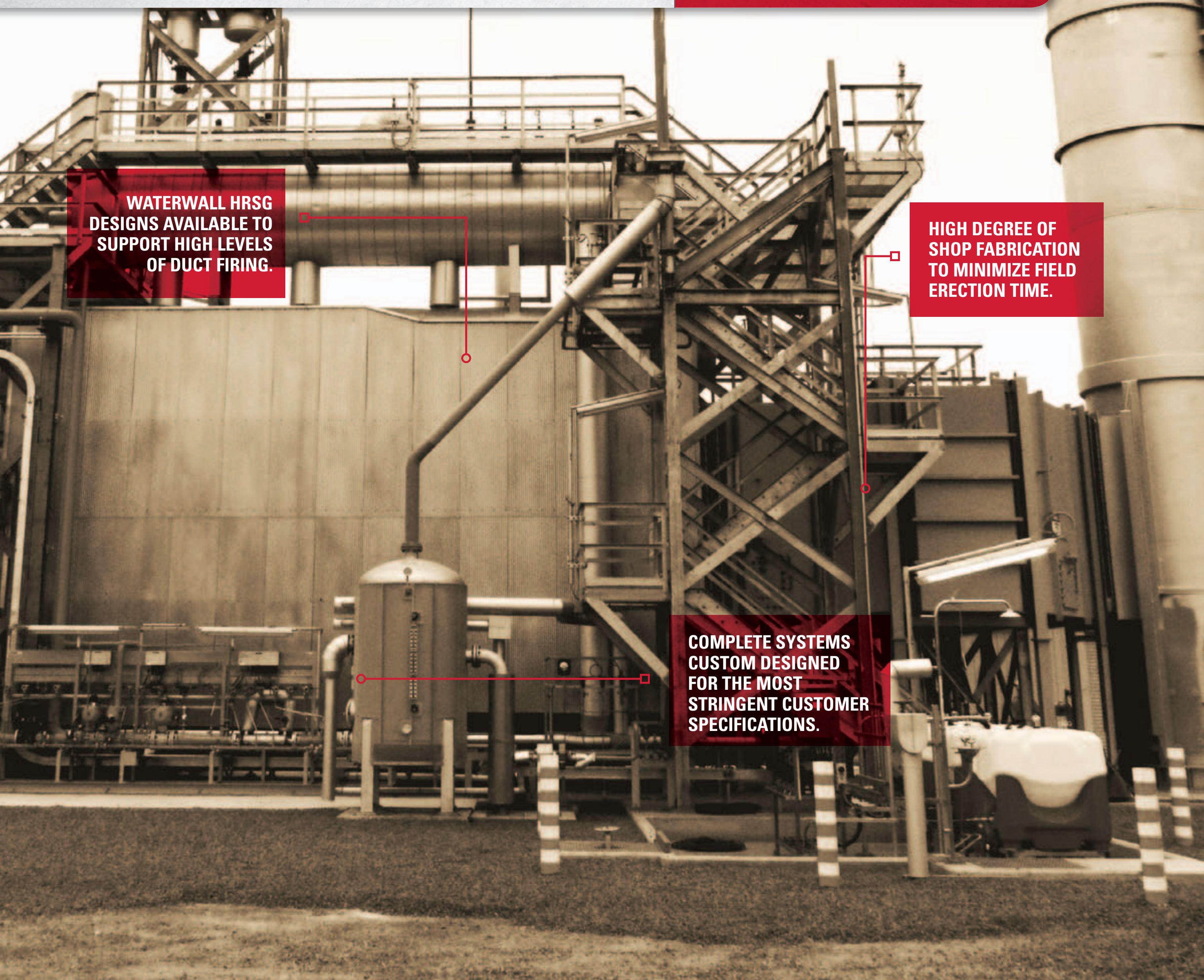
Maintenance Best Practices for Turbomachinery



Also in this issue:

Rotor Hub Installation • Control Systems • Artificial Intelligence
Piping Configurations • Compressor Maintenance • Coupling Bolts
Aeroderivative Upgrades • Combined Cycle Reliability • Laser Scanning



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Richard.Zanetti@UBM.com
Drew.Robb@UBM.com

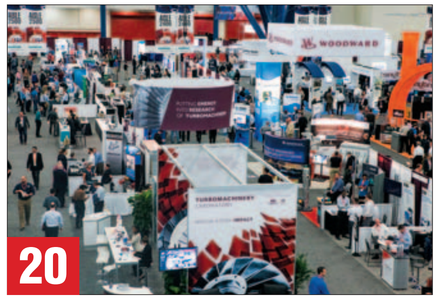
COVER STORY
18 LASER SCANNING

As-built data and models refer to the actual physical sizes, layout and orientation of elements onsite. It is not the orthogonal 2D representation of the original blue print, nor a perfect 3D design model. Instead, it is the imperfect twin of what exists in the real world.

During construction, contractors and engineers modify and correct on the fly to solve problems. The original design drawings and 3D models are rarely updated to reflect these adjustments.

Laser scanning offers a fast and effective way to update as-built records. It can cover a much larger area, is more complete, and is more accurate than traditional methods. A Six Sigma study carried out by DuPont concluded that laser scanning should be used on every revamp and retrofit project regardless of size.
Simon Atkinson

Cover image: Laser scan of turbomachinery, courtesy of Texas Systems



SHOW REPORT
20 A VITAL JOURNEY OF INNOVATION

The Turbomachinery Symposium addressed problems, such as compressor fouling, mechanical seal failure, impeller inefficiency, nitrogen compression, and piping vibration in detail. John Crane, MHI Compressor, Siemens, Baker Hughes GE, ExxonMobil, Southwest Research Institute, and Air Products provided experts to discuss such issues and offer practical solutions.
Drew Robb

OPERATIONS & MAINTENANCE
26 HOW TO INSTALL HYDRAULIC HUBS ON TURBOMACHINERY

This article provides guidelines to help achieve the precise fit required between the shaft and hub, and to prevent equipment damage if proper procedures are not followed when installing hydraulic hubs on turbomachinery.

Before beginning the installation process, be sure to clean the parts. The success of hydraulic mounting coupling hubs is dependent on the condition of contact surfaces. The hub bore and the shaft end must be clean and free from burrs.
Pat McCormack

CONTROL SYSTEMS
30 ARTIFICIAL INTELLIGENCE

Digitalization enables the monitoring of equipment on an unprecedented scale. But just collecting data is not enough. It must be put to productive use. With a concept known as edge computing, data can be processed and analyzed locally with only the most relevant information being sent to the plant. This is one way artificial intelligence is being incorporated into modern plants.
Diego Pareschi

OPERATIONS & MAINTENANCE
34 COUPLING BOLTS

This article is all about how to avoid the various issues associated with seized coupling bolts. Misalignment in steam turbines, for example, causes vibration, puts unnecessary load on bearings, and curtails operation at full power.

Loads associated with the necessary torque transfer within the shaft connections can be high. This makes bolting essential. However, coupling bolts are complex and large. High energy tools are needed for maintenance work. The bolts must be closely fitted or interference-fitted with their mating coupling bores to transfer the proper torque.
Steve Brown

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COLUMNS

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MAINTENANCE BEST PRACTICES

This issue delves deeply into various turbomachinery best practices. One article lays out the intricacies of how to install a hydraulic hub on a rotor. There is a lot more to this than meets the eye, and unfortunately it is done incorrectly too many times.

Another story is all about lubrication best practices concerning various types of monitoring, as well as the fine points of lubrication for rolling element bearings. Bearing troubles have been found to account for around 50% to 70% of all failures associated with small and medium size turbomachinery using rolling-element bearings. Poor lubrication practices account for most of these troubles. Some estimates are that more than 50% of all bearing failures are related to lubrication. Good maintenance procedures, planning, and the use of the correct lubrication oil can improve overall operation and reliability.

> "These Egyptian projects serve to highlight the value of natural gas power plants on the world stage."

Our cover shot is a laser scan of turbomachinery, a practice that is gaining ground in the industry. As-built data and models are often inaccurate. During construction, contractors and engineers modify and correct on the fly to solve problems. The original design drawings and 3D models are rarely updated to reflect these adjustments. Laser scanning offers a fast and effective way to update as-built records. It can cover a much larger area, is more complete, and is more accurate than traditional methods. A study carried out by DuPont concluded that laser scanning should be used on every revamp and retrofit project regardless of size.

Control systems, too, require attention and upgrades. Artificial intelligence (AI) is now being incorporated into the latest systems as digitization gathers steam. It offers a way to put data to more productive use. But the design of the system and its associated architecture must be correct. One way to do it is to institute edge computing so data can be processed and analyzed locally. This reduces the burden on computers and networks as only the most relevant information is sent to the plant's central control system. This is just one way that AI is being incorporated into modern plants.

And then there are coupling bolts. Like hydraulic hubs, there is plenty to know on the subject. This article describes how to avoid the various issues associated with seized coupling bolts. Misalignment in steam turbines, for example, causes vibration, puts unnecessary load on bearings, and curtails operation at full power. High energy tools are needed for such maintenance work. The bolts must be closely fitted or interference-fitted with their mating coupling bores to transfer the proper torque.

The maintenance theme is continued in our annual report from the 2018 Turbomachinery Symposium. This year, the event addressed problems, such as compressor fouling, mechanical seal failure, impeller inefficiency, nitrogen compression, and piping vibration.

But there comes a point where maintenance ends and new construction becomes essential. Our lead news story showcases three new plants built in Egypt in just over two years. At 4,800 MW each, they can all claim to be the largest combined cycle plant in the world. Siemens provided the equipment and technical guidance, working with local EPC firms and the Egyptian government on a fast track basis. Such projects serve to highlight the value of natural gas-based power plants on the world stage.

With the end of the year approaching, our next stop is the annual PowerGen International show, this year in Orlando. We look forward to seeing you there. Wishing you a Happy Holiday Season. ■

Drew Robb

DREW ROBB
Editor-in-Chief

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WORLD'S LARGEST COMBINED CYCLE POWER PLANTS OPEN IN EGYPT

Egypt has had a problem with power availability for many years. So, the government decided to handle it once and for all. The solution was three 4,800 MW combined cycle power plants (CCPPs) built simultaneously.

These are the largest such facilities in the world. In total, Siemens supplied 24 gas turbines (GTs), 12 steam turbines (STs), 36 generators, 24 Benson heat recovery steam generators (HRSGs), and three 500 kV gas-insulated switchgear systems. Engineering, Procurement and Construction (EPC) was provided by Siemens, Orascom Construction and Elsewedy Electric.

The Beni Suef, New Capital and Burullus power plants were ordered, financed and built over a 27-month span. Together they represent about 40% of Egypt's power capacity, at the time of signing contracts, and generate 14.4GW — enough to supply 40 million Egyptians with electricity.

This power was much needed in a country with an aging generation fleet as well as heavy fuel oil steam plants. After the revolution of 2011, power cuts became commonplace. But in 2014, things came to a head.

"Following a long period of repetitive power cuts, we had a situation in 2014 when 90% of the country had no electricity," said Sharif Kotb, Project Director from Siemens Egypt who managed all three projects. "This raised the necessity to find a solution."

The government initiated fast-track projects, one of which was the 640 MW simple cycle Attaqa Power Plant with Elsewedy Electric. It was built in less than six months and consisted of four Siemens E-Class GTs. The success of these projects was the spark needed to put plans in place for the three mega-projects.

The Beni Suef facility is situated in an industrial and agricultural zone about 100 km south of Cairo. It comprises eight GTs, four STs, and eight HRSGs.

The GTs are Siemens SGT5-8000H advance class units. The STs are Siemens SST-5000 units manufactured in Muelheim, Germany. While they run on natural gas, oil fuel lines are planned for one block of two GTs and one ST to be used as a backup fuel in future.

The facility is said to be more than 61% efficient. Each of the H-class turbines provides 400 MW. The inlet air operates at 820 Kg/s and gas consumption at 22 Kg/s per GT.

The combustion temperature is 1,550°C and the outlet temperature is 650°C. The Nile River provides water for once-through cooling. A Siemens SPPA T3000 control system is used to run the plant. Emissions levels are maintained below 25 ppm NOx.

The Beni Suef plant in Egypt is the largest combined cycle facility in the world.

"Beni Suef provides electricity for industry, residential, and agriculture in the south of Egypt, a fast growing area that previously had a weak grid," said Kotb.

The Burullus plant on the coast near Alexandria is cooled with sea water. The New Capital plant in the desert near Cairo will power the new administrative capital for Egypt, which will host around 5 million people once completed.

The New Capital plant will use the biggest air-cooled condensers in the world instead of water cooling. Otherwise, the configurations for each CCPP are the same as Beni Suef: Eight Siemens SGT5-8000H GTs, and four SST5-5000 STs.

Siemens states that this is the largest project in the company's history, providing seven times the production of the Aswan High Dam. Siemens electrical equipment is also being used for eight new substations on the new grid serving the three plants.

Virtual welding equipment at the Siemens School of Excellence in Cairo (Zein El Abedeen)

Siemens has an operations and maintenance (O&M) deal for all three plants for the next eight years. This includes digital services and data analytics to optimize plants and ensure reliability.

Data from the plant operation will be collected, analyzed, and transformed into actionable insights, such as diagnostics, troubleshooting and condition forecasting, improving reliability and reducing downtime. Further, the data processed can help balance maintenance costs, optimize inspection intervals, and reduce operational risks.

Creating a workforce

It is one thing to build huge power plants and quite another to find the manpower to run them. The Egyptian government worked closely with Siemens and the German Development Agency on programs to train a new workforce.

They sponsored and renovated local schools to promote technical and vocational education. They equipped the schools with CAD software, electrical gear, lathes, 3D printing, virtual reality, Computer Numerical Control (CNC) systems, CAD/CAM software, pneumatics, hydraulics, electronics, virtual welding machines, automation, and Project Lifecycle Management (PLM) software.

A new training center will be inaugurated in 2019, which will train 5,500 Egyptians in electrical and mechanical skills. A six-month program had earlier trained 600 engineers and technicians to run the three new CCPPs.

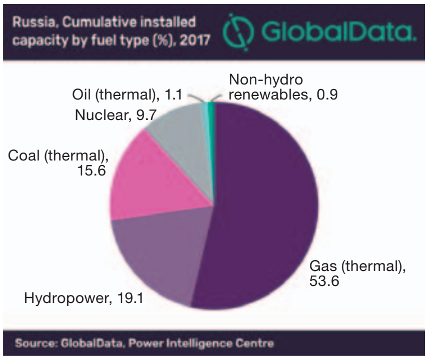
Students receive hands-on training on power plant operation

Continues on page 10

Baker Hughes nuclear upgrade

Baker Hughes GE (BHGE) has been awarded the first part of a contract for six turbine control upgrades at Bruce Power, the largest operating nuclear power facility in the world. The contract includes Mark VIe turbine controls as well as BHGE's Bently Nevada condition monitoring technology, Security ST cybersecurity protection suite, and turbine simulator software.

With more than 47 terawatt hours of electricity produced annually, Bruce Power's Ontario facility is being upgraded to full digital analytic capability to enable greater efficiency. These control upgrade packages will help to extend the life of Bruce Power by 40 years.



Russian power

A report by GlobalData on the Russian Federation power market reveals an abundance of gas, uranium, and hydropower resources in the country. The government favors these resources, which will help maintain their future dominance in Russia's power mix. Electricity generated from nuclear and hydropower should make up nearly half of the total electricity generated by 2030.

Wind and solar power are expected to post the highest growth trajectory in 2018. Non-hydro renewables are expected to reach 3.9% of the total installed capacity of the country in 2030, compared with 66.0% of thermal power, 19.3% of hydropower, and 10.8% of nuclear.

Another report by GlobalData estimates global GT market value at $6.84 billion in 2022, declining at 7.7% per year between 2018 and 2022. The slowdown is mainly attributed to the growing influence of renewable energy and volatility in gas spot-price markets.

Turbine supervision

Machine monitoring specialist Sensonics has introduced measurement algorithm options for its Sentry G3 machinery protection monitor, which operates as a turbine supervisory system. It provides machine protection to the API670 standard, and programmable algorithms in each module to enable plant engineers to identify abnormal conditions and better manage the dynamic behavior of their rotating plant. GT specific measurements, such as first-order vibration tracking and dynamic pressure, are included.

Chromalloy JV

Chromalloy Gas Turbine Corporation and Siemens celebrated the grand opening of their joint venture, Advanced Airfoil Components, in Hillsborough County, FL. Advanced Airfoil Components will hire engineers, technicians, production workers, finance, procurement and logistics personnel.

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Riverhawk Company

Couplings and Diaphragm Coupling Refurbishment

Riverhawk Couplings

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GE digest

GE has signed an agreement with the Iraqi Ministry of Electricity to develop the country's power sector. The plan is expected to generate up to 14 GW and establish a local technology center and support water and healthcare access.

GE's Power Services business completed an aeroderivative GT exchange at Cometa's Talosa plant in Soria, Spain. Cometa is a producer of wood-based panels. The company decided on a new GE LM2500 Base SAC aeroderivative GT rather than a second overhaul of its existing engine, which had already reached 100,000 running hours. This machine will boost output by 2%, heat rate by 3% and electrical efficiency by 1%.

Saudi complex

Saudi Aramco and SABIC have announced their selection of Yanbu, on the west coast of Saudi Arabia, as the site for the development of an integrated industrial complex to convert crude oil to chemicals. It will process 400,000 barrels per day of crude oil to produce 9 million tons of chemicals and base oils annually. It is expected to start operations in 2025.

Saudi Aramco and Total have also signed an agreement for the front-end engineering and design (FEED) of a giant petrochemical complex in Jubail, on Saudi Arabia's eastern coast. It will comprise a mixed-feed cracker (50% ethane and refinery off-gases) with a capacity of 1.5 million tons per year of ethylene and related petrochemical units. The project is scheduled to start-up in 2024.

Rendering of the new Elliott cryogenic facility

Elliott turboexpanders

Elliott Group is relocating the manufacture and testing of cryogenic pumps and expanders to Jeannette, PA. The pumps and expanders, which are used in gas liquefaction applications, are a new addition to Elliott's product lines following the acquisition last October of Ebara International's Cryodynamics division, located in Sparks, Nevada. A new, separate test facility is required. The company anticipates a 110-to-140 increase to its workforce. The facility is scheduled to begin operations in 2020.

New OPRA CEO

OPRA Turbines new CEO, Juha van Riet, has more than 20 years of experience in commercial and business leadership roles as a service/solution provider and system supplier to the energy, oil & gas and process industries. He has worked for Siemens, Woodward and Stork. Van Riet holds a Master of Science degree in Electromechanical Engineering from the University of Ghent and a postgraduate degree in Business Administration from the University of Leuven.

Juha van Riet

Mitsubishi Compressors

Mitsubishi Heavy Industries Compressor Corporation (MCO) has established MHI Compressor Korea (MCO-K) in Seoul. With its launch, MCO-K will work to expand sales in South Korea.

Kuwait microturbine

Capstone Turbine Corp. has secured a 3.4 MW order for a gas processing facility in Kuwait. It includes a C600 Signature Series microturbine, a C800 Signature Series microturbine and two remanufactured C1000R microturbines, which will provide prime power for the facility.

Continues on page 14

Siemens digest

Siemens has successfully concluded the first phase of its Subsea Power Grid shallow water test in Trondheim, Norway in collaboration with Chevron, Equinor, ExxonMobil, and Eni Norge. This program is developing a medium-voltage power grid using pressure-compensated technology.

It consists of a subsea transformer, subsea switchgear, subsea variable speed drive (VSD), subsea wet mate connectors, and a remote control and monitoring system that includes cloud-based user dashboards and data analytics.

Siemens and State Power Investment Corporation (SPIC) of China entered into a Memorandum of Understanding for technology collaboration in heavy-duty GTs. Siemens will support SPIC in conducting research and development and provide training and technical consultation.

Senseye, a provider of predictive maintenance analytics, has a partnership with Siemens to make Senseye's condition monitoring and prognostic software available to manufacturers through the Siemens MindSphere Industrial Internet of Things (IIoT) operating system.

Senseye receives and analyzes data from machines connected to MindSphere, enabling manufacturers to understand the health of assets and schedule maintenance activities more accurately.

Siemens has received an order for three SGT5-4000F GTs from United Arab Emirates (UAE). The turbines will be used in Unit H Phase 4 of the Al Aweer power plant complex near Dubai.

Dubai Electric and Water Authority has awarded the EPC contract to Siemens. With a capacity of about 815 MW, the turbines will increase the total output of the power plant complex to more than 2.8 GW. Commercial commissioning is scheduled for spring 2020.

Siemens will supply three SGT5-4000F GTs, three SGen5-1200A generators and the control system SPPA-T3000, as well as assembly and commissioning on site. As a peak load power plant, it will operate primarily in the summer months.

Siemens and STEAG GuD Herne GmbH have signed an agreement on the turnkey construction of a CCPP with district heat extraction. They have also entered into a long-term service agreement.

The Herne 6 plant will have an electrical capacity of more than 600 MW. Steam will also be extracted, and the thermal energy will be used for the district heating grid of Germany's Rhine-Ruhr metropolitan region.

The fuel efficiency of the natural gas used thus climbs to more than 85%. Siemens will build the plant on the site of an existing power plant. Starting in the spring of 2022, the new gas-fired CHP plant is expected to generate electricity and supply the Rhine-Ruhr region with district heat.

Abengoa, a Spanish engineering, EPC contractor, selected Siemens to supply a compressor train for the Sierra BioFuels Plant owned by Fulcrum BioEnergy. It will use gasification technology to produce low-carbon fuels from municipal solid waste.

The plant will be located in Storey County outside of Reno, NV, and is expected to produce about 11 million gallons of biofuel per year to be used by the aviation industry. Siemens scope of supply includes an ST, three synthesis gas Dresser-Rand Datum compressors, and balance of plant equipment including coolers, filters, and valves. The equipment is expected to ship to Fulcrum's plant in mid-2019.

Specto International, Capstone's distributor in Kuwait, secured the project, which is expected to be commissioned in late 2018.

PW Power Systems

PW Power Systems (PWPS) has its first customer in oil & gas. A 30 MW FT8 MobilePac aero-derivative GT was delivered to U.S. Well Services, which provides high-pressure, hydraulic fracturing services in active shale and unconventional oil and natural gas basins. PWPS units will power mobile electric well stimulation systems powered by natural gas.

RWG contract

National Grid Gas Transmission has awarded RWG a contract to undertake maintenance of its Siemens aeroderivative fleet located across the UK mainland. The contract, with an initial term of three years, includes the major overhaul of SGTA-20 (Industrial Avon) and SGT-A35 (Industrial RB211) gas generators, including field ser-

Ansaldo digest

Ansaldo Energia has unveiled new H_2 solutions for hydrogen-based energy technology. With subsidies and regulatory mandates driving the introduction of massive levels of renewable power generation into the marketplace and stressing the grid network, GT power plants are being thrust into the additional role of following and backing up renewable's inherently volatile generation profile.

The European Union and other global regulatory authorities are looking to incentivize continued CO_2 reductions from the power generation industry. Hydrogen stands out as a combination of storability for long periods and reliability. The goal is to safely and efficiently burn hydrogen alone or in combination with other natural gases.

Ansaldo Energia's portfolio of lean premix technologies for GT combustion systems has been developed with fuel flexibility as a prime consideration. For example, GT26 F-Class and GT36 H-Class GTs leverage the Sequential Environmental (SEV) combustion system platform designed to burn an NG-H_2 blended fuel mixture for new power plants. Ansaldo Energia H_2 solutions are being further developed through combustor tests towards the objective of 100% hydrogen power.

Ansaldo Energia has signed a contract with Shanghai Electric for the supply of the first Ansaldo Energia H class GT36 GT for the 800 MW Minhang CCPP in China. This strengthens the presence of Ansaldo Energia in China, with contracts signed to supply a total of about 30 GTs for the country.

A consortium between Ansaldo Energia and ABB has been awarded an order by Terna to increase the security and support the quality of the Italian electric power system. The scope of supply includes the design, supply, commissioning and maintenance of three asynchronous compensator sets rated 250 MVAR each, two in Matera and one in Manfredonia.

Commissioning will be completed in 2020. Synchronous compensators are a special application of electric generators and are connected to the Terna transmission network to increase the inertia of the system, its short-circuit power and stability. ABB will supply, install and commission the electric system to connect the synchronous compensator set to the grid. The ten-year contract includes maintenance.

Continues on page 16

MAN Energy Solutions digest

The new MAN PrimeServ one-stop shop in Oman was built under a Joint Venture between MAN Energy Solutions and its local agent OHI Petroleum and Energy Services. The Rusayl facility is in southwest Muscat.

One of the main goals of the local entity is to offer services to customers in the region. The facility is equipped technology and machine tools for complex turbomachinery repairs.

An essential feature is the high-speed balancing machine, which has the capacity to test rotating equipment weighing up to five tons at speeds of up to 20k rpm. The capacity will be enhanced to handle 18 tons in the near future. The workshop also has two low-speed balancing machines.

MAN Energy Solutions USA is building a new headquarters and service facility in Brookshire, TX. It will provide repair services for reciprocating engines for marine propulsion and power generation, as well as turbomachinery for oil and gas, petrochemical and general industrial applications.

The 16-acre facility is being sized to accommodate significant future growth and expansion. It combines operations that are currently located at two different gulf coast sites: a reciprocating engine repair facility in west Houston and a turbomachinery repair facility in Deer Park.

High-speed balancing machine for rotating equipment tests

MAN Energy Solutions has received its fourth order for the ITER (Latin: “the way”) fusion experiment. In Cadarache, Southern France, 35 nations are working on the construction of a fusion reactor that works according to the principle of magnetic confinement.

It aims to demonstrate that CO_2-free power generation using nuclear fusion is a realistic energy source for the future. Known as Tokamak (Russian: “Toroidal chamber with magnetic coils”), it is a vacuum vessel which, under extreme heat and pressure conditions, converts gaseous hydrogen into plasma — a hot, electrically charged gas that can be used to generate energy.

One gram of fusion plasma contains roughly the same amount of energy as 12 metric tons of coal. ITER will work with just 3 grams of fusion plasma and, from this, will generate 500 MW of thermal power.

The Tokamak building has been under construction since 2012. Together with CNIM, a French engineering company, MAN Energy Solutions is building a Cryostat, the largest stainless steel high-vacuum chamber ever built. With a height of 30 m and a volume of 16,000 m^3, it provides the high vacuum, the ultra-cold environment for the vacuum vessel and the superconducting magnets.

A fusion energy facility is being built in France.

vices, annual inspection and equipment installation and recommissioning support.

Sulzer support

Sulzer has signed an agreement with Nidec Industrial Solutions to supply high-performance, energy-efficient drives and maintenance services. Sulzer’s network of service centers throughout North America will provide local support from one of the leading independent repair specialists of electromechanical equipment. Nidec manufactures medium voltage drives. Sulzer will provide sales and technical support for MV drives with a focus on the oil and gas industry.

Nidec manufactures a complete range of medium voltage drives for industrial applications.

NAES contract

NAES has been selected by Competitive Power Ventures (CPV) to operate and maintain Fairview Energy Center in Jackson Township, PA. Currently under construction, the 1,050 MW natural gas-fired CCPP is expected to begin operations in December 2019.

CPV Fairview is equipped with two GE 7HA.02 GTs, two HRSGs and one ST. Fairview will use raw water from the Cambria Somerset Authority (CSA) for non-contact cooling, sourced through a new eight-mile pipeline. After the water has cycled through the plant, it will be treated and returned to CSA, where it can be reused for industrial processes.

Voith’s 32,000-square-foot turbomachinery workshop will open in Houston in January 2019.

Voith Houston office

Voith has secured a location in Houston, TX for use as a customer service center for the turbomachinery market. The 32,000-square-foot site is expected to open in January 2019.

The facility will offer services including repairs, retrofitting and overhaul service for a number of Voith products including industrial and high-speed gearboxes, Vorecons, torque converters and fluid couplings. A full-speed part load test stand for Voith’s serviced equipment allows all production updates to be tested and validated before their return to the field. ■

LUBRICATION BEST PRACTICES

CONDITION MONITORING, ONLINE MONITORING, AND VISCOSITY MONITORING, AS WELL AS ROLLING ELEMENT BEARINGS

AMIN ALMASI

Mineral lubrication oils have been widely used for many years. Hydro-treated mineral oils have been employed for many types of turbomachinery because of low fluid solubility (1% to 4%), for example.

Synthetic lubrication oils have been used to address changing parameters, such as the rise in operating temperature and how much dilution is present.

Polyalphaolefin (PAO) oils, for example, have excellent water and oxidation resistance. Polyalkaline Glycol (PAG) oils, which do not readily absorb hydrocarbons or working fluids, have been used in applications where lubrication oil might be in contact with working fluids.

Good maintenance procedures, planning and the use of the correct lubrication oil can significantly improve overall operation and reliability.

Condition monitoring

Condition monitoring can be used for lubrication systems as it can highlight developing problems at an early stage. This is akin to blood tests for humans. Lab testing is one approach. Oil samples are collected and sent to a laboratory

A more popular approach is online monitoring. Online sensors or instruments, meters in most cases, are installed in an oil-lubrication system that is circulating to continuously monitor conditions. They measure particulate, moisture, conductivity and other paraments.

Some data parameters have only upper limits, such as particle counts or wear-debris levels. A few data parameters employ lower limits like flash point and oxidation stability.

Many data parameters, such as viscosity and additive elements, use both upper and lower limits. Rate of change is important and is applied to some parameters, such as particle counting, elemental wear metals, ferrous density and degradation of additives.

Special care should be taken for smaller equipment as online monitoring of lubrication oil is usually not feasible. Lab testing should be performed with great care. When sampling small reservoirs, such as those in machines below 200 kW, a complete oil change may be needed. This can be expensive for small machinery.

Viscosity monitoring

The condition monitoring of lubrication oils is critical for the monitoring and assessing conditions and health of oil-wetted parts and components. An important element in overall reliability is the condition and life expectancy of bearings.

Monitoring and management of the viscosity of lubrication oil can prevent breakdowns. The viscosity of lubrication oil also plays a major role in energy efficiency; demand for more efficient turbomachinery is driving the use of lower-viscosity lubrication oils.

For some turbocompressors and pumps where lubrication oil comes in contact with light hydrocarbons, viscosity can break down quickly. This increases the risk of problems, failures, and oils becoming too thin or too thick.

Managing the viscosity of lubrication oil is critical in maintaining machinery health. Although viscosity is a function of temperature, it does not work the other way around. Real-time temperature monitoring is inadequate when monitoring the viscosity of lubrication oil.

A traditional practice has been to monitor viscosity once a week or once a month by sending a sample to a lab. But rapid changes in viscosity can occur. Therefore, this old fashion method is often ineffective.

It is better to institute real-time viscosity monitoring of lubrication oil via an online viscometer. This can help to prevent bearing wear and turbomachinery failures.

Many factors can affect the viscosity of lubrication oil. These include oxidation, dilution, contamination, bubbles, and temperature changes. Continuous online monitoring of viscosity can detect faults in their early stages.

Modern online viscometer systems allow the operator to select and operate characteristics, such as electronic controls, self-cleaning sensors, built-in temperature detection, multiple output signals, automatic viscosity control, data logging, quick change memory settings, security, and alerts. For an automatic viscosity control, a sensor system that is pre-set but reconfigurable is preferred.

Rolling element bearings

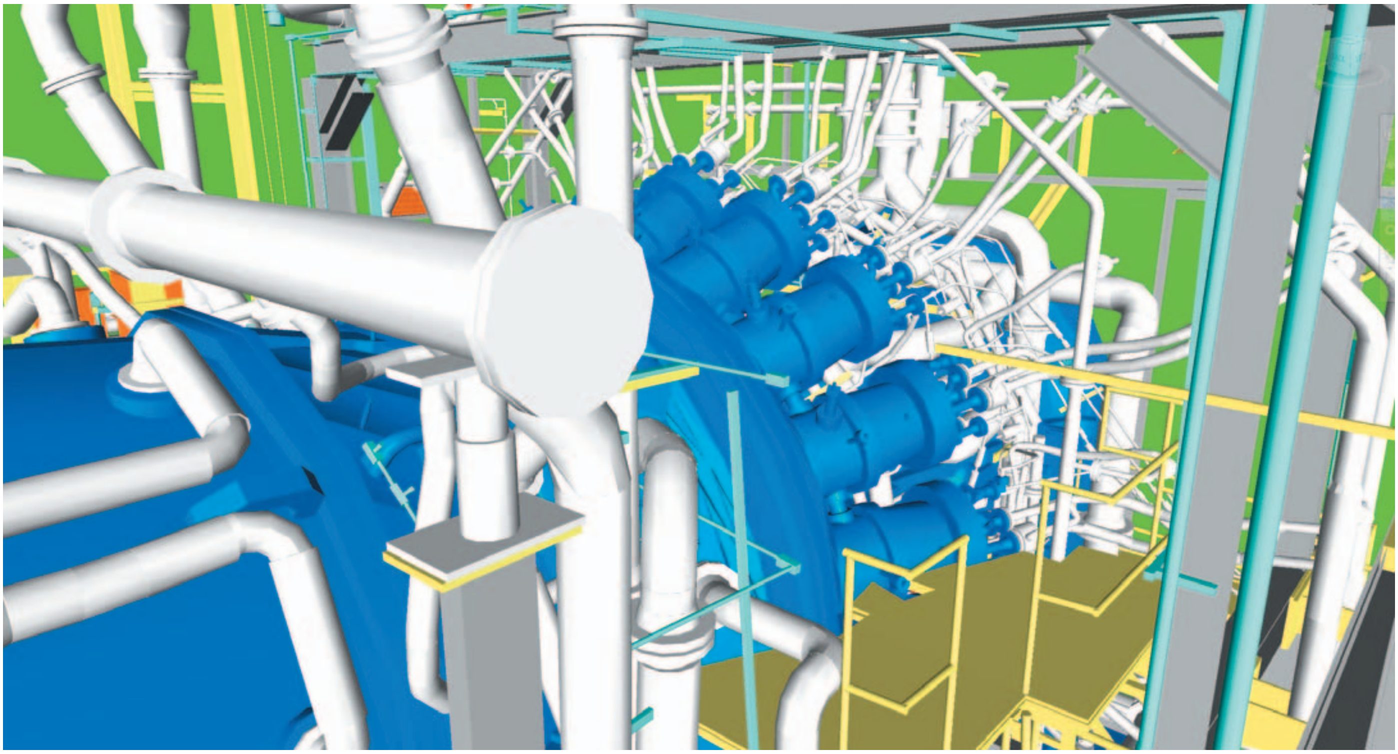
Rolling element bearings are used in many small and medium-size centrifugal pumps and compressors. They have limited life and can suffer a variety of failure modes. The selection and operation of these bearings requires great care, otherwise high rates of failure can be expected.

Incorrect lubrication, contamination, loss of oil, over-lubrication and other problems can occur. Failures can be expected due to the use of the incorrect lubrication oil or oil deterioration.

Lubrication oil is the lifeblood of bearings. It provides an oil film that prevents harsh metal-to-metal contact between rotating elements and races. Bearing troubles account for around 50% to 70% of all failures associated with small and medium size turbomachinery using rolling-element bearings.

Poor lubrication practices account for most of troubles. Some estimates are that more than 50% of all bearing failures are related to lubrication. Good maintenance procedures, planning and the use of the correct lubrication oil can significantly improve overall operation and reliability. ■

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



As-built models created by laser scanning are accurate to an eighth of an inch.

LASER SCANNING

IMPROVING THE ACCURACY OF AS-BUILT MODELS FOR CONVERSIONS, MODIFICATIONS AND UPGRADES

BY SIMON ATKINSON

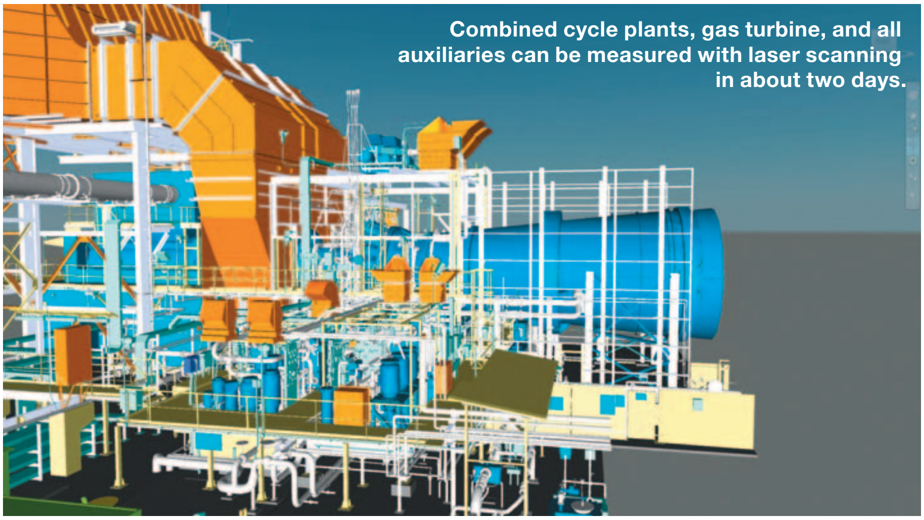
As-built (also known as as-is) data and models, refer to the actual physical sizes, layout and orientation of elements onsite. It is not the orthogonal 2D representation of the original blue print, nor a perfect 3D design model. Instead, it is the imperfect twin of what exists in the real world.

During construction, contractors and engineers modify and correct on the fly to solve problems. The original design drawings and 3D models are rarely updated to reflect these adjustments.

Gas turbine units are never identical, even sister units. It may be a pipe support 6" further down the line, a valve handle rotated to avoid a clash, or a surveyor error in setting out formwork. These subtle differences can cause problems and downtime when the next conversion, modification and upgrade (CM&U) project is underway. Over the life of a facility, these problems are compounded as more projects are executed.

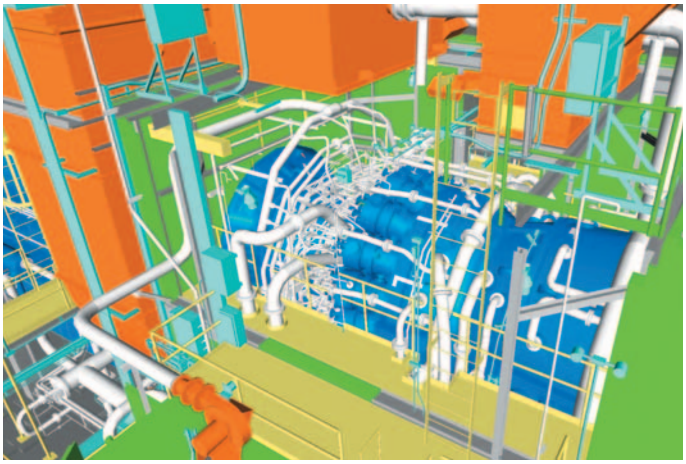
Tape measures

In an effort to operate with accurate as-builts, project managers send out designers and engineers armed with tape measures, plumb bobs, cameras, and note pads to take measurements and evaluate



Combined cycle plants, gas turbine, and all auxiliaries can be measured with laser scanning in about two days.

Laser scanner positioning is critical to project success



All the detail around the turbine and compressor can be captured rapidly by correct placement of laser scanners.

conditions. They crawl into duct work, under turbines, and around skids. However, elements can be missed, numbers transposed, and measurements inaccurately recorded.

Laser scanning is a way to minimize rework due to as-built errors. It is accomplished via a series of 360° × 290° 3D scans that are aligned precisely to generate an accurate and complete digital copy of the real world. This digital copy, accurate to ±1/8", displays each element's size, location and orientation.

A scanner sends out a light wave and collects what is reflected back as a mass of points. The intricate nature and layout of each GT, the fuel nozzles, combustion cans and manifolds configuration dictate how and where the scanner is placed. Incorrect placement results in partial coverage, shadows (where one object obscures another), and holes. Best practices on how and where to place the scanner and reference targets have been developed over time.

The scanners used in power stations, oil & gas plants, and petrochemical facilities are eye-safe and conform to the same safety protocol standards as a cellphone or regular digital camera. They do not generate heat, trip sensors, or interfere with electrical equipment. Their range is over 185 meters.

Two surveyors can generally capture all the essential details of the enclosure, gas fuel module, water treatment skid, accessory compartment, air inlet, exhaust and all related structural, piping, and other equipment within a 10,000 ft^2 area in less than two days.

This first stage deliverable is a collection of 2D views known as a Visual Database. The database is like a digital site-walk and allows the design team to investigate the project area, take measurements and check dimensions on their computers.

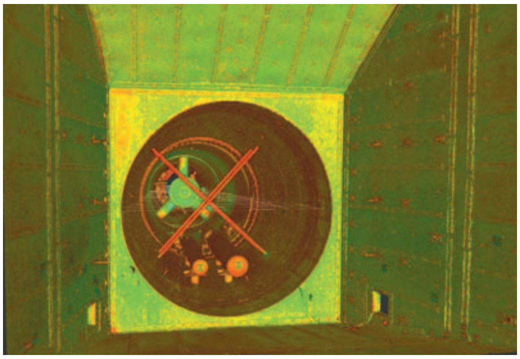
This data is then used to generate a replica 3D as-built model, commonly known as a digital twin. It can be delivered in any mainstream 3D CAD format, including AutoCAD, Microstation. Creo 3.0, AVEVA E3D, Catia, and NX. It takes roughly 10-to-14 days to generate.

Best practices

For best results when laser scanning a gas turbine CM&U project, certain key points should be addressed. There are many different laser-scanner makes and models available, but not all are suitable for collecting the necessary data on a gas turbine measurement project.

The size and weight of the scanner, the range, resolution, filtering and point integration into a desired 3rd party software, are all factors to consider.

Prepare the area by making it as clean as possible. Remove clutter such as pallets, boxes, mobile equipment, trash, and scaffolding. Ideally, personnel and forklift traffic should be minimized during scanning as they appear as streaks and ghosts.



Laser scan of the inside of an inlet duct

As the laser works on a line of sight, lagging from flanges and connections should be removed to provide a more detailed and accurate data set. Scanning is best done with an engineer on site who knows the project and can identify critical elements.

In a power station and around a CCGT where everything is gray, lagged pipes, steel columns on concrete footings, the use of color is redundant. Gray scale scans are faster to capture, file sizes are smaller, and there are fewer files to manage and archive.

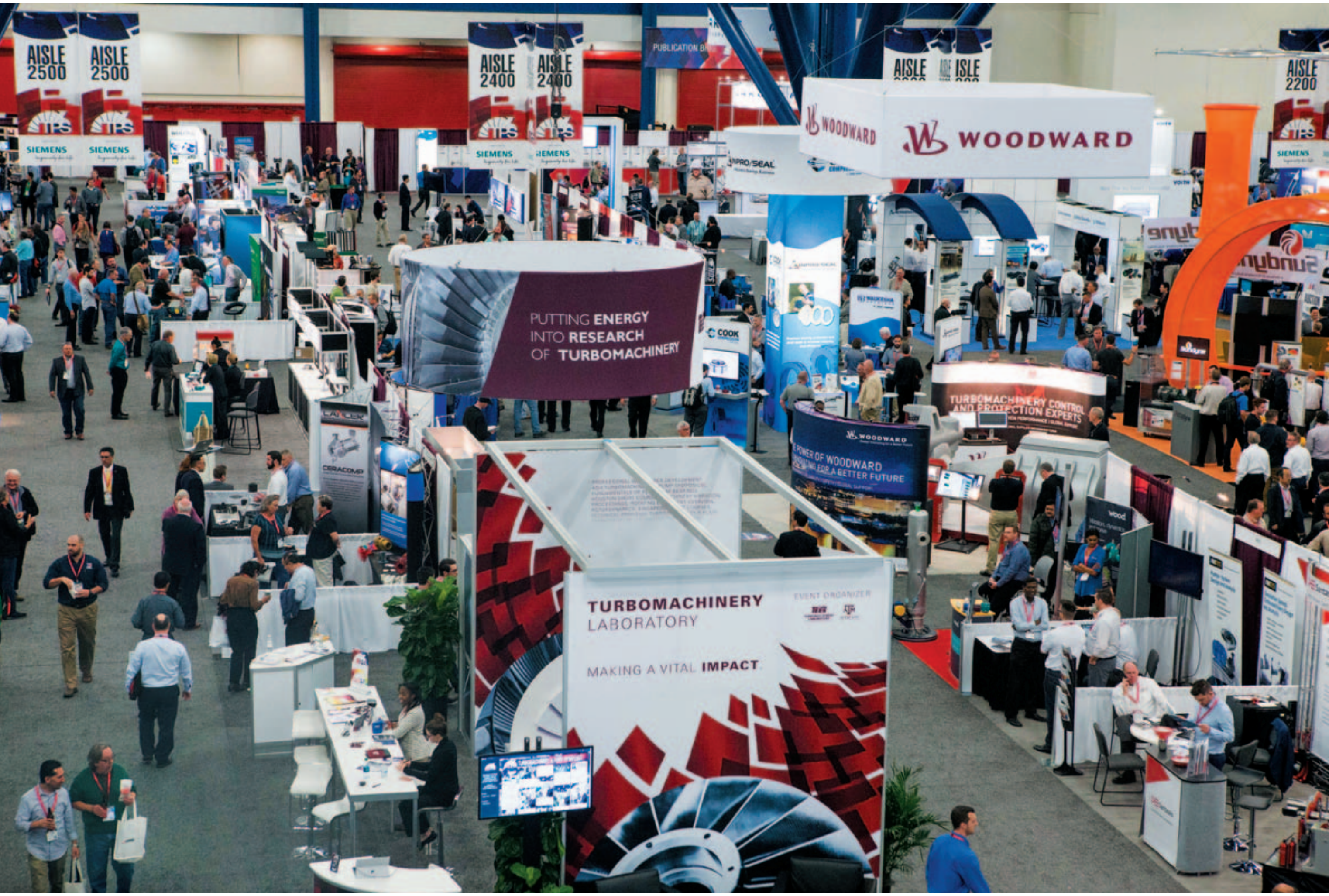
As a result, gray scale scanning is preferred by most design teams as it offers more contrast and delivers crisper detail. It can be undertaken in darkness while still producing photo-quality resolution, as it does not rely on any external lighting. Color scanning may offer a more realistic feel, but requires additional photography, consistent lighting, takes much longer, and is more expensive.

Benefits

The approximate cost for a two-day laser scan project is equivalent to the traditional method of sending a larger team armed with tape measures and notepads.

The difference, however, is that laser scanning covers a much larger area, is more complete, and is far more accurate. A Six Sigma study carried out by DuPont concluded that laser scanning should be used on every revamp and retrofit project regardless of size. ■

Simon Atkinson is CEO of Texas Surveys, a power & process laser scanning and 3D as-built modeling specialist. For more information visit Texas-Surveys.com.



A VITAL JOURNEY OF INNOVATION

TURBO SYMPOSIUM 2018 SHOWCASES MECHANICAL SEAL INTEGRITY, LNG EFFICIENCY, COMPRESSOR FOULING AND PIPING DESIGN

BY DREW ROBB

Some shows stress engineering talent. Others are all about vendor experience or academic excellence. The Turbomachinery Symposium — one of the year's premier events — brings together all three. And 2018 was no exception.

Problems, such as compressor fouling, mechanical seal failure, impeller inefficiency, nitrogen compression, piping vibration, and more were covered in detail. John Crane, MHI Compressor, Siemens, Baker Hughes GE, ExxonMobil, Southwest Research Institute, and Air Products, for example, provided experts to discuss such issues and offer practical solutions.

Welcome address

The 47th Turbomachinery and 34th International Pump User's Symposia (TPS 2018) attracted 365 exhibitors, and 4,750 attendees representing 45 countries. Engineers and technicians, from novice to experienced, chose from a combination of 18 short courses, 18 lectures, 23 tutorials, 24 discussion groups and 32 case studies.


Eric Petersen

Eric Petersen, the new Director of the Turbomachinery Labora-

tory, delivered a welcome address on the first morning of the show.

"I am grateful to all of our authors, leaders, delegates, exhibitors and advisers who make TPS a staple event for the industry," said Dr. Eric L. Petersen, Turbo Lab director. "This is a unique forum where the best in the industry come to share their expertise."

He laid out the history and services offered by the lab. For example, it conducts high-pressure flame propagation tests for gas turbines (GTs). Models that are validated in the laboratory can then be used in the field to predict real world performance.

"We also use shock tubes and lasers to study high temperature reactions," said Petersen. "We have unique devices that give us the ability to predict and measure extreme conditions."

A 37,000 ft^2 facility contains 12 vibration-damped test cells. Extreme temperatures, pressures, rotational speeds, loads, and flow rates can be studied at large scale.

In these tests, a shock wave is generated at around Mach 3 to produce high temperatures. Chemical and high-pressure reactions are studied under conditions commonly experienced by GTs. This helps to predict operation at different temperatures and extremes.

Research, education, and professional workforce development are conducted for rotordynamics, aerodynamics, vibration, heat transfer, tribology and bearings, combustion, and advanced materials. This work addresses challenges, such as durability, reliability, emissions, performance, stability, and efficiency.

Students with advanced degrees research industry problems. Texas A & M is ranked seventh in the world in mechanical engineering based on published research, citations, collaboration with industry and awards. Currently, 14 projects chosen by industry are being funded at $50,000 each.

"As the new Lab Director, I will continue to promote investment in state-of-the-art equipment and test rigs to keep up with current technology and measurement techniques," said Petersen. "We will nurture multi-disciplinary research that is both fundamental and applied."

Compressor fouling

Masaki Shakuda, Engineer, Compressor Engineering and Design Section of MHI Compressor Corp. (MCO), discussed fouling of process gas compressors in ethylene plants. Several types of contamination can often foul the compressor flow path, and plant production is significantly lost.

Wash-oil injection is a traditional remedy: oil is injected through nozzles installed on the suction piping and return bend of each stage. However, fouling material has been reported during turnarounds in machines with relatively few years of operation even though wash-oil injection was carried out at the required intervals.

Discussion groups encouraged users to originate challenges and hear how their peers addressed them

"Fouling disturbed the gas flow and reduced compressor performance," said Shakuda. "A greater amount of power had to be consumed to maintain the intended ethylene production level. "

MCO and ExxonMobil worked together to find a more effective approach to develop an improved online wash-oil injection system using CFD/FEM analysis. They carried out a flow pattern analysis on conventional systems.

They discovered that oil was not getting to the entire compressor. Researchers considered the option of increasing the number of nozzles. The size, direction and angles of injection were also considered, along with various parameters in order to develop a new system.

The injection flow rate was decided by adjusting momentum ration of gas phase and liquid phase. This varies depending on user process data, and provides the required washing oil flow rate.

"The new design gave the best oil coverage on both the pressure side and suction side," said Shakuda. "From a range of delivery of 20°, it was improved to up to 40° of the circumferential area."

Piping design

Benjamin White, PE, of Southwest Research Institute, delivered a talk on mechanical stress and flow considerations for the piping design of centrifugal compressors. He addressed a range of factors that must be considered in the piping associated with the installation of any new centrifugal compressor system.

Multiple factors must be balanced in the piping design to have an overall successful installation. The piping must be configured and supported in a manner to safely contain the mechanical forces from the internal fluid pressures, as well as the weight of the piping, fittings and valves.

It must not place any unusually high loads on the compressor itself or any piping supports due to thermal expansion, pressure elongation or weight loads. The layout should result in an even flow velocity profile that does not result in detrimental impact to the aerodynamics performance of the compressor.

For piping surrounding large HP compressors used in refineries and in natural gas transmission, he laid out a recommended sequence. Begin by determining the initial layout for the compressor and associated components. Draw up a process flow diagram, followed by a piping and instrumentation diagram.

Anchor flanges and pipe clamps are often needed for stability, as well as thermal offsets to prevent thermal expansion from influencing the compressor. Pipe diameters should be based on maximum flow velocities.

For example, natural gas pipelines typically operate at 500 to 1,500 psi, with flow velocities for the main piping between 20 and 65 ft/sec. Recycle and anti-surge or blowdown piping, though may have flow velocities up to 120 ft/sec at times.

At low velocity, liquid or settlement can build up at low points. At high-velocity pressure drop, noise, erosion, flow-induced pulsation, and flow turbulence-induced vibration can occur.

"You have to balance various trade-offs between competing objectives," said White. "There is no obvious standard design for all applications."

Once piping diameter is calculated, piping thickness should be considered. Internal pressure determines thickness. However, there can be additional concerns related to economics, material temperature limits, suitability of material for certain applications, and so on.

A long list of codes and standards also should be considered. API 617, for example, covers the centrifugal compressor, but not the piping system. In the U.S., most piping systems are based on several ANSI/ASME standards.

However, these codes offer limited guidance on some topics. That is why it is important to do a thermal analysis and a vortex-shedding, induced-pulsation analysis.

The elevated discharge temperatures of compressors cause thermal expansion, as well as shifting loads and stresses. Computer modeling helps to determine the types of piping restraint, their locations, and loads.

"Be sure to look at flange loads on coolers and compressors based on allowable OEM limits," said White. "The ideal thermal system is flexible enough to allow for thermal expansion without excessive stress but also control vibration."

That is why you have to balance the findings of thermal and mechanical analyses to find the optimum approach for a specific location. Thermal expansion is a function of pipe length, temperature differential, and the expansion coefficient.

The resulting stress is a function of the amount of thermal growth, pipe size and layout, restraint types and locations, and allowable stress related to the design code, materials, and load case.

Any analysis should consider a variety of temperatures, pressures, differentials, and conditions. Run the analysis with one unit off, then another off, or with ambient condition changes to see how the model is influenced.

For any problems that show up, the usual solution is to change restrain types, locations or quantity to better channel thermal expansion. Further options are to reroute the piping and replace 45° with 90° elbows. The 45° elbows add flexibility and have lower pressure loss, but tend to provide a higher resistance to bending. The 90° elbows also reduce loads in the axial direction by 25% to 50% in some cases, whereas the 45s offer a smoother flow.

Near the compressor itself, anchors and spring supports may be required to reduce loads. But as piping diameter rises, the system gets stiffer and more modifications are needed (pipe stiffness increases exponentially with diameter). This must be done in such a way to allow a certain amount of flexibility.

Compressor flange loads should be minimized. Misalignment of coupling or bearing loads can be issues as well as flange integrity issues. API 617 determines compressor nozzle loads on centrifugal compressors.

"With piping of 16-inch diameter or below, it is fairly easy to meet the criteria and standards, but above that can be challenging," said White.

When scaling up a system, engineers sometimes make the mistake of doing so linearly. White noted that this results in a different system, and a new analysis is required.

But those are only a few of the factors to consider. Pulsation and vibration are also important. Centrifugal compressors are much less susceptible to vibration than reciprocating compressors. Nevertheless, there are some risks due to machinery-induced pulsation, mixed compression, flow-induced turbulence and piping vibration.

Mixed compression using centrifugal and reciprocating compressors in the same process, for example, can result in pressure and flow fluctuations at the centrifugal compressor. A tee or bend can generate vortices which bring about low frequency vibration.

Common fixes include bigger branches on tees and reducers to lower

365 exhibitors represented the entire range of turbomachinery and pump products and services

vortex frequency, valve relocation, or increasing the diameter of the main line.

Small-bore piping is another area that can experience vibration. White's suggestion was to keep things as short and stiff as possible and avoid fittings with high stress.

"Thermal stress effects on piping should be considered early in the design phase," he said.

Mechanical seals

Jack Bagain, Senior Staff Mechanical Engineer at John Crane, covered design aspects and considerations for mechanical seals in midstream pipeline applications. He focused on applications that place significant demand on mechanical seals, particularly those associated with the handling of various fluids through pipelines. These deal with a wide range of conditions, including variable fluid properties, as well as fluctuations in temperature, pressure, and speed.

There are additional challenges in the midstream pipeline sector associated with the remote nature of the installations and limited accessibility, he said. That is why equipment monitoring and preventive maintenance support are placing increased emphasis on the criticality of selecting a robust mechanical seal design and associated support equipment.

"Proper seal selection for a pipeline must consider specific gravity, vapor pressure, operating pressure, shaft speed, the presence of dirt or solids, viscosity, temperature, the equipment involved, and the hydrostatic flange pressure rating," said Bagain. "High-pressure sealing is difficult if a wide range of pressures exist."

The pressure ratings for mechanical seals are covered in API 682; however, this does not apply to all seals. API 682 defines maximum allowable pressures for different flange classes. The higher the class of the flange, the lower the number of pumping stations required.

Several different materials that can be used in mechanical seals. Carbon graphite is typically metal (antimony or nickel) impregnated carbons. They are good on fluid lubricity, but relatively weak (probably not to be used beyond 1,200 psi).

Silicon carbide can either be reaction-bonded or self-sintered. These seals are hard, wear resistant, and have good mechanical properties. When viscosity is high, they are often deployed.

Tungsten carbine is more common in midstream pipelines. Silicon carbide and graphite composites offer improved dry-run survivability and thermal shock resistance. 316 stainless steels are also found in midstream applications as they are easy to machine. However, duplex stainless steel has increased tensile and yield strength compared to 316.

"For higher pressures, duplex is better," said Bagain. "In hardware components bigger than 4.33" diameter, 316 deflects under pressure."

Turboexpanders

Robert Benton, Jr., Global Expander Technology Manager for the CryoMachinery Department at Air Products, presented on the successful application of nitrogen turboexpanders-compressors to floating and land-based LNG facilities.

"LNG production in the form of large land-based mega-trains and floating production, storage and offloading (FPSO) facilities can be challenging to design," said Benton.

He included a couple of specific examples: The Ras Laffan LNG project in Qatar uses 6 × 7.8 mtpa LNG trains with four nitrogen expanders per train. Land-based designs have the advantage of being able to accommodate multiple larger skids throughout the site. In Ras Laffain, though, interconnected piping became an issue due to the distance between some skids.

Accessibility, weight, and lack of space are big issues offshore. Ideally, many systems can be consolidated on one skid. Reconfiguration is often needed to improve accessibility.

"It is necessary to work closely with the EPC contractor to understand and chose the best approach for a combination of requirements and to resolve situational concerns," said Benton.

LNG impellers

High-Mach, high-flow-coefficient impellers for LNG plants can pose design problems. Simone Corbo, Lead Engineer for New Product Introduction at Baker Hughes GE (BHGE), has had to deal with such issues as the new generation of LNG plants progress toward larger footprints.

These compression stations are driven by higher-power GTs (more than 100 MW). This increase in power also necessitates an increase in compression gas flow. As a result, the impeller stages in propane compressors require higher specific flow coefficients and a higher Mach number.

He pointed out that the delivered volume of LNG around the world is increasing on average by 5% each year. Currently, 265 mtpa is produced. But it is expected to grow significantly by 2020, primarily driven by demand in Asia, and Europe to a lesser extent.

With production costs rising, BHGE is turning to standardized configurations, larger train capacities, larger GTs and compressors. But design challenges abound: High flow coefficients, high peripheral Mach numbers, impeller stiffness, transonic and supersonic conditions at the leading edge, rotor shock phenomena, and flow distortion within stator components.

"We undertook a study to mitigate shock effects on rotor efficiency and flow distortion at the impeller exit," said Corbo. "Stator components must also be able to handle non-uniform flows over a wide range of operating conditions."

BHGE used 3D Computational Fluid Dynamics (CFD) to devise a different blade shape and surface curvature. It included a mixed flow impeller exit, and a vaneless diffuser. This design brought about a 3% increase in polytropic design efficiency and lowered the design head coefficient by 4%.

Mechanical seals

Michael Huebner, Principal Engineer at Flowserve, detailed best practices for cartridge mechanical seal installations. The reliability of a mechanical seals depends on more than the design of the seal itself, he said. It also depends on the practices used to install the seal into the centrifugal pump or other equipment.

The actual installation may occur in a controlled environment, such as a factory or repair shop. Alternatively, it could be in the field in an installed pump. The steps taken during installation set the foundation for success of seal in operation.

Different pump and seal designs may require different procedures, but there are key elements: inspection, requirements for equipment condition, preparation for installation, installing the seal, setting the seal drive, and more. ■

The 2019 Turbomachinery & Pump Symposium is set for September 10–12 in Houston. Short courses will be held in conjunction with the symposia on September 9. To learn more about TPS and see photos from this year's event, visit tps.tamu.edu.

HOW TO INSTALL HYDRAULIC HUBS ON TURBOMACHINERY

PROPER INSTALLATION IS CRITICAL TO TRANSMITTING TORQUE CONSISTENTLY AND RELIABLY

BY PAT MCCORMACK

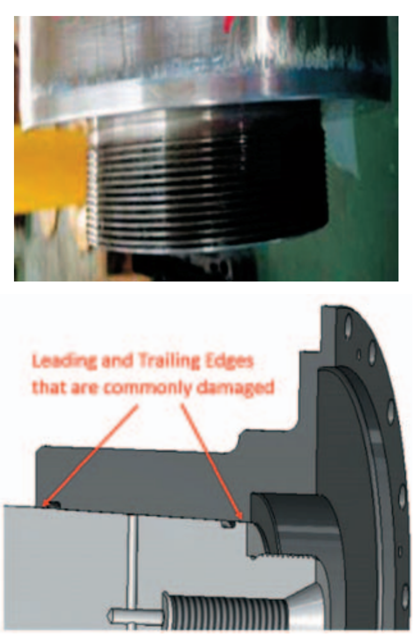
The number of methods used to hydraulically mount tapered bore hubs onto tapered shafts is as numerous as the equipment manufacturers in the industry. Each Original Equipment Manufacturer (OEM) has its own design philosophy regarding the placement of O-rings, type of hydraulic fittings, and even the installation equipment to be used.

This article should not override methods defined by the OEM. It is intended to provide guidelines to help achieve the precise fit required between the shaft and hub and prevent equipment damage if proper procedures are not followed.

A common area of damage associated with hydraulic hub installation is scoring of the shaft or hub on the leading or trailing edges of the mating components.

Configurations can vary due to the location of O-rings on the hub and shaft and the means used to introduce dilation pressure, which is used to expand the hub.

Scoring of the shaft or hub during hydraulic hub installation is common on the leading or trailing edges of the mating components

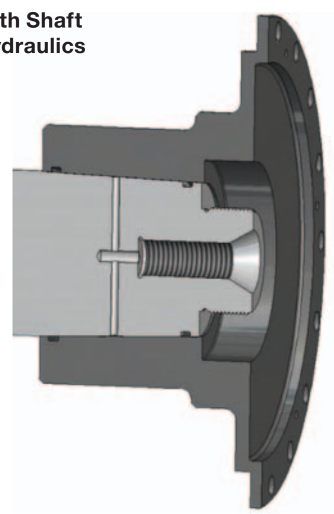


A typical O-ring arrangement can be one O-ring groove on the shaft and the second on the hub.

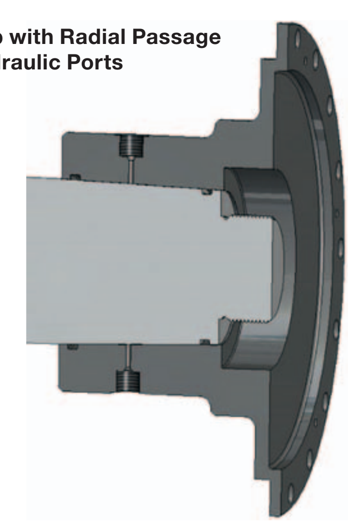
Alternatively, both O-rings can be located in the hub, and occasionally, no O-rings are used. The dilation pressure can be introduced through the shaft end or through a radial passage through the hub.

Before beginning the installation process, be sure to clean the parts. The success of hydraulic mounting coupling hubs is dependent on the condition of contact surfaces. The hub bore and the shaft end must be clean and free from burrs.

Hub with Shaft End Hydraulics



Hub with Radial Passage Hydraulic Ports



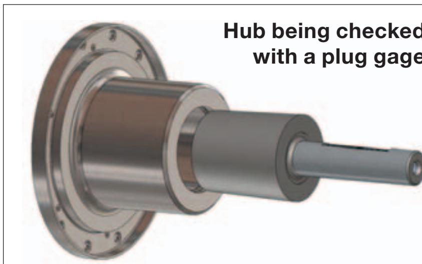
The smallest particle trapped between the shaft and the hub bore can distort the hub enough to make the fit up unsuitable for use. Any nicks, scratches, and edges on mating surfaces must be polished smooth.

Checking for proper contact is the next step. According to API Standard 671 4th Edition:

> "Para 8.6.2.6, Tapered bores shall be checked by using the plug gage from a matched plug and ring gage set provided by the purchaser. A light coat of bluing shall be used for the check. Tapered bores for keyless, hydraulically fitted hubs shall have at least an 85% blued fit (surface contact) to the taper gage."

If less than the required 85% contact is found, and it can be attributed directly to nicks and scratches in the hub bore or shaft, this damage may be lightly stoned or polished to remove the high spots and

Hub being checked with a plug gage



Typical ring and plug gage set

then checked again with the ring and plug gage set.

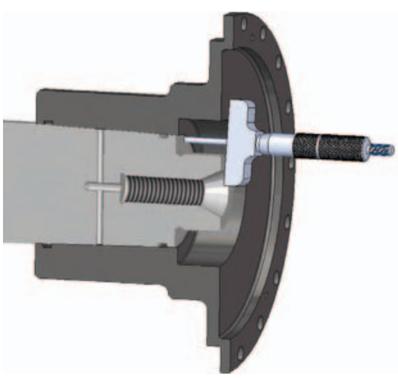
If minimum contact of 85% is still not achieved, the shaft and hub should be independently lapped using a ring and plug lapping tool set to achieve the 85% minimum contact. Lapping the shaft with the hub is not recommended due to the possibility of forming a "step" on each mating surface at the point of initial engagement.

Once the tapers match with an 85% or better contact, set the Zero Start Position. Without any O-rings or back up rings installed on the shaft or hub, put the hub on the shaft with only hand pressure, pushing the hub onto the shaft.

The point where the hub stops advancing up the shaft is considered full engagement and is referred to as the Zero Start Position. This location is the initial position for starting the hub installation.

Once the hub is in the Zero Start Position, it is critical to take a measurement and record the distance the hub is from the shaft end. Using a depth micrometer, measure from the hub face to the shaft end. This value needs to be recorded for final use once the hub is fully installed. It is good practice to mark the hub and shaft location where the measurement was taken, so the same spot is used to measure once the hub is installed.

Depth micrometer measuring hub standoff, Zero Start Point



The Zero Start Position is important because the hub must be advanced up the shaft exactly the amount specified by the OEM, which is usually stated on the coupling drawing as the "pull-up" distance. This pull-up is the predetermined axial movement of the hub relative to the shaft which is made possible by dilation of the hub.

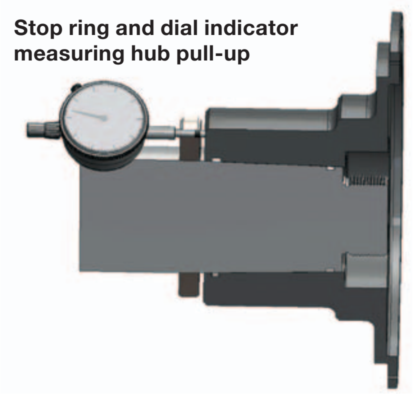
There are two popular methods for establishing pull-up distance:

- Dial indicator method: Locate a stable and flat stationary surface in relative proximity to the hub end on which to mount a magnetic base dial indicator. Set up the indicator to measure axial movement of the hub. This provides a direct and accurate reading of the desired pull-up distance.
- Stop ring method: In this method, a gap corresponding to the pull-up is established between the end of the hub and a stop ring. The stop ring is usually a split-ring mounted on the shaft. It is common to use feeler gages or gage blocks to accurately set the distance between the stop ring and the hub, which establishes the pull-up distance. The stop ring should never be relied upon to act as a positive stop as the mounting tool forces will exceed the resistive force of the ring. Therefore, the stop ring should only be looked upon and used as a gauging fixture.

It is recommended that both methods are used to set the pull-up.

After the Zero Start Position has been determined and some method of measuring the pull-up is established, the hub can be removed. The last step in preparing the hub

Stop ring and dial indicator measuring hub pull-up

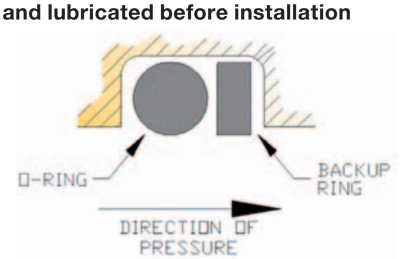


for installation is installing the proper O-rings and back-up rings.

The back-up ring is located on the anti-pressure side of the O-ring. It is imperative that the O-rings and back-up rings be kept clean and lubricated before installation. For lubrication purposes use the same hydraulic fluid that will be used to dilate the hub. It is also recommended that a light coat of the same hydraulic fluid is used to lubricate the hub and shaft interface areas.

Everything up to this point is in preparation for the installation. Skipping any of these steps will inevitably cause problems.

Keep O-rings and back-up rings clean and lubricated before installation

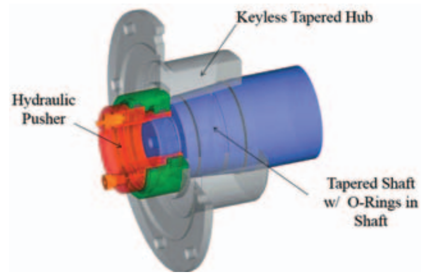


With O-rings and back-up rings installed, replace the hub on the shaft. When advancing the hub up the shaft ensure the O-rings and back-up rings are properly seated and not pinched or damaged.

More than likely, O-ring interference will prevent the hub from reaching its Zero Start Position. One accepted method of moving the hub up the taper is to use a lead hammer. Several blows of the hammer will seat the rings and allow the hub to move to the Zero Start Position. A more accurate way it to use the pusher tool to advance the hub to the Zero Start Position.

The pusher tool is designed to match the shaft end threads as it is required to be threaded onto the shaft at this location. The pusher tool is a hydraulic cylinder that will stroke enough to accommodate pushing the hub up the shaft the full pull-up distance. Once it is threaded onto the shaft end, it can be used to apply pressure to the hub, re-establishing the Zero Start Position.

The use of a hydraulic pusher is preferred to a lead hammer



An installation kit comprised of two hydraulic pumps is required. The two hydraulic pumps are manually operated, providing independent sources of both high pressure 35,000 PSI (241,320kPa) and low pressure 10,000 PSI (68,950kPa).

The low-pressure pump connects to the pusher tool and the high-pressure pump connects to the dilatation port (either in the shaft end or through a radial passage through the hub). Note that equipment damage and personal injury can result from mixing up the connections.

Hydraulic installation kit

Before beginning the actual installation of the hub on to the shaft, recheck the Zero Start Position one last time. To begin installation, use the high-pressure pump and slowly increase pressure to about 12,000 PSI (82,740kPa) to begin dilating the hub. To prevent the hub from moving down the shaft as the dilation pressure builds up, use the low-pressure pump to develop sufficient force in the pusher tool to maintain the hub at its Zero Starting Position.

Some oil may bleed out between the hub and shaft joint. The degree of bleeding will vary from installation to installation which is a function of equipment arrangement and part tolerances. It is important that the hub be maintained at its Zero Starting Position as the initial dilation pressure is developed. Continue applying pressure using both pumps until conditions are stable before advancing the hub up the shaft. Stabilized hydraulic pressure should be in the range of 12,000 to 15,000 PSI (82,740 to 103,420kPa).

Using only the low-pressure pump, slowly advance the hub on the shaft continually monitoring hub movement with the dial indicator. As the hub advances, the dilation pressure (high-pressure pump) may rise without activating the pump. This dilation pressure may reach a level of 27,500 PSI (189,600kPa), but should not exceed 28,000 PSI (193,050kPa).

If it does, bleed off some of the pressure using the pressure release valve of the high-pressure pump until the pressure drops to 25,000 PSI (172,370kPa) before proceeding with further advancement. Caution: Always consult the OEM for the maximum dilation pressure as it is dependent on the hub material and the design being used. Continue to advance the hub to the pull-up position, always observing the high-pressure and low-pressure limits.

Should the low-pressure pump, connected to the pusher tool, reach its max limit 10,000 PSI (68,950kPa), stop the installation and remove the hub to inspect it and the shaft for damage to determine possible causes of the hang-up.

When the specified pull-up has been reached, the dilation pressure from the high-pressure pump can be slowly relieved to zero. Then disconnect the hose from the hub or shaft. It is important not to relieve the pressure on the low-pressure pump connected to the pusher tool.

After waiting a minimum period of one hour to allow the hydraulic oil to drain from the hub to shaft interface, release pressure at the low-pressure pump very slowly. At the same time, keep a close eye on the dial indicator to see if there is any movement of the hub.

If noted, stop releasing the pressure and hold for approximately 15 minutes then release pressure again. When all movement has ceased, the pusher may be disconnected from the shaft end.

Once the pusher tool and all hoses and fittings are removed, a final measure of the pull-up distance should be done using the same depth micrometer in the same location as the initial measure taken for the Zero Start Position.

This measurement should be the pull-up dimension from the drawing used in the installation process. If less than specified, repeat the installation procedure. If pull-up is greater than specified, it would be best to remove the hub and restart the entire process. ■

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Condition monitoring can be extended from critical assets to all areas of the plant via control systems, smart sensors and digitalization

ARTIFICIAL INTELLIGENCE

KEEPING A WATCHFUL EYE OVER THE CONDITION OF ROTATING MACHINES

BY DIEGO PARESCHI

Condition monitoring is a fundamental discipline using digital technologies that helps improve the safety and reliability of rotating equipment. Digitalization enables the monitoring of equipment on an unprecedented scale.

But just collecting data is not enough. It must be put to productive use. With a concept known as edge computing, data can be processed and analyzed locally with only the most relevant information being sent to the plant or enterprise-asset-management system.

This offers the opportunity to greatly extend the value of condition monitoring, which traditionally has been restricted to critical machinery. With edge computing, large fleets of non-critical assets are within easy reach of round-the-clock condition monitoring.

Checking condition

Condition monitoring has evolved over the years. From the 1980s, the focus was on wiring. Probes are wired to junction boxes and the signals are fed to monitoring systems housed in cabinets where they are read by a higher-level system.

Operational parameters are continuously captured and studied to predict future behavior. If the system detects an abnormality that exceeds a threshold value, it trips the machine to avoid damage. The data is extrapolated for further health analysis.

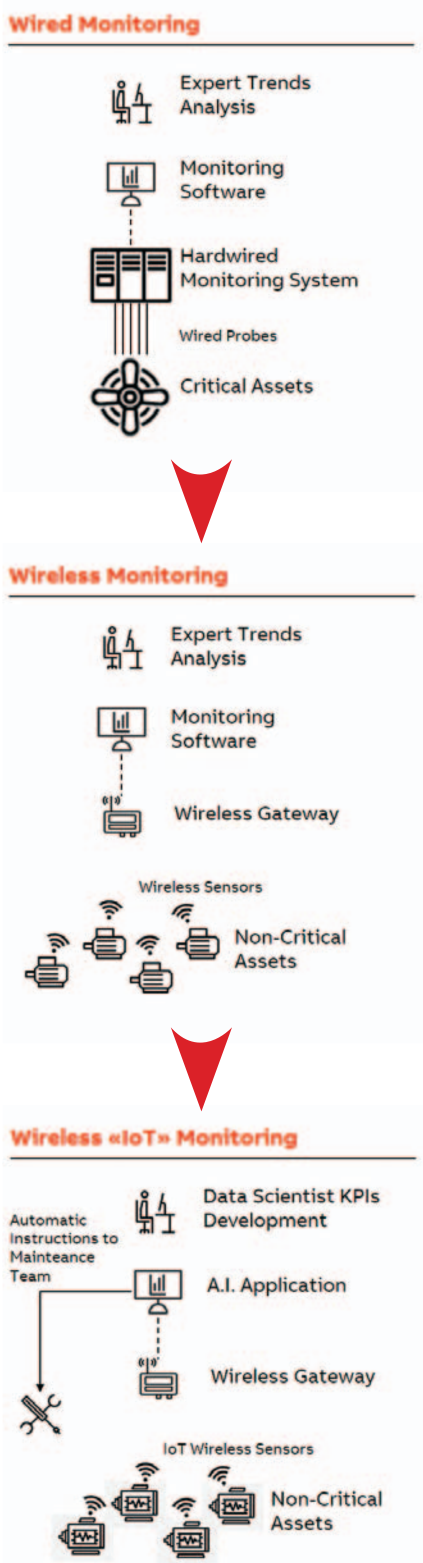
In the early 2000s, low-cost wireless technology became widely available. This expanded condition monitoring to more machines. However, it meant sacrificing the ability to continuously monitor the asset, as wireless sensors provide readings on a periodic basis to save battery power. Readings were collected and analyzed.

The use of wireless sensors has grown in the process and energy industries. But the investment required made it difficult to justify their deployment across large fleets of assets and auxiliary systems.

Brownfield sites, for instance, typically lack an existing wireless network infrastructure. More recently, technologies based on the Internet of Things (IoT) and Artificial Intelligence (AI) have improved the cost-effectiveness and accuracy of the condition monitoring.

This makes it feasible to monitor the condition of the many non-critical

The evolution of condition monitoring



Edge computing can bring the benefits of AI to turbomachinery in order to detect failure and prevent downtime.

devices that support rotating equipment. Wireless access points can be placed around the facility within range of these machines. Sensors communicate with the wireless gateway that transmits the raw data to a system for analysis.

With wireless technology, the fleet of monitored assets can be increased from less than 5% to about 20% of all machinery. But what about the remaining assets? This is where edge computing comes in.

At BASF's main site in Ludwigshafen, Germany, only a small number of its many rotating machines were being monitored. Sensors were deployed across the facility to detect bearing temperatures and vibrations and to send readings for analysis.

A single wireless sensor can generate up to 250 megabytes (MB) of raw data per day. More than 99% of it, however, is irrelevant to machine health trends.

Edge computing solves this problem. By processing data locally, inside the sensor attached

Sensors designed to capture and extensively analyze the readings are often referred to as smart sensors

to the machine, the volume of data sent to a higher-level monitoring system can be reduced from hundreds of MBs to a few kilobytes (kBs).

These devices store the measured raw data for a period of time, in the event the user wants to compare the raw readings with the processed information. Peripheral assets can tell the higher-level system any detected symptoms (such as vibration or temperature readings), and what it thinks the problem is.

This approach to monitoring is now being applied to critical machinery. These assets can be connected to a remote center enabling a team of experts to monitor a greater number of assets.

But critical machinery requires more than a smart sensors for analysis due to the quantity of information to be processed. Instead, a dedicated edge computer is connected to the machine's control panel.

It reads even larger large streams of data than a smart sensor and converts it into health insights and maintenance relevant information. This can replace the need for 24/7 monitoring performed by a remote operator. Human support is only needed when an anomaly or malicious threat is identified.

AI's role

There may be a trend in a vast sea of data that a human cannot detect, such as subtle changes over time. Artificial Intelligence (AI) can help to find these patterns.

Condition monitoring is about understanding status. Data can be translated into numerical key performance indicators (KPIs) that provide a value for the likelihood of a specific equipment failure. Data scientists are working to develop methods to predict failure modes.

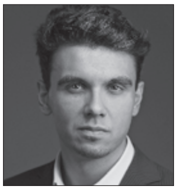
By using mathematical modelling techniques, it is possible to define how a KPI will evolve in the upcoming weeks or months and calculate the residual time to failure.

With this information, a shutdown can be planned and executed. The more data processed by an AI engine, the more accurate become the predictions of the future behavior of the KPI. In turn, the threshold defining good or critical health can be even more precisely evaluated.

There will always be abnormal conditions caused by unexpected events or external factors. To cover all potential failures in all applications, it takes the involvement of human experts to add real value.

Monitoring systems can distinguish between a known pattern and an abnormal condition. Abnormal conditions are turned over to staff. A feedback loop can then be used to create new KPIs to consider new conditions and failure modes.

Edge computing and AI technologies, backed up by qualified employees, can systematically analyze the health of large fleets of rotating equipment, reducing plant downtime while improving productivity and performance. ■



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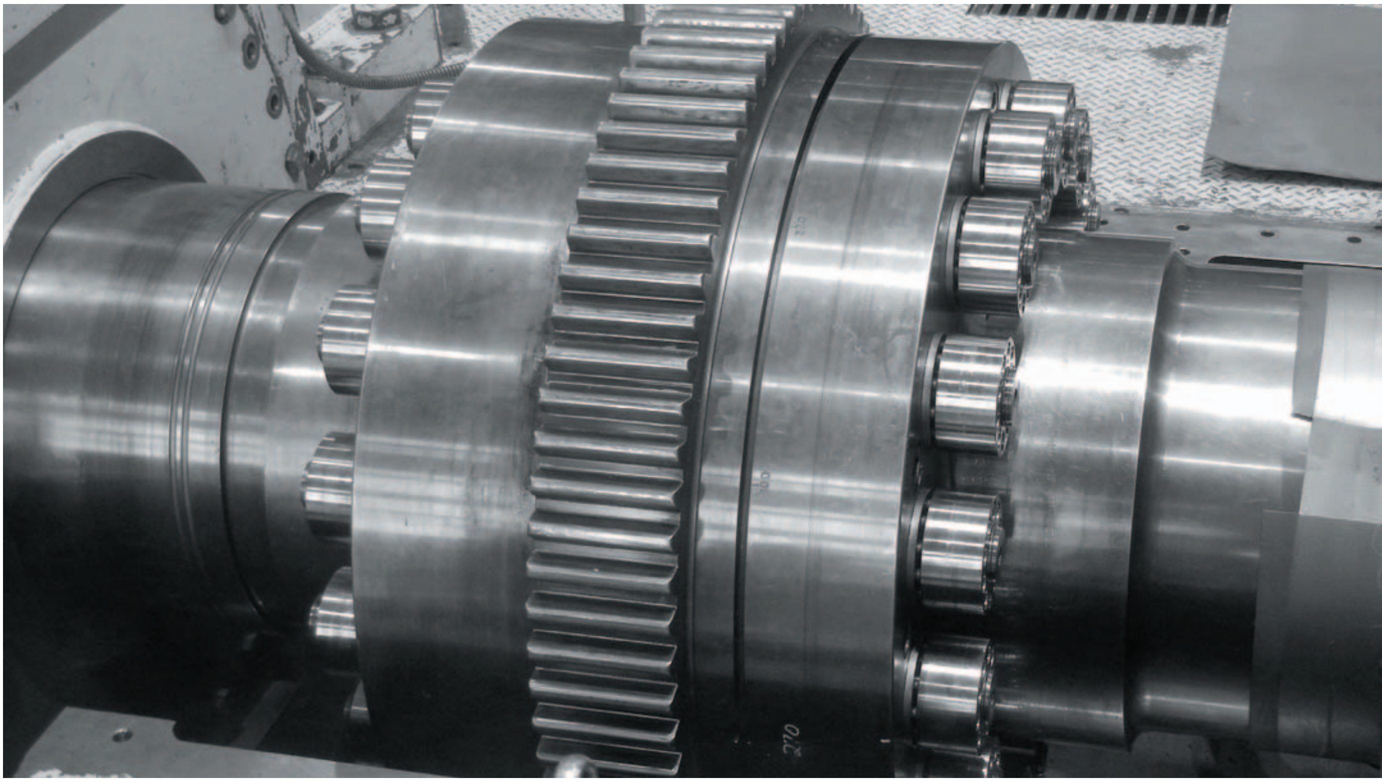


Superbolt EzFit assembled on a turbine generator coupling. This mechanical expansion bolt combines multi-jackbolt tensioners and an expansion bolt with controlled sleeve expansion

COUPLING BOLTS

HOW TO AVOID THE VARIOUS CHALLENGES RELATED TO SEIZED COUPLING BOLTS

BY STEVE BROWN

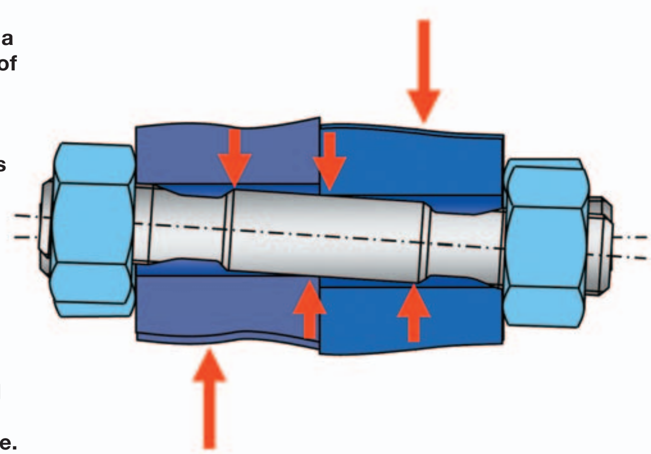
Couplings play an important role in maintaining shaft alignment and transmitting drive. However, they also present their fair share of challenges. This is especially the case when traditional fitted bolts used to secure couplings seize up.

A coupling bolt is a mechanical means of holding two halves of a flanged shaft together to properly transfer the torque while maintaining shaft alignment. Misalignment in steam turbines, for example, causes vibration, puts unnecessary load on bearings, and curtails operation at full power.

High loads associated with the necessary torque transfer within the shaft connections (couplings) can be high. This makes bolting essential. Coupling bolts are complex and large.

High energy tools are needed for maintenance work. The bolts must be closely fitted or interference-fitted with their mating coupling

Fitted bolts fill the bore within a few hundredth of a millimeter. They are pre-loaded axially with nuts on both ends to create the friction connection in the contact plane of the coupling flange faces. This can cause the fitted bolt to position itself at an angle.



bores to transfer the proper torque. Ideally, one shaft would be used, but this is impossible due to the need for simple maintenance. Bolts must be used to attach the two halves of the shaft together via the coupling.

Standard fitted bolts often used to secure couplings are inexpensive and readily available. However, these bolts and their mating bores require precision machining, extreme tolerances, and high-quality surface finishes.

Operators often have to machine the bolts to fit the bores or rework the bores to match the fitted bolts. Despite this, they never fit perfectly. There is always minute sliding in the joint. Pressure at the four contact points leads to plastic deformation of the flange. As well as failures, this can make it impossible for operators to remove fitted bolts during maintenance.

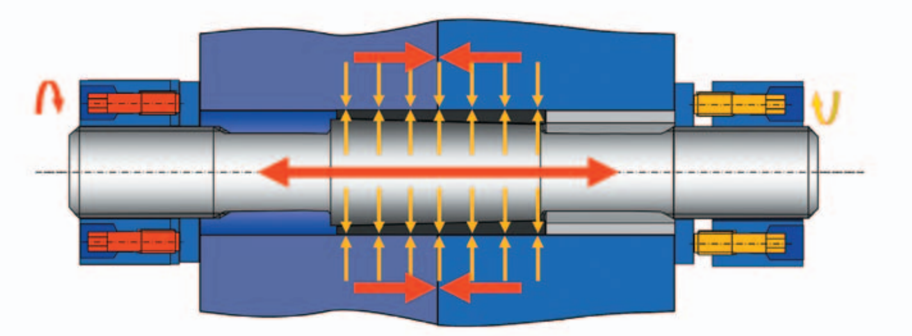
Fitted bolts that seize must be removed by force, which damages the coupling hole

Galling and seizing

Galling and seizing in bolts are caused by a combination of friction and adhesion between metallic surfaces during sliding. Generally, this appears when fasteners are tightened, as pressure builds up between the sliding thread surfaces. The ductility of the material used in the bolt affects the tendency toward galling: softer materials are more prone to damage.

Galling is common in fasteners made of stainless steel, aluminum, titanium, and various alloys. Once galling has begun, lumps form, which accelerates the process. In extreme cases, galling leads to seizing. The bolt freezes into the hole. Continued tightening may lead to breakage of the bolts, including torn-off threads.

When fitted bolts seize in their bores, operators will try to remove them with breakout tongs, hammers and chillers. If unsuccessful, outage managers call for drilling and boring. But this generally damages flange bores and coupling faces.



The Superbolt EzFit Expansion bolt is designed to be installed and removed in clearance conditions, avoiding problematic interference fits. By closing the clearance between the sleeve outer diameter and the bore inner diameter, coupling slippage or micro-movements can be prevented during coupling drive operations.

An alternate approach is to use expansion bolts. As the bolt's tapered body and the mating tapered bore sleeve are smaller than the hole itself, operators can install it perfectly by sliding it into the hole. Interference fits are unnecessary, with no need to freeze or heat the bolts. This eliminates radial clearance during the installation process and ensures uniform load distribution during operation.

Expansion bolts are positive locking bolting elements. Due to their increased rigidity, load amplitudes on the shaft line are reduced. Unlike traditional fitted bolts, the amount of radial force in the hole can be controlled.

When tightened axially, the bolt does not decrease in diameter. Accurately known loads combined with an increase in the effective cross section available for power transmission lower shaft stresses and prolong service life.

With modern turbines experiencing more cyclic loads, couplings have to deal with heavy torsional stress during each startup or shut down. A coupling bolting system with zero clearance allows for better torque transfer during these conditions and extends the useful life.

Hydraulic expansion bolts are another option. They are radially fitted during coupling drive operation and perform as clearance bolts during removal. Hydraulic expansion bolts are especially suited for power generation turbines of all types as the time required to fit or remove such bolts is short and can be easily programmed into maintenance schedules.

However, hydraulic expansion bolts have solid sleeves and the expanding sleeve requires very close tolerance between the coupling hole. Operators must use precision machining. Although tolerances on hydraulic expansion bolts are much bigger than traditional fitted bolts, they are still smaller than those of mechanical expansion bolts.

Instead of a solid sleeve, mechanical expansion bolts use a split sleeve which is operated mechanically rather than with high-pressure hydraulics. The split sleeve mates with the machined coupling hole and requires less tolerance on mating parts than is traditionally required with interference fit bolts.

Since the sleeves are installed in clearance conditions and are expandable, the mechanical expansion bolt can accommodate slight hole size variations and hole misalignment.

They are suitable for couplings using bolts of 1-1/8" (28mm) diameter or bigger. This technology enables a controlled expansion of the split sleeve. This means that a precise radial force is imparted into the hole.

Designers can calculate the exact radial force needed for optimal expansion. This increases the reliability of the coupling and in turn, the application in which it is installed.

Reliable coupling bolts provide correct driving forces, are easily installed and removed without fear of galling or seizing and provide accurate maintenance scheduling. Traditional fitted bolts suffer from coupling slippage and seizing.

Alternative bolting solutions such has hydraulic and mechanical expansion bolts enable planned outages to be programmed precisely and guarantee optimal operating conditions. ■

Steve Brown is the Mechanical Production Engineer at Nord-Lock Group specializing in couplings. Nord-Lock Group provides high-quality, innovative, and safe bolting solutions. For more information, visit www.nordlock.com.

GE BETS ON AERODERIVATIVES

Martin O'Neill, General Manager of Aeroderivative Gas Turbine Services for GE's Power Services business, discusses the company's plans for its aeroderivative fleet.

How confident are you of growth in the aeroderivative market?

According to a 2016 study by Technavio, the global aeroderivative gas turbine industry is expected to grow at an annual rate of nearly 5% between 2016 and 2020. Aeroderivatives are likely to become the go-to technology to provide balancing services for renewable energy. These mounting power imbalances are increasingly forcing conventional generators to operate in a more flexible manner, ramping more frequently to balance intermittent renewables and provide grid-firming services. Given this crucial role in power infrastructure, downtime can be expensive, and it's critically important that operators have plans in place to ensure continued operations and minimal lost time for maintenance and repairs.

How is GE investing in aeroderivatives?

$200 million is being spent to develop new technology and enhance our service capabilities. GE is investing in its Houston Service Center with an overall maintenance overhaul. We have added approximately 40 jobs, and will continue to improve the work environment, tools, fixtures and implement new IT systems. We have added digital capabilities and processes to service more than the current 500 engines and modules per year. This is more volume than any other GE repair center.

On the technology side, GE is continually upgrading the reliability and availability of the existing fleet, as well as repairs for the fleet. We also have some new units, including the LM6000-PF+, the next generation of the LM2500, which is in development, and the recently launched LM9000 aeroderivative.

What about overall strategic direction?

The three pillars of our strategic direction are decentralization, digitization, and decarbonization. Decentralization is an area where aeroderivatives have been on the forefront in distributed generation applications under 100 MW, such as microgrids, combined heat and power (CHP), and others where the point of power generation is close to the point of consumption. Aeroderivatives were designed and built for these applications and have been doing it for 40 years. Distributed generation is a significant part of the energy mix and where a large portion of our current fleet is in service.

How are you addressing decarbonization?

Decarbonization is about adding more solar and wind onto the grid to reduce the emissions footprint. Aeroderivatives are a critical component for renewables balancing. With quick start times under 10 minutes, they can cycle quickly without maintenance penalties and are therefore best suited for renewables balancing. In addition, Dry Low Emissions (DLE) technology, which does not use water, further reduces emissions from these gas turbines.

How is digitization being applied to aeroderivatives?

GE's Asset Performance Management (APM) software provides aeroderivatives with data analytics to help predict and eliminate unplanned downtime and improve plant reliability and availability. GE provided a digital upgrade for an Italian petrochemical company's aeroderivative gas turbine. GE's LM2500+G4 aeroderivative gas turbine and generator will be upgraded with digital technology enhancements. The project marks the first digital implementation of an aeroderivative unit in Europe. APM software is expected to increase the availability of the power plant up to 97%.

What do you see as the primary role of the LMS100?

The LMS100 has a fleet of over 60 operating units (with another 13 being commissioned during 2018–2019). The majority are in North America, and those units are primarily being utilized to provide grid-firming for grids highly penetrated by renewables. As renewables grow around the globe, we believe the LMS100 will continue to be a good fit for much needed grid reliability with its ability to start up and provide 120 MW of power per unit within eight minutes, as well as high simple-cycle full-load and part-load efficiency.

What are your plans for the LM6000 and LM2500?

The LM6000 and LM2500 have greater than 2,500 gas turbines in service with a combined operating experience of over 130 million operating hours. Continued investment in these machines will improve product performance and flexibility. The original LM6000PA configuration was rated at 42 MW. Upgrades resulting in the LM6000PF+ have boosted that to 56 MW at 42% simple cycle efficiency. The first PF+ reached commercial operation earlier this year. The LM2500 platform was originally rated at 22 MW and that has grown to 34 MW in the LM2500+ G4 with 38% efficiency. The TM2500 mobile gas turbine utilizes the same LM2500 gas turbine technology and is the fastest growing aero fleet for GE.

What is a cross-fleet repower?

The replacement of an entire engine is known as repowering, while upgrading is the replacement of individual components within the engine. The time taken to replace a unit is a critical factor. Cross-fleet comes into play where there is an existing other-OEM gas turbine running. Typically, these are older technologies with low efficiency and high emissions. A cross-fleet repower removes the other-OEM turbine and repurposes the plant with an aeroderivative unit. This creates greater output, better efficiency, and lower emissions. This allows older plants to become more economically viable. GE can use both new and refurbished equipment, depending on the customer's economics and lifetime of the plant.

What turbines can you repower?

We can repower gas turbines manufactured by Siemens, Rolls Royce, Pratt & Whitney, Westinghouse and Mitsubishi, with our aeroderivative technology. We already have more a backlog of more than $15 million in cross-fleet repowers. ■

AD INDEX

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4. Requested Copies Distributed by Other Mail Classes Through the USPS	0	0
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GEmeasurement.com

New LNG carrier

Mitsubishi Shipbuilding held a christening ceremony for a next-generation LNG (liquefied natural gas) carrier under construction for MOG-X LNG Shipholding. The ship, named "LNG JUNO," is the third "Sayaringo STaGE" type vessel.

STaGE, an acronym deriving from "Steam Turbine and Gas Engines," is a hybrid propulsion system combining a steam turbine and engines that can be fired by gas. Efficient use of the engines' waste heat to drive the steam turbine improves propulsion efficiency, enabling high-efficiency navigation throughout a full range of speeds.

It is Mitsubishi Shipbuilding's newest carrier to feature improvements in LNG carrying capacity and fuel performance through the adoption of a more efficient hull structure and a hybrid propulsion system. The LNG JUNO will go into service transporting LNG for the Freeport, Texas LNG Project and other clients.

The LNG JUNO features LOA (length overall) of 297.5m, width of 48.94m, depth of 27.0m, and draft of 11.5m. Deadweight capacity is about 80,300 tons, and the total holding capacity of the tanks is 180,000m^3.
msb.mhi.co.jp/en/

High-pressure hoses

Kurt Tuff Hoses are designed for rugged, high-pressure applications of up to 6,500 psi. Bending twice as tight as standard SAE hose can be done with half the bend radius. Reinforced with braided layers of high tensile steel wire, this hose retains flexibility and durability. With an abrasion resistant outer cover (10 times as resistant compared to standard hose cover), Kurt Tuff hose is rated to 1 million impulse cycles.
kurthydraulics.com


Baumer bearingless encoders

Bearingless encoders

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

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

Fluid analysis

Spectro Scientific has introduced the TruVu 360 Enterprise Fluid Intelligence Platform, a web-based, fluid-analysis system for data management. It streamlines the fluid-analysis process, closing the gap between maintenance recommendations on the oil analysis report and the impact on continuous process improvement.

It provides a dashboard, so management can see the effectiveness of the program. TruVu 360 integrates Spectro's MiniLab on-site oil analysis hardware used in industrial applications in manufacturing, mining, oil & gas and power generation.
Spectrosci.com

Air monitoring

Kemper's air monitoring system can be integrated into environments where there is an inadequate digital infrastructure, without interfering with corporate networks. It analyzes the amount of ultra-fine dust particles.

By connecting to an internet-based cloud, different users can monitor the systems via fleet management. Integrated mobile radio technology and sensitive sensors ensure that machine-to-machine communication operates efficiently. It can detect ultra-fine dust particles that are

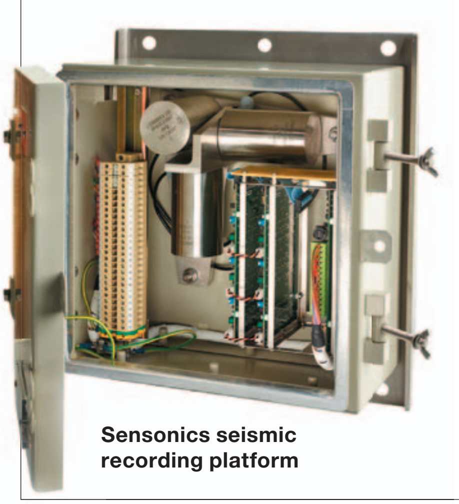
Kemper air monitoring system

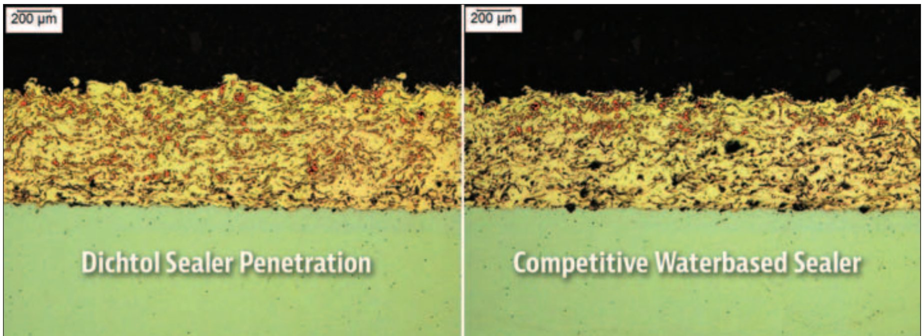
Seismic recording

Sensonics has enhanced its seismic equipment product range through the development of a new seismic event recording platform. This development represents an upgrade path for existing legacy systems and provides data acquisition equipment.

Applications include automatic safe shutdown of a critical process in the event of an earthquake, in addition to the recording of any seismic events to allow post analysis of structural impact. The essential elements of such a system are reliability, minimal spurious trip occurrence, full sensor loop proof testing, maximum design life and maintainability combined with a low demand and high integrity shutdown system.

The Linux-based recording system offers up to 16 channels of seismic data acquisition on a solid state platform expandable up to 32 or 48 channels by using the separate hub option to create a single flash memory store for the data and central configuration. Data analysis in waveform, FFT and spectral density is available as standard.
sensonics.co.uk


Sensonics seismic recording platform



Comparison of sealing penetration

Polymeric capillary action sealers

Stronghold Coatings has released the Dichtol family of polymeric capillary sealers for castings, steel and composites that seal micro-porosity and hairline cracks without vacuum or pressure. These formulations penetrate deeply, (up to .004”), to prevent corrosion of the metal substrate.

Pressure resistant to 8,700 psi, and temperature resistant to 932°F, this coating is ideal for castings, composites, all kinds of steel surfaces, and more. Applied by dip, brush or spray, it dries in minutes and cures at ambient temperature.

It increases machinability and dampens vibration, to further enhance the utility of the components being treated. Applications include sealing of engine casings, pump housings, bridge cables, composite parts, and all thermal sprayed coatings.

StrongholdOne.com

smaller than 0.3 microns. Extraction and ventilation systems are controlled as required on the basis of specified workplace thresholds.

kemper.eu

Plant analytics

Siemens and Bentley Systems have announced a joint technology and service solution, consisting of their complementary offerings, to speed up the digitalization of power plants and provide intelligent analytics with a range of offerings.

The new service, to be hosted on Siemens’ cloud-based open Internet of Things (IoT) operating system, MindSphere, will combine Bentley’s advanced asset performance software capabilities with Siemens’ complementary technology and service expertise to empower power plant owners to take advantage of digitalization. This will improve maintenance operations and planning.

Siemens’ asset performance management (APM) solution, part of the company’s Omnivise digital solutions portfolio, covers the entire power plant, including the combustion and steam turbines as well as associated generators and pumps, motors, transformers, valves, switchgears, and other equipment. Using intelligent models based on predictive analytics, the solution takes data from multiple sources, applies domain and analytical expertise, and then integrates into a customer’s existing Computerized Maintenance Management System (CMMS)/Enterprise Asset Management (EAM) system.

Bentley.com

New sensors

NewTek Sensor Solutions introduces the RV series of RVDT (Rotary Variable Differential Transformers) Rotary Positions that offer accurate angular displacement measurement of rotating elements such as quarter-turn ball and butterfly valves, actuators, throttles and dancer arm tensioners used in industrial machine-to-machine applications. With a shaft that rotates a full 360° with no stops and virtually no friction, these AC-operated rotary position sensors measure shaft angle position over a nominal range of ±30°.

Newteksensors.com

NewTek sensors for measurement of angular displacement

The PosiClutch 200 by Force Control

Clutch for pumps

Force Control Industries has introduced the PosiClutch 200 Series PTO clutch, a hydraulically actuated microprocessor-controlled Oil Shear PTO clutch for high-volume pump applications. Designed to mount on a diesel engine with flywheel housing, it can include up to four pump pads to drive additional hydraulic pumps, up to 400 HP.

There is no need for separate transmission fluid cooling equipment. At 33-¼ inches in length, including sheave support bracket, this is the most compact package available. It includes an internal brake that can be released to allow free movement of the output for inspection or freeing a jam.

The controller communicates through the J-1939 communications protocol used on most engines, to prevent damage by limiting engagement at proper engine speed, protecting the engine from overload and stall conditions, and detecting clutch damage.

www.forcecontrol.com

Checking bore gages

L.S. Starrett has introduced Digi-Check Height Masters with an electronic digital readout. The new Digi-Check No. 258 Series Height Masters combine Starrett-Webber Gage Blocks with a precision micrometer head and digital readout display. Accurate, stable and easy-to-read, they provide a reference setting for checking bore gages, inside micrometers, end measuring rods and other gages, and height measurement of parts. ■

starrett.com

MUST CHP OBEY THE LAWS OF THERMODYNAMICS?

When I ask engineers of all ages their least favorite class in college, thermodynamics usually comes out on top. But in real life, when thermodynamics conflicts with hopes, wishes and desires, thermodynamics usually wins. Enter combined heat and power (CHP).

Although there are differing definitions, CHP is generally understood to be the beneficial use of exhaust heat from a heat engine, such as a gas turbine (GT) or gas engine, for domestic or industrial heating, drying, chemical conversion, refining, food processing or other thermal energy application.

In heat engines, almost all of the energy losses (i.e., the inefficiencies of the engine) are converted into hot exhaust gas. Since most heat engines operate between 20% to 45% efficiency, most of the remaining 55% to 80% of the energy is theoretically available as thermal energy. That means that a lot of hot air is available for CHP.

One of the somewhat misleading features of CHP applications is that efficiency appears to be very high. Quoted efficiencies often exceed the Carnot limit which is the theoretical highest possible efficiency for any heat engine.

But how can relatively simple CHP machines achieve better than 80% efficiencies, while the most state-of-the-art combined cycle plants barely reach above 60%? The answer: not all efficiency is created and calculated equally. In other words, there is difference between electricity produced and heat produced.

The first law of thermodynamics states that energy is conserved. A GT converts fuel into either electric power or hot exhaust gas. If we somehow manage to use all the hot exhaust gas from a GT for some practical and useful purpose, we could claim a 100% efficient process.

Unfortunately, heat has often limited use compared with electricity. We can convert nearly 100% of electrical energy to low-grade heat (a stove does this), but we cannot convert low-grade heat into an equivalent amount of electricity. This points to the irreversibility of energy conversion processes.

In CHP efficiency calculations, heat and electricity are treated the same. It does not matter whether the recovered energy in a CHP system is electric energy or low-quality heat.

It is true that an 80% efficient CHP cycle converts 80% of the fuel into useful energy. But more than half of that useful energy is in the form of heat and the rest is electricity.

Why is electricity more valuable than heat? If we have electricity, we can use it to generate heat, but we can also use it to run motors, computers and lights. If we have heat, only a small portion of the heat energy can be converted into electricity or used for other applications.

In a CHP application, the energy in the fuel gets converted into heat and electrical power, and the limit of the conversion efficiency is simply the minimum temperature achievable for the exhaust gases.

This minimum temperature is determined by the size of the exhaust gas heat exchanger and the minimum exhaust temperature allowed to avoid condensation in the exhaust.

In other words, the efficiency of the GT has practically no impact on the CHP efficiency, but simply determines the ratio between electrical power output and heat output. A more efficient gas turbine will produce more electricity and less heat.

On the other hand, the firing temperature of the GT has a significant impact on exhaust heat and any heat lost through radiation or the engine lube oil is not available for CHP.

Published CHP data for engine exhaust heat, engine power and engine heat rate, often neglects first law principles. What goes in must come out. Not more. Not less.

Energy in the fuel at the inlet into the system is defined by the lower heating value of the fuel. This energy can show up as shaft output power or as exhaust heat. Some amount leaves through radiation, the lube oil, or minute inefficiencies in combustion. The exhaust heat can be used for a bottoming cycle or used directly in some processes. This energy extraction results in a reduction in exhaust temperature.

Typical bottoming cycles use the exhaust heat to create steam to drive a steam turbine, organic Rankine cycles or supercritical CO_2 cycles. In some cases, the heat is used directly for industrial process heat input, heating, drying and refining.

The exhaust heat available depends on the GT exhaust temperature and the allowable stack exit temperature (which cannot drop below a certain value to avoid water condensation). The practical exit temperature is higher since increasing the removed energy requires larger heat exchangers.

Also, analyzing operational data sometimes shows inconsistent results. For a given GT model, engine performance can vary. If an engine is cited that provides a better than average heat rate and shaft power while the exhaust heat and exhaust flow numbers are used based on average engine performance, CHP efficiency becomes too optimistic.

Why? An engine that performs above average on heat rate will have below average exhaust heat. The GT experiences heat losses. All the fuel energy is not leaving the system as exhaust heat or shaft power, but rather is radiated from the engine casing via losses in the generator, the gearbox, or via heat rejection in the lube oil coolers. But if the available exhaust heat is calculated as the fuel heat input minus the shaft power output, it is over estimated.

Making beneficial use of exhaust heat from a gas turbine is obviously the right thing to do. But a simple cycle GT cannot exceed Carnot efficiency and is seldom higher than 45%. Adding exhaust energy in CHP applications makes total efficiency artificially high. It should never be directly compared to GT efficiency. Apples are not oranges. ■

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