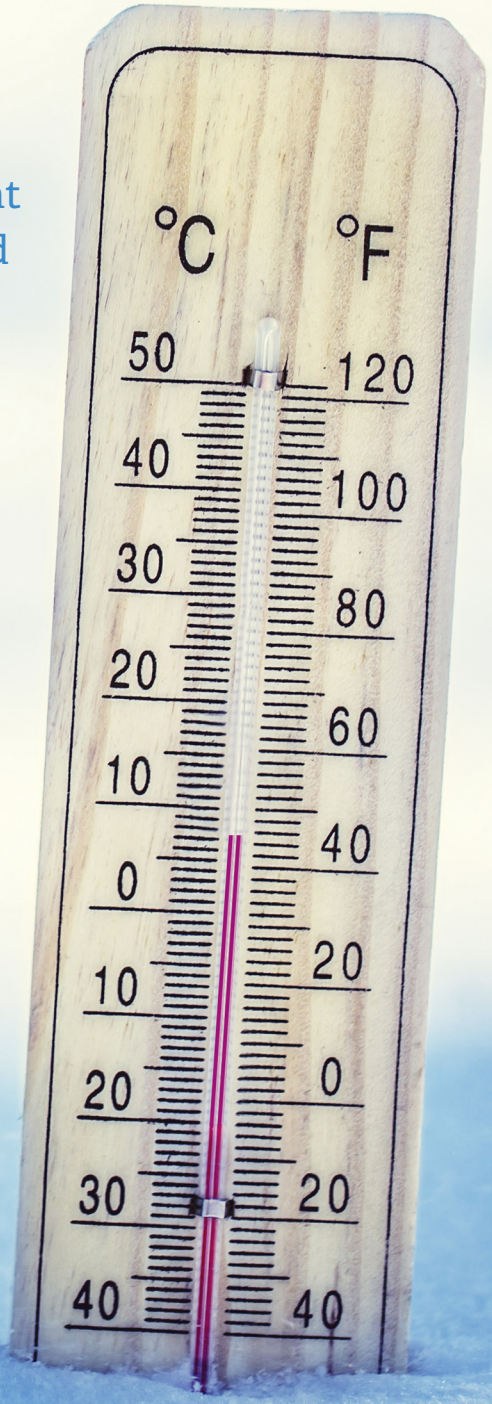
Cool it down

Curtis Lovelace and Craig Kedrowski, Stellar Energy, USA, explain how LNG plant performance and stability can be improved with the use of turbine inlet air chilling.

Ambient conditions have a significant impact on the performance of gas turbines used to drive refrigeration compressors for gas liquefaction. This is primarily due to the fact that as temperature rises, air becomes less dense and mass flowrate through the turbine decreases. LNG plants located in climates where ambient temperatures exceed the turbine's inlet air design point can experience degraded performance and unpredictable power output. In severe cases, it can even turn the gas turbine into a production bottleneck.



One way for operators to eliminate this issue and stabilise LNG production is with turbine inlet air chilling (TIAC).

An overview of TIAC

TIAC is a proven technology that cools inlet air before it enters the compressor side of the turbine. This can take place either through adiabatic cooling methods, such as fogging or wet compression, or through mechanical chilling. Both technologies have been used extensively in the power industry over the past two decades and are widely recognised by gas turbine original equipment manufacturers and power plant operators as a reliable tool for maximising efficiency and maintaining constant output.

Figure 1. Aerial view of construction progress; the three chiller plants are located on the left side of the photo.

Figure 2. Modular assembly allows for factory-tested wiring and piping that is fully connected at the job site.

For LNG plants, TIAC systems using mechanical chilling can be a cost-effective method of optimising liquefaction and stabilising production. When chosen early in the project design phase, the use of TIAC can also aid in the selection of compressors for liquefaction. Often, compressors are required to operate across a broad range of power inputs because, as ambient conditions change, so does gas turbine output. By using TIAC to maintain a constant inlet air temperature, gas turbine performance becomes much more predictable, thus allowing for the refrigeration compressors to operate efficiently in the narrow power band.

Currently, there are a number of LNG facilities throughout the world that employ some form of TIAC. The remainder of this article will introduce an alternative TIAC system that offers a number of operational advantages. This system is currently being installed at Cheniere Energy's liquefaction facility near Corpus Christi, Texas, US.

Use of TIAC at liquefaction facility

Owned and operated by Corpus Christi Liquefaction, a subsidiary of Cheniere Energy, the liquefaction facility is designed for three trains (two of which have been contracted) with expected aggregate nominal production capacity of up to 13.5 million tpy of LNG.

In June 2015, Stellar Energy was awarded a contract by Bechtel Oil, Gas, and Chemicals, Inc. to supply a TIAC system for the Corpus Christi facility. Stellar Energy assessed the design inputs of ambient design condition, turbine inlet temperature, and site footprint, and designed a modular air-cooled TIAC system that uses centrifugal compressors and a non-flammable hydrofluoro-olefin refrigerant to provide a constant 45°F inlet temperature to the turbines.

The three-train TIAC system at the facility features a common header, and is capable of producing a total of 36 900 t of refrigeration. The common chilled glycol piping system and redundancy on the chillers provide excellent plant reliability.

System advantages

The solution proposed by Stellar Energy implements design principles that are common to power plant applications. When used in regions like the Gulf Coast with warm, humid conditions, the system offers a number of advantages over inlet air chilling systems using propane refrigeration. Some of these are outlined below.

Reduced project risk

Early in the project design phase, Stellar Energy proposed modular, off-site fabrication of the TIAC system instead of a field-erected system. This afforded a number of

Figure 3. The module is assembled on a skid and enclosed with insulated metal panels.

Figure 4. Rendering of the Corpus Christi liquefaction facility.

benefits, including reliable access to skilled manpower, improved fabrication quality, a controlled manufacturing environment, and reduced site safety risk. Using modular methods ultimately allowed Stellar Energy to reduce construction time of the TIAC equipment packages from 16 weeks to 8 weeks.

Increased reliability

Although screw compressors are generally capable of producing higher compression ratios than centrifugal compressors, they often have drawbacks with regards to reliability. This is largely due to the fact that they use high-speed, twin-rotor positive displacement compressors, which place stress on the rotors and bearings and create the need for high-lubricating oil circulation rates. This oil can carry over into the refrigerant stream, causing the need for protective measures to prevent the fouling of heat transfer surfaces. In contrast, centrifugal compressors are variable volume machines that have fewer moving parts and are simpler to operate than screw compressors. In addition, the reduced flow and function of the refrigerant oil in a centrifugal compressor essentially eliminates the risk of oil migration.

Improved safety

In a conventional propane refrigeration cycle, gaseous propane is sent to an air-cooled condenser where it liquefies and drops back into a receiver. In the Corpus Christi Liquefaction TIAC design, a secondary heat transfer fluid (low-concentration glycol solution) is sent through condensers to a radiator field via vertical inline pumps. This eliminates the need to directly condense the primary refrigerant, thus confining it to a much smaller area and reducing refrigerant system charge. Additionally, the hydrofluoro-olefin refrigerant used has an ASHRAE A1 classification, which signifies that it has the lowest rating for flammability and toxicity. The decision to use a non-flammable refrigerant eliminates the cost and hazard of the equipment running in a classified electrical location.

Ease of maintenance

Due to fewer moving parts and simpler operation, the maintenance requirements for the TIAC system at Corpus Christi Liquefaction are substantially less than would have been required for a propane system. Increased accessibility was made possible by the design of the modules, which feature large open walkways for equipment with overhead pull panels and oversized garage doors. The design team strategically located all the valves and instrumentation to allow personnel the ability to easily pull, clean, and maintain equipment.

Lower construction cost

Modular construction in Stellar Energy's fabrication facility in Jacksonville, Florida, US, eliminated weather delays and shortened delivery time compared to a field-erected system. Direct-employed fabricators eliminated the need to rely on the project site's tight labour market. Furthermore, material costs were reduced by the use of standard and readily-available components that are common to the TIAC industry.

Conclusion

TIAC technology is widely recognised throughout the power industry as a proven solution for improving gas turbine performance and ensuring stable power output. These benefits also translate to the LNG industry, where predictability and reliability affect the bottom line. Expert analysis of project-specific variables is key to ensure a custom solution for optimal performance. The TIAC system in Corpus Christi Liquefaction is currently in the installation phase. First gas at the facility is expected in 2018. LNG