The Global Journal of Energy Equipment

SEPTEMBER/OCTOBER 2022 • VOL. 63 no.5

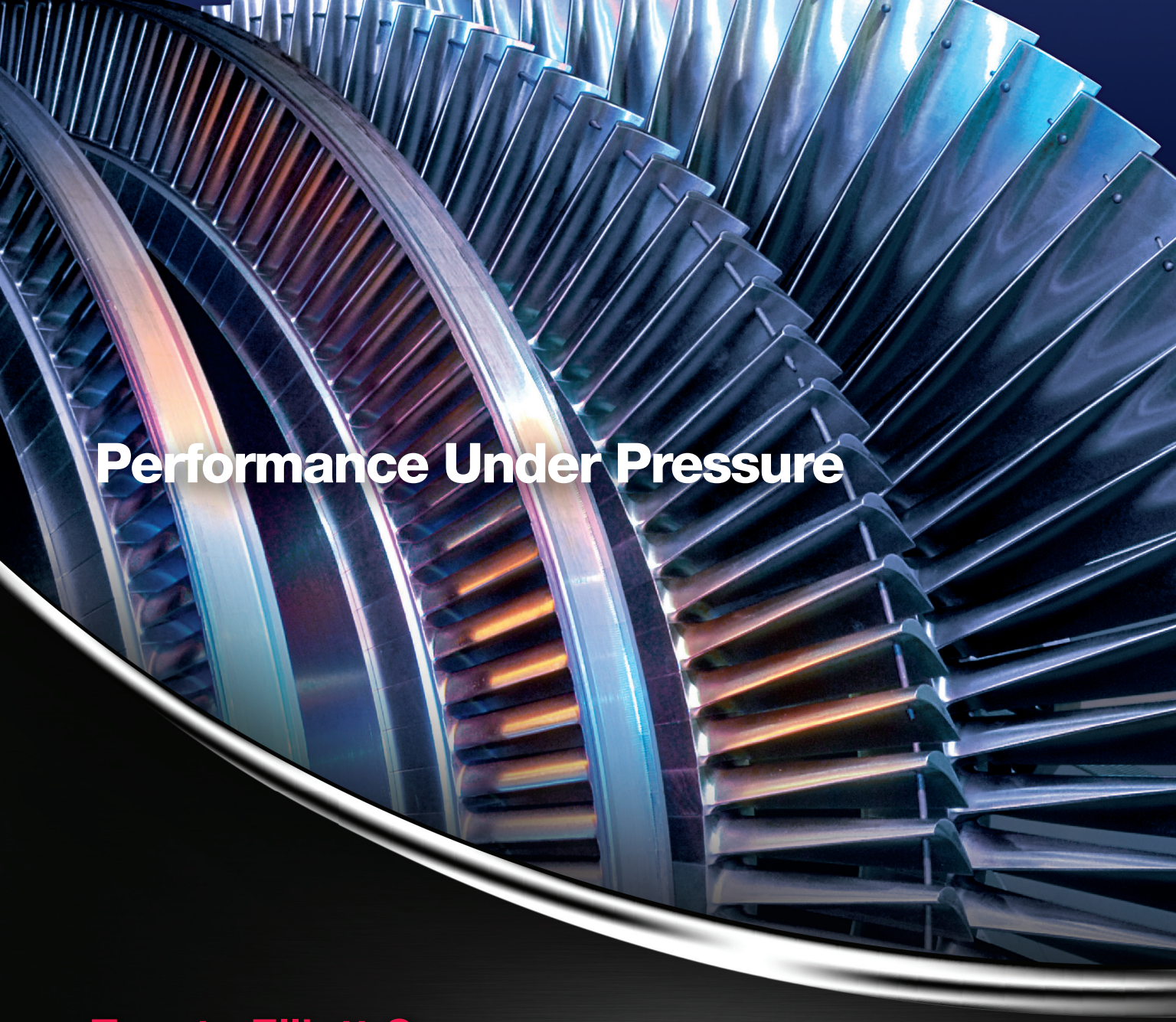
TURBOMACHINERY INTERNATIONAL

TURBOMACHINERYMAG.COM

Controls Go High Tech

Also in this issue:

Supercritical CO_2 • Compressor Maps • Storage • Dual Drive
Turbines • Software & Controls • Compressors
Components & Auxiliary Systems • Maintenance & Repair



Turn to Elliott Group for a partnership you can trust.

For nearly a century, Elliott steam turbines have earned a reputation as the most rugged, reliable, and versatile drivers in the industry. Customers choose Elliott for exceptional value and unmatched reliability in mechanical drive, power generation, and power recovery applications. Who will you turn to?

■ **Learn more at** www.elliott-turbo.com

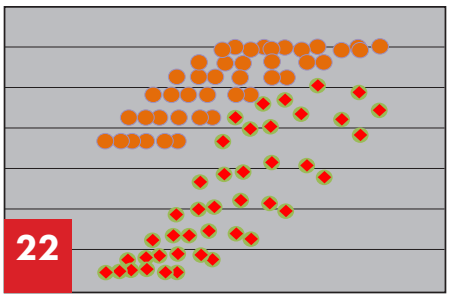
The World Turns to Elliott.

COMPRESSORS | TURBINES | CRYODYNAMICS® | GLOBAL SERVICE

ELLIOTT® GROUP
EBARA CORPORATION

CONNECT WITH US:
www.turbomachinerymag.com
www.turbohandbook.com
@ turbomachinery-international
MTracey@MJHLifeSciences.com
ARobb@mmhgroup.com
TLukac@mjhlifesciences.com

FEATURES



COVER STORY
16 TURBOMACHINERY CONTROLS GO HIGH TECH

The evolution of turbomachinery control systems is a necessity for continued innovation. A great many technologies from the IT space are being incorporated into turbine controls. These include remote monitoring, digitalization, cybersecurity, AI, and digital twins. Experts offer their thoughts on how these developments impact turbomachinery controls.

Drew Robb

COMPRESSORS
22 COMPRESSOR MAPS

This article shines a light on the shortcomings of traditional manufacturer centrifugal compressor performance maps. It goes into detail about formatting of these maps, discusses the debate about performance metrics, covers pipeline compressor design, and gives recommendations for gas pipeline compressor station upgrades.

Roberto A. Hein

COMPRESSORS
28 DUAL DRIVE COMPRESSORS

Using multiple mechanical drive components with an electric motor in hybrid/dual-drive configuration offers a number of positives over single-drive configurations.

Gautam Chhibber

COMPRESSORS
30 SUPERCRITICAL CO_2

A 10 MW demonstration project in San Antonio answers questions about the benefits of supercritical carbon dioxide in turbomachinery applications.

John Marion

COMPRESSORS
32 LONG-DURATION STORAGE

The success of renewable energy requires both short- and long-term duration storage solutions.

James Berry

SHOW REPORT
36 2022 TURBO EXPO

The first Turbomachinery Expo since 2019 featured a wealth of information from big players in the power generation industry. Hydrogen, decarbonization, supercritical CO_2, and liquified natural gas were emphasized.

Drew Robb

Cover Photo: Two Elliott employees program a Woodward 505 Governor Control which provides electronic speed and trip control for a turbine.

TURBOMACHINERY CONTROLS GO HIGH TECH

Remote Monitoring, Digitalization, Cybersecurity, Artificial Intelligence, Hydrogen Blending, Auto-Tuning, Big Data, and Digital Twins.

BY DREW ROBB

Let's begin with a home-appliance analogy. Modern refrigerators come with a long list of features including sophisticated temperature settings, voice control, alerts when certain supplies are low or the milk goes bad, and more. On the downside, their motherboards sometimes struggle to cope with cold temperature. Hence, you sometimes hear people longing for the old days when an old-school freezer could last for decades. However, those old freezers were also energy hogs and would be unlikely to receive an acceptable Energy Star rating. In any case, their manufacturing costs would probably be difficult to justify today.

Similarly, I've been to trade shows and heard veterans lament the demise of old turbomachinery control systems. They complain that the new versions come with all kinds of digital bells and whistles, yet they sometimes lack reliability and can be difficult (or expensive) to fix. There can be some truth to their assertions. Yet, modern controls can do so much more than legacy systems.

Gone are the black box controls, replaced by open standards. Integration with other systems is far easier. Plant-wide, fleet-wide, and grid-wide controls become feasible as everything is running on the same set of protocols and standards. A maintenance person no longer must walk a mile to take a reading from a dial. That same function can be carried out at remotely via centralized controls.

Meanwhile, the turbomachinery controls vendor community continues to innovate. Companies such as Elliott Group, EthosEnergy, Continental Controls Corp., Siemens Energy, Honeywell, Solar Turbines, Mitsubishi Power, Emerson, and Rockwell Automation, are steadily introducing more technologies and features into their tools. Let's hear what they have to say about the latest trends and products.

Siemens Energy SPPA-T3000 controls.

SIEMENS ENERGY

Philipp Lange, Solution Manager for Controls Modernization at Siemens Energy has noticed several trends impacting the controls space. This

"It is always a challenge to ensure security without compromising the comfort of system handling," said Philipp Lange, Siemens Energy.

includes a greater focus on functional safety in all areas of turbomachinery control, as well as digitalization, which is bring about virtualized applications, data-driven maintenance approaches, and paperless documentation. He also noted the slow emergence of "low-manned" operation of certain assets.

"The pandemic highlighted the usefulness of remote capabilities, but also showed there is room for improvement to realize their full potential," said Lange.

Accordingly, Siemens Energy has added a variety of remote monitoring, digitalization, cybersecurity, safety, and compliance enhancements to its controls. In addition, the company is looking into technologies such as 5G networks and rugged smart mobile devices that could help address the skills shortage due to workforce retirements and limited accessibility.

The Siemens Energy SPPA-T3000, for example, has been upgraded to address cybersecurity challenges such as online patching, user management, improved hardening, and digital signatures. This has enabled these controls to earn IEC and ISO certifications for security. Further advances include the use of object-oriented project databases, augmented reality for guided commissioning and operation, as well as cloud-based infrastructures to provide engineering and testing environments independently from location and available hardware.

SPPA-T3000 will also be enhanced with SCADA functionalities to control multiple distributed remote assets. New simulation capabilities built into SPPA-T3000 aid users in working on digital twins of their own assets to create test scenarios for any adaptions without impacting the real system.

CONTINENTAL CONTROLS

Continental Controls Corp offers a range of fuel control products for gas turbines and gas engines. For example, its pressure control valve handles a variety of gases that are typically delivered at a low pressure with a lower capacity than primary fuel control valves. This valve is also used to control what would have been flare gas by admitting the gas into an enclosed combustor.

Rick Fisher, Vice President at Continental Controls, noted several trends including: the desire to blend various gases to reduce greenhouse gas emissions (GHGs); instead of recording fuel consumption for two or more units, a requirement is evolving to include unit specific flow consumption; and due to regulations about venting of excess gas, users are exploring the options to eliminate gas flaring and minimize fugitive emissions.

"Many customers are looking for valves that can control some percentage of hydrogen," said Rick Fisher, Continental Controls.

"Controls vendors will need to know how to mix and change the mixture as needed to maintain efficient operation and emissions reduction," said Fisher. "Valve manufacturers will need to have secondary control valves to control the proportion of gases in the mix as well as gas mixers to provide a homogeneous mix."

Continental Controls provides variable pressure control valves and venturi mixers to allow for precise blending of fuels. It is currently engaged in qualifying all its gas turbine products for up to 25% hydrogen.

ETHOSENERGY

EthosEnergy EcoMax is a Dry Low Emissions (DLE) and Dry Low NOx (DLN) automated tuning technology that continuously optimizes output, emissions and combustion dynamics. This eliminates the need for manual gas tuning approaches that can led to untapped capacity and efficiency.

Take the case of a 775 MW combined cycle power plant in Turkey where two GE Frame 9FA gas turbines suffered from combustion chamber issues that caused the engine to trip. The facility implemented EcoMax to eliminate the trips

"AI-supported programs open a new and wider window for users," said Hande Puhaloglu, EthosEnergy

during changes in temperature. As well as major financial savings, the plant has gained improvements in reliability, output, better manage its emissions, and reduced the risk of human error through manual tuning, according to Hande Puhaloglu, Sales Account Manager, EthosEnergy.

She, too, noted a definite trend toward hydrogen blends. The company has signed a partnership agreement with Politecnico di Torino for the research and development of technology to allow for the conversion of 40 MW gas turbines to accept up to 40% hydrogen.

"Plant operators are asking for control systems that can collect more qualified data and smarter solutions so that they can be more efficient and flexible while operating the plant.

ROCKWELL AUTOMATION

For turbomachinery control, Rockwell Automation focuses primarily on controls for single-stage compressors and one- and two-valve steam turbines. They include communication and diagnostic capabilities for improved uptime. It has recently been expanding its condition monitoring product portfolio for compressor control systems. The Dynamix 1444 Integrated Condition Monitoring System, for example, operates in conjunction with its Emonitor condition monitoring software and condition monitoring sensors.

"Emonitor condition monitoring software provides automated analytics capabilities for users," said Andries Ernst Kruger, Engineering Team Lead for LifecycleIQ Services at Rockwell Automation.

MITSUBISHI POWER

Tom Logan, Senior Manager, Technology Integration – Intelligent Solutions, Mitsubishi Power Americas, highlighted trends such as operational flexibility, reliability, cybersecurity, and support for hydrogen and ammonia.

"Extreme weather events, like what Texas experienced in February 2021, the grid complications related to intermittent renewable sources, and the grid frequency impacts related to solar are driving the demand for flexibility and reliability solutions," he said.

As a result, users want turnkey solutions that incorporate plant hardware and controls logic, and that provide improved capabilities. For example, Mitsubishi Power has invested heavily into its Tomoni portfolio to provide users with faster startup, higher ramp rates, continued operation during extreme environmental conditions, analytics, and a route to decarbonization.

"There is an increasing focus on integrated and predictive condition monitoring on turbomachinery to better comply with the API 670 standard," said Andries Ernst Kruger, Rockwell Automation.

"NERC CIP regulations and the increased frequency of cyber-attacks on critical infrastructure are driving development of cyber-security controls," said Tom Logan, Mitsubishi Power Americas.

A recent controls scheme project validated fuel blending of hydrogen and natural gas at partial and full load on an M501G natural gas turbine. This was done at Georgia Power's Plant McDonough-Atkinson in conjunction with Electric Power Research Institute (EPRI) with a 20% blend. New instrumentation and control logic protected the turbine during fuel transitions and sudden fuel mix changes to support safe operation. The electrical ratings of all components in hazardous areas had to comply with NFPA Class 1, Div 2, group B criteria.

"Reviews of grounding were critical since the minimum ignition energy of a hydrogen-air mixture is one-fifth that of natural gas," said Logan.

Gas turbine instrumentation was modified to increase the speed of measurement response time utilized to detect abnormal combustion. The application of higher speed devices also required review of prior control setting limits to verify that the higher speed of the new devices would not impact the protective logic associated with prior devices. In addition, over-firing logic had to be applied for the case where the gas turbine is operating on blended natural gas and hydrogen fuel under the condition that the hydrogen fuel supply tripped and natural gas operation continued. The sudden stopping of hydrogen would result in an increase in natural gas flow that would exceed the heat input required for base load operation and would result in over-firing of the gas turbine. New logic helped the system react quickly to the loss of hydrogen and inject a feed forward response to the position of the throttle valves.

Mitsubishi Power's Netmation Protect Pack provides cybersecurity for turbine control systems to the NERC CIP requirements.

On the cybersecurity front, Mitsubishi Power's Netmation Protect Pack provides an NERC CIP compliant operational technology (OT) network with a smaller attack footprint. The physical security of this server-based system is easier to maintain than that of individual human-machine interface (HMI) stations. It provides centrally managed access control, an integrated intrusion detection system, and antivirus and malware protection, as well as failover capabilities, centralized disaster recovery, and automated backup and patching.

ELLIOTT GROUP

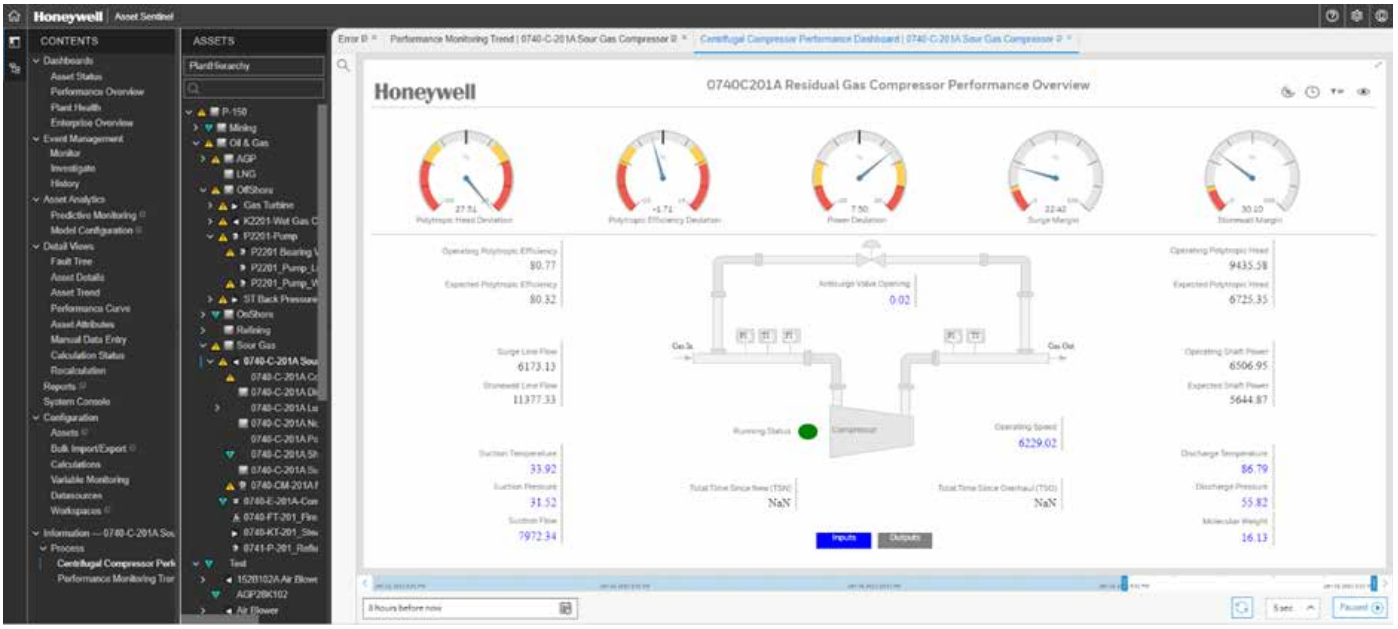
Klaus Brun, Director, Research & Development, Elliott Group, pointed to digital twins as a growing trend along with self-learning neural networks being used to augment turbomachinery controls. This raises the capability of analyzing large amounts of sensor data being collected on modern turbomachinery. Also, advanced diagnostic and rotordynamic monitoring capabilities are emerging within compressor control systems. In addition, Brun is seeing greater usage of remote and fleet monitoring systems for improved, continuous monitoring and analysis of equipment operations on an OEM's fleet. In some cases, operators are integrating these systems with plant SCADA systems for improved operational control and efficiency.

"When combined with historical trending, digital twins can improve predictions for maintenance intervals and potential failure risks," said Klaus Brun, Elliott Group.

"Improved diagnostic capabilities can help to identify potential machinery problems early to schedule required maintenance and to avoid shutdowns due to failures," said Brun. "Digital twins have demonstrated the capability to identify and reduce performance losses due to fouling and equipment degradation."

Elliott Group works with Tri-Sen as its primary controls solution provider to develop machinery control systems that are customized for customer requirements and Elliott designs. They are equipped with mechanical and aerodynamic diagnostic features such as a digital performance twin, rotordynamic analysis, remote monitoring, non-linear surge control, and optimized integrated plant load-sharing. The newest Elliott Tri-Sen Gemini control system also includes machinery health monitoring and predictive forecasting to detect operational problems early on. The digital

Elliott/Tri-Sen Gemini Controls



Honeywell Forge APM Asset Sentinel for asset performance management.

twin that Elliott provides is based on the selection tools for the original compressor design and is automatically remotely updated to reflect the most up-to-date performance prediction for individual compressors. The Gemini control system also includes mechanical diagnostics capabilities such as rotordynamic waterfall, orbit, FFT and bode plots to help identify and address any potential mechanical issue early and quickly. It can be accessed and monitored remotely using any mobile platform. Cybersecurity safeguards are built in.

HONEYWELL PROCESS CONTROLS

Bret Walter, Engineering Consultant for Rotating Equipment and Turbomachinery Controls, Honeywell Process Solutions, has observed a trend of users moving away from the proprietary black box solutions for turbine and compressors controls. Instead, they favor a distributed control systems (DCS) that can handle the fast process response times required for turbine governor, and compressor anti-surge and performance controls.

"As workforces are aging and fewer workers are trained on the proprietary systems, customers struggle to maintain them," he said. "They want turbine and compressor control system that can be maintained easily and efficiently."

Traditional black box vendors, therefore, will have to adapt to meet customer requirements to run turbine governor and compressor anti-surge & performance controls inside the DCS. Honeywell is responding to these trends with Experion controller and IO Hive technology. It delivers a range of features to facilitate modular and parallel project execution and is based on a resilient, high-speed Ethernet field IO network that connects controllers to Honeywell's Universal IO mounted in the production areas. Additionally, the company offers asset management via Honeywell Forge Asset Performance Management (APM) Asset Sentinel. It offers early detection of issues with the turbine and compressor while enhancing machinery monitoring and protection systems. Further, the Honeywell Experion PKS Turbomachinery Control Solution integrates with Honeywell's Safety Manager Safety Controller SC300 to provide an API-670 / IEC-61508-compliant system for safety interlocks of the turbine and compressor. ■

"As workforces are aging and fewer workers are trained on proprietary systems, customers struggle to maintain them," said Bret Walter, Honeywell Process Solutions.

MKT.5252.0922