

FAST AND EFFICIENT

**Sam Gooldy, Nick Botkins
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outline the benefits of
using integrally geared
centrifugal compressors
in small scale LNG
applications.

Ensuring the continued and steady availability of natural gas fuel required by gas-fired power generation stations and transportation infrastructure creates significant challenges on a global basis. One of the key technical decisions that engineers will need to make early in the project is the selection of the core compressor technology used in the process.

Process gas compression technology

Integrally geared centrifugal (IGC) compression technology was originally developed in the late 1940s and has a history of being instrumental to gas processing applications. Since its debut over 65 years ago, IGC compression technology has evolved to handle higher pressures and flows in a compact

and highly efficient package. Through this progression, and the associated recognition from the American Petroleum Institute (API), IGC compressors now see significant market penetration and have become a dependable solution that many industries look to for their compression needs.¹

Case study

On a recent project intended for installation in Nigeria, compressor manufacturers were approached in 2H14 regarding their ability to supply multiple compressors for LNG trains on an expedited basis. A 0.50 million tpy LNG plant was at stake, which would need, among several other major purchased components, a mixed refrigerant (MR) gas compressor. The specifications of the project would require four compressors to manage the total flow of gas, and they would all need to be delivered in a critical six to eight month window. Based on reliable and proven designs with similar applications, it was expected that more than one supplier would be able to develop the right solution within the time constraints, as well as begin contract-specific engineering work less than a month after the original inquiry. As with many fast-tracked projects, an original equipment manufacturer's (OEM) ability to quickly assemble a team, formulate a solution, and provide the necessary information are vital to meeting the customer's goals.

Efficient and reliable

The client was determined to meet the project schedule, but also knew that it needed to meet the given efficiency and reliability requirements. IGC compressors were selected due to their proven ability to meet all of these requirements. Equipment durability parameters, such as reliability, availability, and mean time between failures (MTBF), were compared and evaluated during the equipment selection. Table 1 illustrates the relative differences in such categories.²

Finding an LNG compression solution

Fortunately, the compressors required by this application aligned well with a recently completed project for another end-user. As is typical in the process gas compression business, no two applications are ever the same, and thus the main compressor design would need to be tweaked. Details ranging from high level API requirements, to finer specifics, such as superheat, rise to surge, and turndown

range, were worked through at great pace and with a high level of detail in an effort to create a clear path forward.

The essential front-end engineering for the compressor design needed to be worked on in an expedited basis due to the schedule constraints. In the weeks leading up to the contract award, direct dialogue between the aerodynamic design engineers and the client's process engineers was often required to quickly work through specific questions and to iterate the best design solution. Requested changes in the preliminary process conditions needed to be analysed and the individual engineers responsible for the impeller (aero) design, rotordynamic stability, and mechanical integrity all verified the design selection, which was then reviewed with and approved by the client. Project management resources responsible for the execution of the compressors were also mobilised early in the process to assist in the necessary meetings, as well as with customer documentation requirements. The compressor contract was ultimately signed by the involved parties by the end of September 2014, with a forecasted ship date for all four compressors in the late spring of 2015.

Scope of design

IGC compressors are well suited and adaptable to the varying process conditions for gas compression applications. The compressor utilises a large helical-cut bullgear driven at low speeds to drive multiple pinion gears with overhung impellers. The integral gear design allows for the rotational velocity of each pinion gear to be designed based on the optimal aerodynamic characteristics of the impeller. The intrinsic design arrangement of IGC compressors naturally separates the lubricating oil in the gear casing from the process, ensuring oil-free process gas without the need for additional separation systems. Some OEMs employ enhanced measures, such as an atmospheric air gap between the gear casing and compression volutes and/or maintaining the gearbox at vacuum pressure to keep lubricating oil from seeping out of the casing, to further ensure the delivery of oil-free gas.³

Based on the requirements of the LNG train, the MR IGC compressor was rated for a maximum power of 9300 hp, sized accordingly for a variety of design points, such as maximum flow, maximum ambient temperature,

minimum ambient temperature, and gas recycling. In this case, and as with most designs, it was imperative to fully understand and analyse each of the required operating conditions; specifically, changes to the inlet suction temperature, coolant temperature, molecular weight, and required gas

Compressor type	Availability (%)		Reliability (%)		Proactive maintenance downtime (hr/yr per five years)		MTBF (yr)	
	Best	Average	Best	Average	Best	Average	Best	Average
Reciprocating (lubricated)	99.5	97.3	99.8	97.8	120	240	1.5	0.5
Screw (oil-flooded)	99.2	97.7	99.8	98.8	250	300	3	1.5
Screw (oil-free)	99.6	99	99.9	99.7	150	300	10	5
Centrifugal (clean service)	99.9	99.7	100	99.8	12	30	15	8

flow. All of these conditions were known to change from season to season, and on a more granular level from day to day.

Along with the aforementioned basic scope, the contract required integrated API 617/614 features, including an on-skid lubrication system, which fed the compressor and main drive motor, tandem dry-face seals, the seal support system, and a custom integrated control system.

The integrated seal support system was fully engineered and fabricated in-house by the compressor OEM. This integration of the seal support system included complete tubing to and from the dry-face seals prior to shipment. By having the OEM both design and supply the seal support system, potential field fit-up issues were eliminated along with the potential for site work delays associated with the seal system. Figure 1 depicts an integrated skid design for a typical MR IGC compressor. Based on the client's requirements for minimising the assembly work in the field, the compressor core unit, lubrication arrangement, seal support system, instrumentation rack, and customer-supplied controller were all integrated on a common base, and were able to ship in place for ease of transportation and installation. It was estimated at the time of shipment that the total commissioning time for the skids would be reduced by 30 – 40% compared to an arrangement fully erected at site.

LNG applications

It is important to note that IGC compressors have been increasingly selected by LNG engineering, procurement and construction (EPC) contractors and end-users for their flexibility in design, reliability, efficiency, and expedited delivery. Since the completion of this project, IGC compressors have continued to gain on alternative technology in this growth space. Subsequently, portfolios continue to expand with players specifically developing products that can handle more flow, increased power, and higher pressure, and that fit into new applications and can be easily mobilised. Within the liquefaction process, there are a variety of compressor applications in which IGC compressors are a good fit (Figure 2).

A bright future

The authors expect application-specific compressor offerings to continue to mature and evolve, in line with the small scale LNG market. Some of the expected developments include additional standardisation in OEM product offerings for various applications, modular designs for ease of transportation and installation, and partnerships with EPCs to align OEM products with standardised plant offerings.

The number of successful plants utilising IGC compressors for MR applications continues to increase at an accelerating pace due to the reliability and wide market acceptance that the technology offers. This successful project is yet another example of how IGC compressor OEMs are leading the industry towards a faster, more efficient and ultimately more profitable way to engineer, design and operate small scale LNG plants. **LNG**

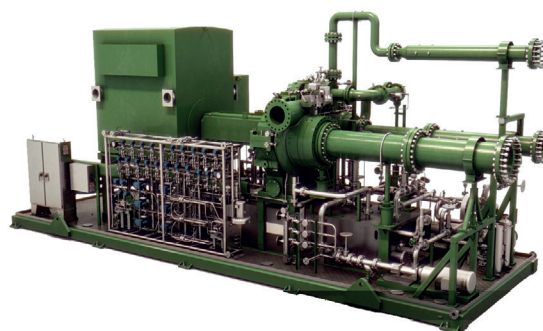


Figure 1. A three-stage MSG®-8 integrally geared centrifugal (IGC) compressor serves the main cryogenic heat exchanger refrigeration loop in a liquefaction process.

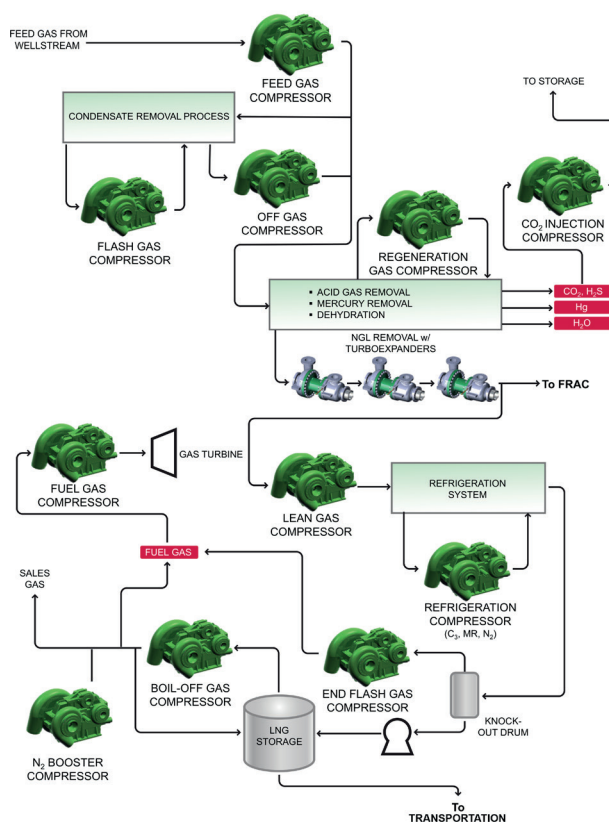


Figure 2. A simplified diagram of the liquefaction process, demonstrating potential applications for IGC compressors.

References

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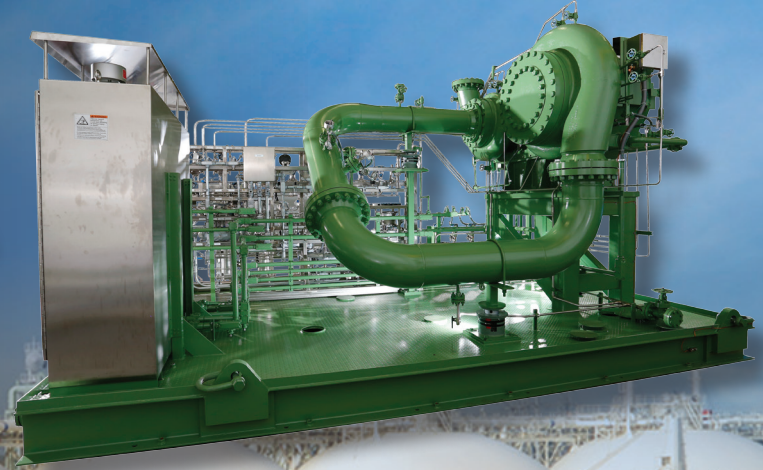
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