SINT Technology Field-Testing Compressor Performance

> Design for minimal impact on industrial production

BY ANDREA NICOLETTI

Figure 1. SINT Technology Laboratory. Detail of the flow test rig. Calibrated orifice for flow measurement.

Thermodynamic performance testing

When a project involving the construction of a new plant or the installation of a new machine reaches the final stage before entering commercial service, it is necessary to verify that performance complies with the contractual and guaranteed parameters. In this context, SINT Technology believes it is important to design the performance test for minimum impact on the industrial production of the plant, both in terms of financial resources and machine downtime.

For these reasons, performance testing is not limited to a set of measurements and calculations. It requires skilled and trained engineers to manage all the aspects involved in the machine or plant operation, from the thermodynamics to the legal/contractual requirements of the test. Working in partnership with the major original equipment manufacturers (OEM) and engineering, procurement and construction (EPC) contractors, SINT Technology has acquired an extensive knowledge of reciprocating compressors, centrifugal compressors, gas and steam turbines, electric motors and generators.

Why is it necessary to field test compressor performance?

The proper setup for optimal in-field operation of a centrifugal compressor is a complex issue. When a new unit starts commercial life, the owner of the plant wants the machine to run at its rated polytropic head and capacity, and assurance of performance with the guaranteed absorbed power and efficiency stated in the purchase contract. Higher-than-expected power consumption resulting from poor efficiency can lead to a substantial reduction in the economic profit of the plant at the end of the year.

Moreover, at the end of commissioning, manufacturers usually implement a surge line into the control system of the machine that is determined with design calculation or during in-factory string tests. This line is used as a reference by the control system to protect the compressor from surge phenomena at very low capacities by controlling the opening of the anti-surge valves. Too often, this curve is conservative and does not represent the real surge line of the compressor, limiting its operating map at low capacities more than would actually be required.

All these reasons make it worth testing the compressor in the field, to assess the real absorbed power on the guaranteed point and to explore the compressor-operating map until the real surge line is found. Testing results can provide valuable insight into the true potential of the machine in terms of performance and flexibility in operation.

Through operating in oil and gas fields of North Africa and the Middle East, SINT Technology has gained

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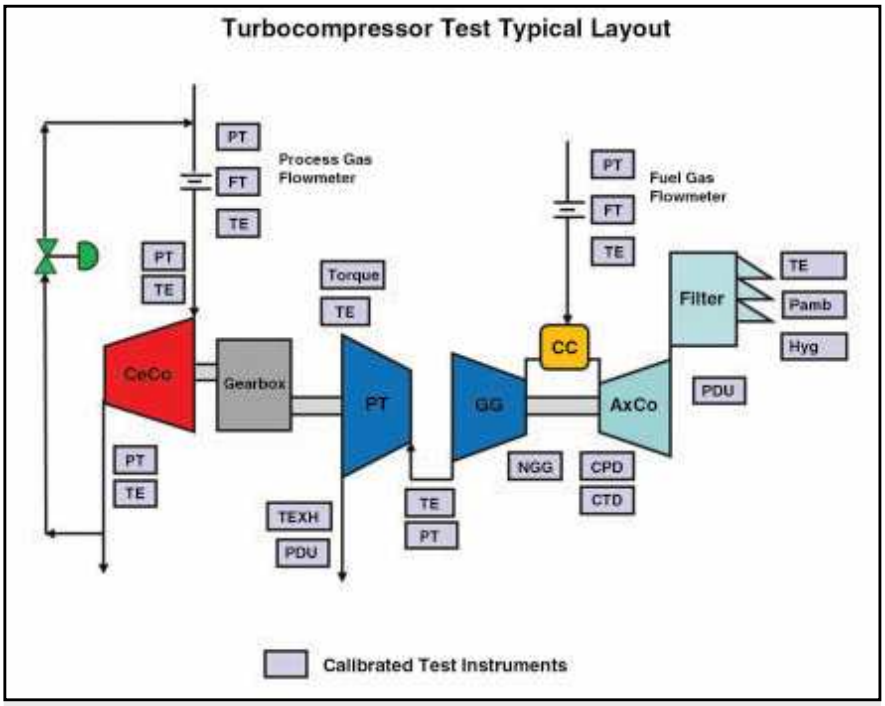

Figure 2. Schematic example for site test layout. Single-phase turbo compressor unit.

wide experience in designing and conducting tests on centrifugal compressors for guaranteed point and surge line verification.

Compressor field-testing starts in the office

The test procedure is the baseline document regulating all test activities on-site and describing the further data reduction to results calculations. Test engineers working at SINT Technology can assist manufacturers or EPC contractors in the accurate analysis of contract requirements, which is necessary to identify compressor figures and to prepare a consistent test procedure. The contract shall also define which test code has to be followed for performance of testing (for example, ASME PTC 10 or ISO 5389).

Generally, plants are not designed for testing; therefore, it is crucial to verify that both plant layout and process allow the compressor to be tested. SINT engineers have the experience required to find and suggest a solution for any conflict that may arise between what is required by the contract and what is feasible on site.

Figure 3. Temporary instrumentation installed on a centrifugal compressor suction line.

Test instrumentation

The test procedure highlights the mandatory requirements for the instrumentation to be used during testing. Using the proper instrumentation leads to achieving accurate results, ensuring good quality testing.

SINT engineers bring to the site their own high-accuracy, temporary instruments, calibrated by accredited laboratories under the ILAC Mutual Recognition Arrangement. SINT Technology also provides and installs the data-acquisition system for real-time calculations during testing.

How is a compressor test conducted?

Once the data-acquisition system is properly installed, SINT test engineers will manage all the plant personnel involved in the test and will verify that the requirements for the thermodynamic stability of the compressor are met.

To verify the compressor design point, the centrifugal compressor is operated at the design speed in several different operating conditions and recorded for analysis to explore its own envelope. The plant process is properly set to establish the suitable suction and discharge pressures across the compressor, and the compressor curve is plotted. In these conditions, the relevant thermodynamic parameters are carefully measured and the power required for gas compression is calculated. If the process cannot fulfill the design condition, recorded data are then reduced to design conditions by applying similarity laws.

When the surge line has to be drawn, the operating map of the compressor at different speeds is explored by reducing the inlet capacity until low-frequency pulsations occur (causing surge), to take into account the different behaviors of the machine at different pressure ratios.

Results calculations

According to the test procedure,

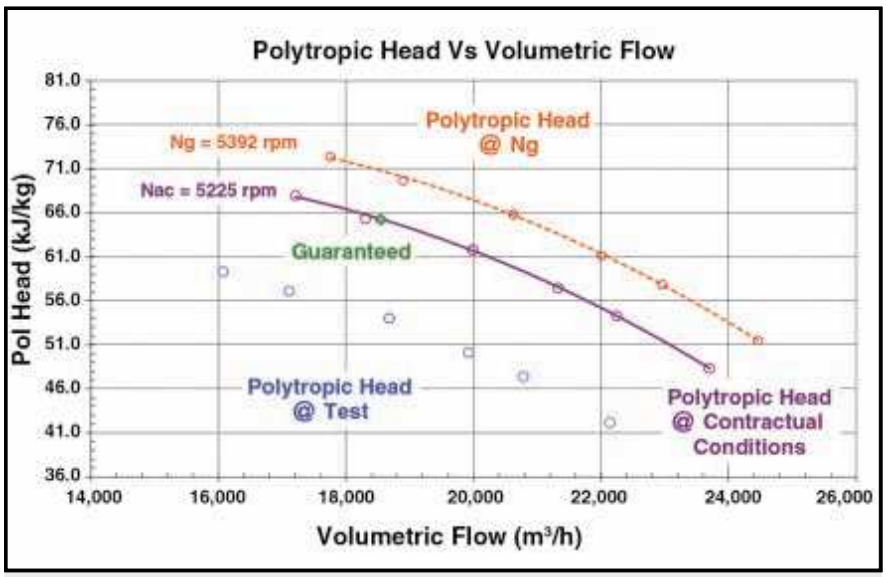

Figure 4. Centrifugal compressor performance testing. The plot represents the tested point curve (test), the calculated curve at the design speed (Ng) and the calculated curve passing through the guaranteed points (contractual conditions).

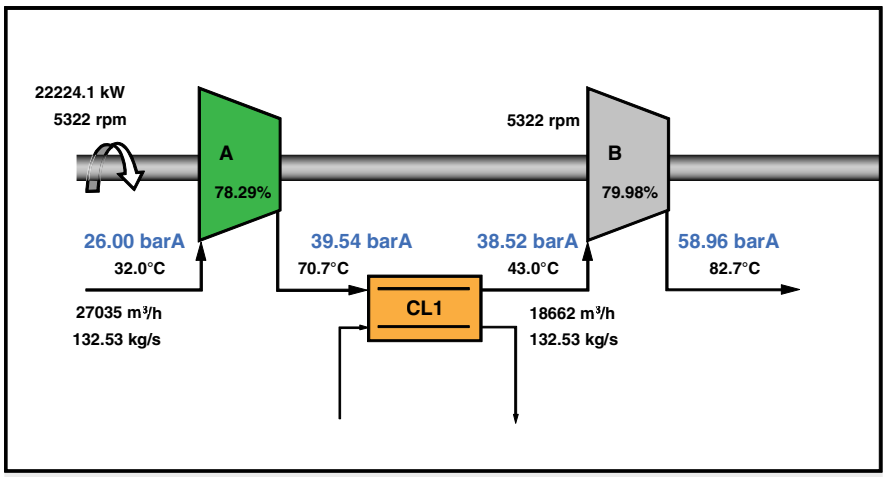

Figure 5. Two-phase compression train performance, simulated at reference conditions.

data are gathered and analyzed by SINT engineers for performance evaluation. SINT calculation tools can simulate the actual compression of the gas by implementing the most suitable real gas state equations, according to the current application. When nonsingle phase compression has to be studied, a simulation is required for taking into account the tested curves of each phase. Figure 5 is an example of a two-phase compressor performance, simulated at reference conditions.

SINT Technology

Since 1990, SINT Technology has delivered a wide portfolio of services for testing rotating machinery, compression stations and power plants to the oil and gas and power generation industries. The company's global solutions include operations at its headquarters in Florence, Italy, where it has its own laboratories, and in the field, to assure service based on flexibility, speed and accuracy.

The company holds ISO 9001 and OHSAS 18001 certifications. SINT Technology's test laboratory is accredited with ISO/IEC 17025. This accreditation recognizes the technical competence to conduct thermodynamic tests in accordance with ASME PTC codes, vibration tests, modal analysis tests, acoustic tests, etc. CT2