GAS COMPRESSION magazine

JULY 2021

DRONE-BASED LEAK DETECTION

ORGANIC RANKINE CYCLE TO BOOST THE GAS TRANSPORTATION PROCESS

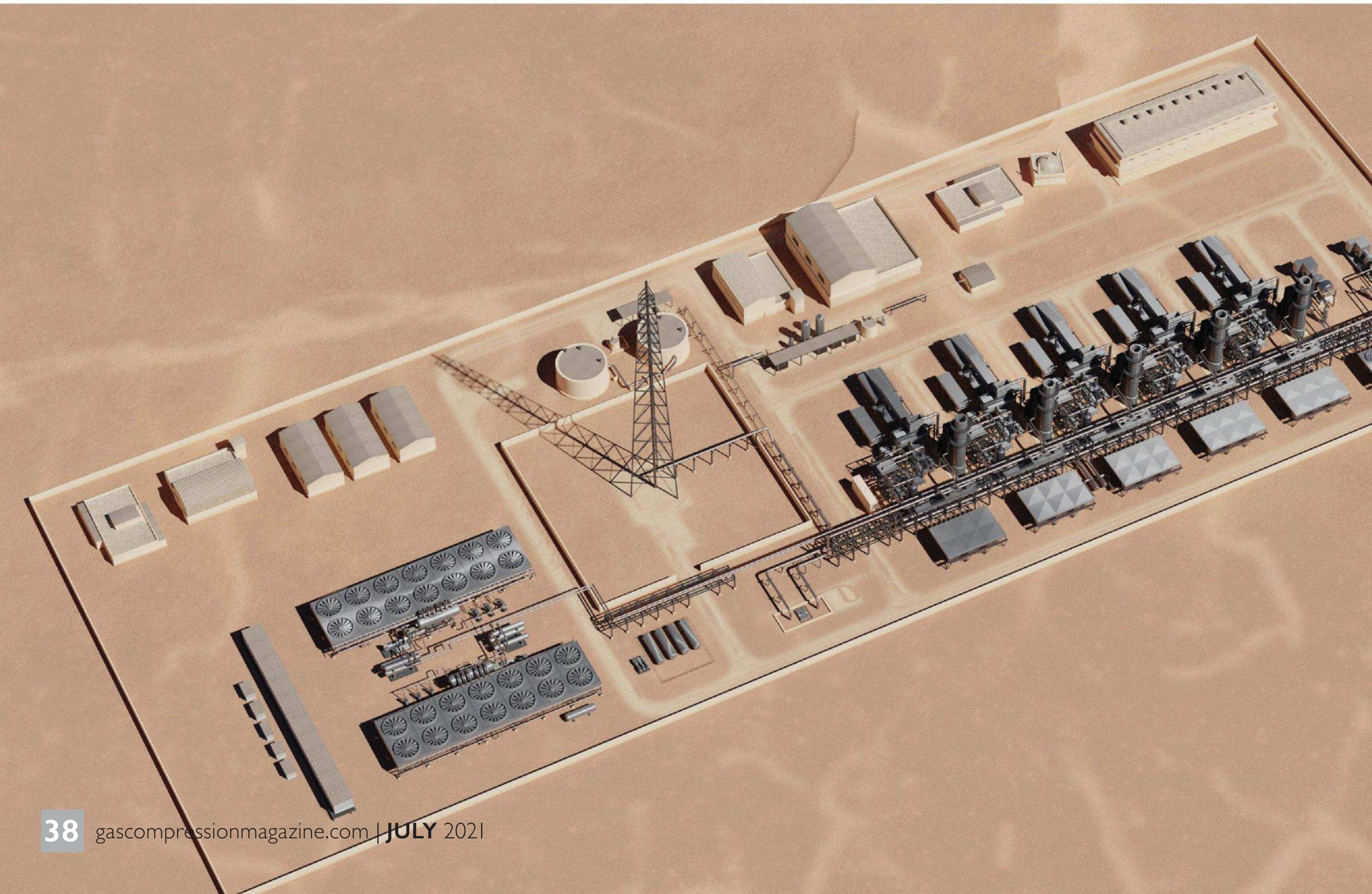
A 28-MWE ORGANIC RANKINE CYCLE SYSTEM COUPLED TO ELECTRIC MOTOR-DRIVEN COMPRESSOR TRAINS WORKING IN ISLAND MODE WILL INCREASE CAPACITY AT EGYPT'S DAHSHOUR COMPRESSOR STATION WITHOUT ADDITIONAL FUEL CONSUMPTION

BY NICOLA ROSSETTI, DAVIDE RIZZI, AND DAVID DANESI

Industrial sectors are looking for sustainable solutions to reduce their carbon footprint while maintaining high competitiveness. Implementation of organic Rankine cycle (ORC) technology, which turns waste heat into useful power, represents a clever way to reach both targets, helping hard-to-abate industries undertake the path toward decarbonization.

Thanks to its efficiency and flexibility, ORC technology has been used widely to generate clean energy and enhance the sustainability in industries such as biomass, geothermal, waste heat recovery, solar power, and waste-to-energy. Now, ORC technology is ready to boost the energy transition within the oil and gas industry.

Artist Rendering Of The ORC System In The Dahshour Compressor Station



Considering the upstream, midstream, and downstream segments of oil and gas, it is possible to identify many different processes where a source of waste heat is available and where heat recovery ORC systems can be implemented. For example, sources include the exploitation of the flare gas in upstream facilities, the compression trains of midstream facilities, and the waste heat available within downstream processes.

With a focus on efficiency solutions for the midstream sector, this article discusses the application of ORC in a gas compressor station, presenting a first-of-its-kind project developed by Turboden. The project implements ORC technology to increase a compressor station's pumping capacity without any additional gas consumption.

Egyptian Natural Gas Holding Company (GASCO) owns and operates the Dahshour Compressor Station, located south of Cairo. The compressor station is used to move natural gas that has been extracted from the Mediterranean Sea on Egypt's north coast to southern Egypt.

To meet increasing gas demands in the south, GASCO needed to extend the Dahshour station's capacity by 652 MMscf/d (18.46 x 10^6 m^3/d), approximately 70% of the existing plant capacity.

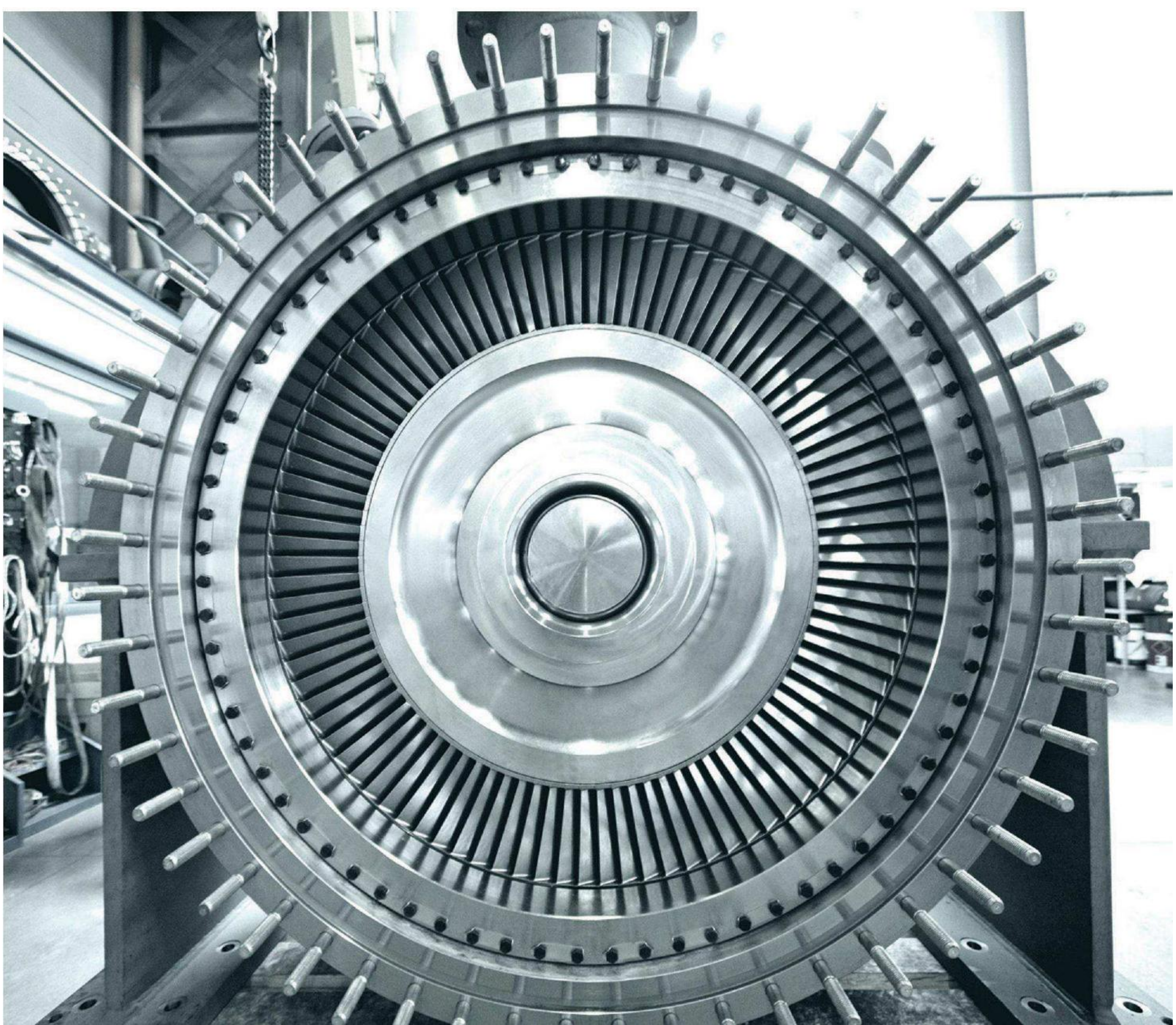
THE SOLUTION

The traditional approach to meet GASCO's need would have been the installation of new gas turbine trains operating in open cycle used as prime movers for the mechanical compressor to move the gas along the pipeline. Despite being reliable and field-proven, this scheme wastes a significant amount of energy (as well as releasing a large amount of carbon dioxide [CO_2] into the atmosphere) and burns gas that otherwise could be sold to the market. To meet GASCO's need, Turboden developed a first-of-its-kind solution made of an ORC coupled with an electric motor-driven compressor that will increase the facility's pumping capacity by converting the waste heat into electric power without any gas consumption. The upgrade will be accomplished by installing a new gas turbine and a heat recovery system rather than installing two new gas turbines.

The Dahshour Compression Station Project will see the expansion of the four gas turbine-driven compression trains to include an additional new gas turbine-driven compression train and two electric motor-driven compression trains. The project also will improve the energy efficiency of the station with the addition of two Turboden ORCs that use waste heat from the gas turbines' exhaust gases to generate the electricity to power the two

Continued on page 40

Turboden's ORC Turbine



Dahshour Compressor Station Operated By GASCO

new motor-driven compressor trains. The power produced by the ORC systems will also power the remaining electrical loads of the compressor station, making it electrically self-sufficient.

Currently, the Dahshour Compressor Station utilizes four GE gas turbines. As part of the project, a 50-MW Siemens gas turbine compressor train will be added, and one of the existing GE trains will be used as a spare. The ORC system will be powered by the waste heat from the four simple-cycle gas turbines. The ORC system will produce 28-MWe gross (two ORC units of 16 MVA) to feed two electrical motor-driven compressors that will power compressor station pumping capacity, replacing the power generated by one existing gas turbine. In other words, ORC will replace one compression train entirely, achieving a fuel- and emission-free compressor train.

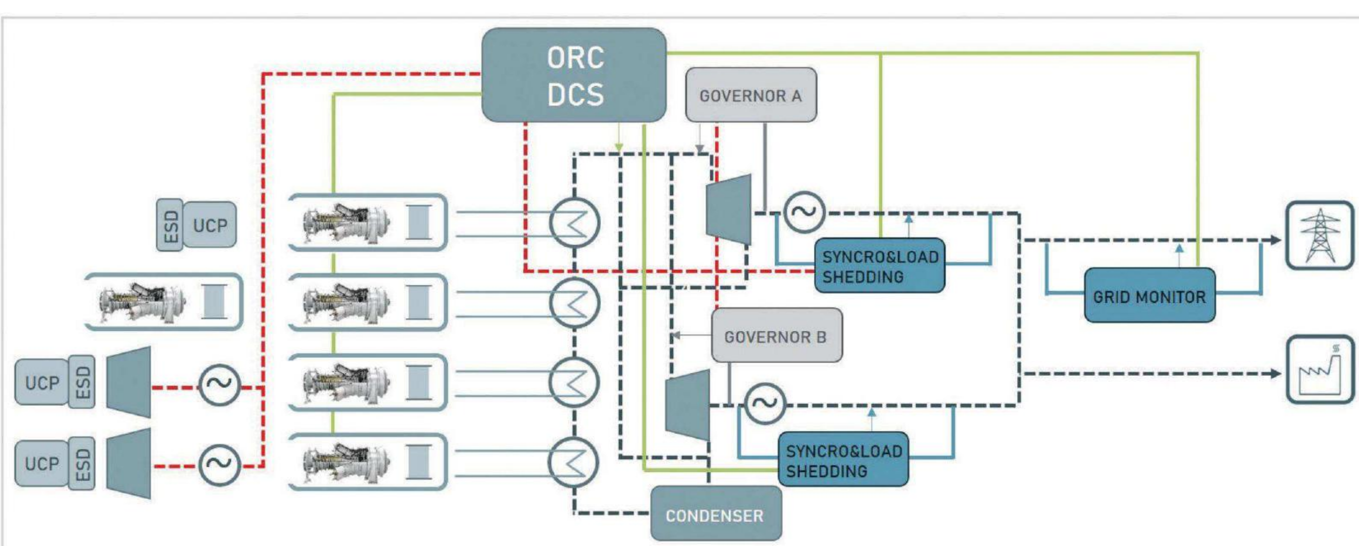
The installed gas compression capacity will be expanded from 979 MMscf/d (27.7 x 10^6 m^3/d) (four 326.3 MMscf/d [9.2 x 10^6 m^3/d] compressors in N+1 arrangement) to 1632 MMscf/d (46.2 x 10^6 m^3/d) by adding 653 MMscf/d (18.49 x 10^6 m^3/d) capacity (one 326.3 MMscf/d gas turbine and two 163.15 MMscf/d [4.6 x 10^6 m^3/d] motor-driven compressors), with one gas turbine-driven compressor as a standby unit. The increased capacity goal set forth by GASCO is achieved thanks to the waste heat recovery system through the ORC technology.

Waste heat recovery units install a heat exchanger to the exhaust gas systems of existing and new gas turbines. The heat from the hot flue gas streams (exhaust gas temperatures of up to 1040°F [560°C] are present in the gas turbine exhaust) can be recovered into a hot oil loop that is used to transfer this heat into the ORC. In the ORCs, the heat captured in the hot oil loop is transferred to a secondary loop, where cyclopentane is heated and vaporized at high pressure. This cyclopentane is expanded in the Turboden expansion turbine where mechanical energy is converted into electrical power by an electric generator. The fluid in the turbine is then condensed in an air-cooled condenser from where the condensed cyclopentane is pumped to the vaporization steps, prior to being fed to the expansion turbine again. The hot oil, cooled down while heating up and vaporizing the cyclopentane in the process, is pumped back to the waste heat recovery units' heat exchanger. Both the hot oil and cyclopentane operate in a closed loop to recover and transfer the heat from the gas turbines' flue gases to the ORC systems, converting it into electrical energy, which, in turn, is used to power the motor-driven compressors and other electrical consumers in the gas compressor station.

ISLAND MODE OPERATION

The ORC will work in island mode, continuously feeding the compressor station's internal electrical loads (motors; new compressors; existing equipment; heating, ventilation, and air conditioning [HVAC]; lighting; etc.) without importing electricity from the national grid.

This mode of operation requires a very flexible and reactive power plant, able to keep the electrical parameter (frequency and voltage) within very strict limits. To achieve this goal, the electricity generated and the electricity consumed within this local small grid must be regulated with a dedicated control automation system or power management system (PMS). The PMS will prioritize the power needed for all available operating gas turbine-driven compressors and continue operation of electric motor-driven compressors based on the remaining power generated from available operating ORC units.



ORC Automation General Scheme

Artist Rendering Of The ORC Units At The Dahshour Compressor Station

The system is designed to guarantee the operation of the power station covering all the operating scenarios (transient and normal operation), taking into account that the connection with the national grid is not possible.

The ORC control system/PMS will provide the electricity frequency signal (50 Hz ± 2%) as a set point to the compressor's suction flow controller, which will set the electric motors' speed controller, achieving a flow corresponding to the maximum available power level, aiming at keeping the frequency at 50 Hz, plus acceptable frequency tolerance, continuously. New motor-driven compressors are configured in a master/follower arrangement floating over the same suction/discharge conditions of other parallel turbo compressor units.

The gas pumping capacity of the electric motor-driven compressors, therefore, will be decided by the electrical frequency controller. The overall automation system will balance the remaining pumping capacity, and, if necessary, adjust the operating gas turbine loads or switch on/off the available gas turbines.

The ORC systems, with an overall gross power of 28 MW (14 MW each), will be used to power two electric motor-driven compressors rated 10 MW each. The remaining power will be used to sustain the facility grid in island mode. Assuming the yearly operation of the Dahshour Compressor Station, the system will generate 192 GWh/year of fuel-free electricity, fully used to enhance the efficiency of the facility, avoiding CO_2 emissions. This ORC solution allows the client to save 65 million Sm^3 (standard cubic meter [Sm^3] = cubic meters at a temperature of 15°C and a pressure of 101.325 kPa) natural gas per year. Gas that, rather than being burned, is now transported and then sold to the market, converting waste power into revenues while increasing the pumping capacity.

ABOUT THE AUTHORS

Nicola Rossetti is the sales and business development manager of Oil and Gas and Combined Cycle at Turboden.

Davide Rizzi is a sales engineer of Oil and Gas and Combined Cycle at Turboden.

David Danesi is a technical proposal leader of Oil and Gas and Combined Cycle at Turboden.