RETHINKING COMPRESSOR SELECTION

Yavuz Ertune and Megan Schaenzer, Siemens Energy, make the case for using integrally geared compressors in high-flow applications.

Historically, horizontally split compressors have been the most widely used technology for compression in chemical and steel plants where high-volume flows are required. This has particularly been the case for large air separation units (ASUs) i.e., blast furnace blowers, and regeneration air applications in propane dehydrogenation (PDH) facilities. However, end users often cite many pain points with axial compressors, including a large footprint, long lead time, high costs, and frequent service – the latter of which increases plant downtime.

Although integrally geared compressors (IGCs) can solve many of these issues, they have traditionally not been viewed as a viable option for high-flow applications. However, in recent years this has changed, as advancements in the design of these machines have enabled them to reliably achieve rates of up to 1 million m^3/hr in a single stage. IGCs are also smaller and require less maintenance than axial compressors, and lead times are shorter. When evaluating the entire compression train, significant cost savings can be achieved.

This article looks at some of the specific design enhancements that have made IGCs a suitable alternative to axial machines, and makes a case for why they should be considered in high-flow applications.

Axial compressor pain points

Across the oil and gas industry, the adoption of new technology is often viewed as a risk to production. This is particularly the case in the downstream sector, where downtime can result in millions of dollars in losses per day. Operators of these facilities have traditionally been reluctant to implement new rotating equipment configuration, instead electing to replicate 'tried-and-true' designs that they are familiar with.

In PDH, blast furnace blower, and fluid catalytic cracking (FCC) applications, axial compressors have been the solution of choice when it comes to process air compression. Up until recently, these machines were widely recognised as the best available technology (BAT) for such purposes. They offer high efficiency and, with thousands of project references, provide relatively predictable performance. However, the units come with several trade-offs.

For example, axial compressors utilise complex designs – often with four to six stages for PDH applications and up to 17 stages for blast furnace application. A single unit can contain up to 400 blades, each of which is critical to compressor operation. The higher number of intricate parts increases the likelihood of component failure and results in the requirement for more frequent service. Owing to their design complexity, they are also often associated with long lead times.

Additionally, the up-front cost of an axial compressor is comparatively higher than other types of technologies. Other drawbacks include high oil consumption, a large footprint, and expensive maintenance. The last of these is attributable to several factors, including the need to remove inlet cones for bearing and/or seal exchange, and the requirement for heavy lifting equipment when servicing the rotor.

These pain points have generally been accepted by end users as unavoidable because there were no other suitable compressor technologies available for high-flow applications.

However, this is no longer the case. Advancements in the design of IGCs have allowed them to achieve comparable flow rates to axial compressors. They are now a viable and cost-effective option in PDH plants, FCC units, blast furnace blowers, and large ASUs.

Figure 1. Typical compression train setup with a single-stage STC-GV compressor.

Old technology, new application

An IGC comprises one or more compressor stages, each of which is fixed to the end of a high-speed pinion. The pinions are mounted in a housing that contains a low-speed bull gear.

For each pinion shaft, an optimal combination of shaft speed and impeller size can be achieved. All impellers are of overhung design and can be fitted with adjustable inlet guide vanes (IGVs) in front of each impeller. Inter-stage cooling of the gas stream can be achieved after each impeller discharge.

Combining these features allows for high-volume flows and energy efficiency (even under partial loads). It also results in a very compact footprint.

Although IGCs have only recently been considered for high-flow applications, they have been used successfully for decades. Siemens developed the first IGC in 1948 (formally named the VK). The first single-stage overhang design was implemented in 1996. In total, the company has more than 2300 units in

Table 1. Comparison of single-stage STC-GV vs axial compressor

Train features	Single-stage STC-GV (200-1)	STC-SX axial compressor (450-06)	Reduction (approximate)
Train length (without concrete)	12.7 m	15.3 m	-20%
Reduced machine house (single-stage: 535 m^3, axial: 730 m^3), (€320/m^3)	€170 000	€233 000	-27%
Foundation weight	275 t	460 t	-60%
Maximum maintenance weight	10 t	47 t	-78%
Rotor weight	3.7 t	12.5 t	-70%
Rotor dimension (length, diameter)	2400 mm, 1700 mm	5900 mm, 1900 mm	-60%

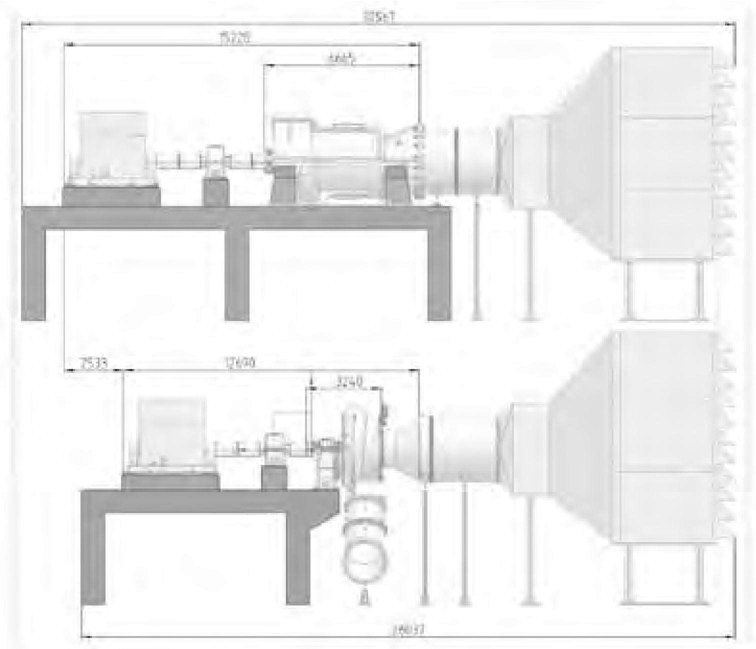

Figure 2. Train length comparison with axial (top) vs integrally geared compressor (bottom).

operation worldwide, many of which are being used in applications with flows exceeding 400 000 m³/hr.

One of the latest advances in the STC-GV line is the single-stage overhang compressor specially designed for atmospheric air compression at low pressure ratios (Figure 1). It covers a broad flow range, from low to very high volumes of up to 1 million m³/hr. In higher pressure ratio requirements, such as blast furnace blowers and FCC units, two single-stage overhung machines driven by a double-ended steam turbine drive between the compressors can be utilised.

The STC-GV line uses proven and standardised components from IGCs, which have achieved decades of reliable operation. All units are designed as per API 617.

Benefits

When compared to axial compressors, the single-stage STC-GV can provide a number of advantages to end users (Table 1), including:

- Lower CAPEX – the up-front cost of an axial compressor can be as much as three times higher than that of a single-stage overhung compressor. Additionally, with far fewer components, end users can reduce the number of spare parts in their inventories and associated costs. With the IGC, › 90% of parts are standardised (e.g., volute, low solidity diffuser [LSD], IGV, contour ring, etc.)
- Reduced OPEX and simpler maintenance – generally speaking, a single-stage IGC requires less frequent service than an axial compressor. Much of this is attributable to the lower number of rotor stages (1 – 2 rotor stages instead of 4 – 6) and simpler design. Oil consumption is also reduced by 25% (approximately 190 l/min. or 50 gal./min.). The requirement for jacking oil is eliminated. Additionally, the simplified design makes maintenance tasks easier to carry out. With the STC-GV, for example, bearings can be inspected without lifting the upper half of the compressor. The overall maintenance weight of the unit (i.e., the weight of parts that require lifting) is also 80% lower. When a base frame is included, the entire compressor assembly can be moved with a single lift. Overall, compression train lifecycle costs can be as much as 10 – 20% lower with an integrally geared machine.
- Efficiency and performance – as previously mentioned, the single-stage IGC can achieve up to 1 million m³/hr or 590 000 ft³/min. – with a pressure ratio of approximately 3 (up to around 6.5 in case of two units). The performance of the compressor is virtually identical to that of an axial machine, with efficiencies of around 90%.
- Smaller footprint – the train length is 12.7 m, roughly 20% less than the axial compressor. Rotor length is also reduced by approximately 60%. This results in a much more compact train footprint (Figure 2).
- Reliability/availability – fewer highly sensitive and intricate parts in the IGC mean less likelihood of failure. All of the components used in the machine are proven and have accumulated millions of hours of uninterrupted service in many different types of compression applications.
- Flexibility – the STC-GV was designed with a flexible installation concept. This includes an adjustable volute position. Additionally, installation on concrete without a tabletop foundation is possible. This modular design also offers the advantage of an unchanged compressor design, irrespective of whether the machine is driven by a steam turbine, gas turbine, or electric motor. For example, if the steam supply at the facility decreases over time, the compressor can be driven with a motor. In such cases, an intermediate gearbox is implemented, but the compressor itself can remain in place, with no design modifications.
- Shorter lead time – the typical lead time for an IGC is approximately 25 – 30% faster than an axial compressor.

Conclusion

Axial compressors continue to be the machine of choice for compression in high-flow applications, including PDH plants, FCC units, blast furnaces, and large ASUs. However, recent advancements have now made IGCs a suitable alternative. Given their capabilities, they should, at the very least, be evaluated during the front-end engineering and design (FEED) phase.

As this article has outlined, IGCs are not new technology. Their implementation can yield numerous benefits for the end user, including lower lifecycle costs, higher reliability, and increased design flexibility. All of these can translate directly into bottom-line savings.