Compressor of choice, part two

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Michael Rimmer and Grant Johnson, Costain, UK, explain how proper specification and selection of compression equipment can have a major impact on life cycle costs.

COMPRESSOR OF CHOICE PART TWO

Compressor technologies continue to evolve, and environmental impact has become more of a focus than ever before. Keeping abreast of developments and engaging early with suppliers ensures that innovative technologies can be integrated successfully within projects. This article discusses compressor and driver types, and examples of how compressor selection has resulted in a reduction in capital and operational expenditure, boosted gas production, increased gas security and improved project environmental performance.

Hermetically sealed compressors

Technologies that have enabled the development of hermetically sealed compressors include high speed motors, variable frequency drives and active magnetic bearings. These technologies, both in hermetically sealed compressors, and with conventional barrel compressors with external motors and mechanical seals, avoid the need for speed increasing gearboxes and lubrication oil systems, and significantly reduce maintenance requirements.

The use of sealed compressors started in pipeline service, with designs later being developed for tandem casings with a centrally located motor, enabling a greater number of impellers and inter-cooling. Further development of the technology has now seen it deployed in subsea applications.[1]

Sealed compressors are ideally suited to the requirements of underground salt cavern gas storage, and their advantages have seen these compressors installed on a number of facilities. The main objective for compression in gas storage is to move gas to and from the caverns as quickly and efficiently as possible. Use of sealed compressors minimises operating cost as there is no leakage from seals, the system can sit pressurised indefinitely with no losses, no fuel gas is needed and the power requirement is minimised. With active magnetic bearings being used instead of traditional journal bearings, the compressor can start in minutes and run at a wide range of speeds.

During the injection of gas from the network into the cavern, or during withdrawal operations, the gas can either free flow or require compression. A transition is therefore required from free flow to compression operation, and the wide speed range that can be achieved with the use of active magnetic bearings is ideal for this application. At 30% speed, the head produced will be around 10% of that at 100% speed, enabling the compressor to pick up operation from free flow without excessive throttling or power consumption.

Figure 1. Wellhead reciprocating compressor.

Figure 2. Wellhead compression facilities.

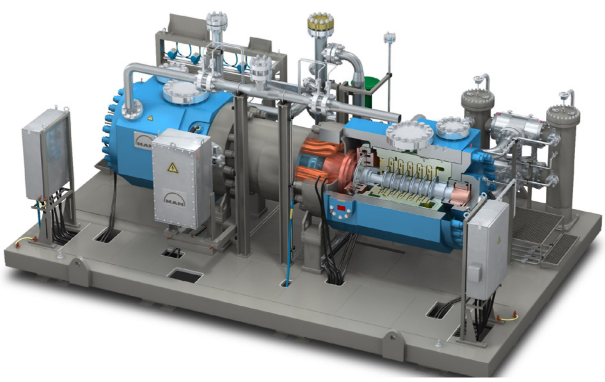

Figure 3. A HOFIM type compressor (source: MAN Diesel & Turbo).

At a 'fast cycle' underground salt cavern gas storage facility in the UK, Costain installed three 8 MW hermetically sealed compressors to provide the required capacity. The machines are single stage and are used for both gas injection and withdrawal duties. With wide operating speed ranges, from 30 – 105%, and the ability to run either one, two or three machines in parallel, the efficient operating flow and head range is very high. Gas trading can be quickly and efficiently handled by the site, as operation is fully automated. When gas trading requirements are nominated, depending on the gas transmission system pressure, cavern pressures and volume to be traded, the control system selects the appropriate number of machines and duration to minimise operational costs.

Although the compression trains are extremely compact, the space needed for electrical infrastructure and electrical equipment is considerable, including variable frequency drives and associated transformers. Equipment for harmonic filtration was also installed on the incoming high voltage electrical supply, to avoid unacceptable harmonic currents and voltage distortion impacting the supply network. Understanding all electrical system requirements as early as possible in design is essential to avoid costly later addition of equipment or electrical constraints impacting on compression operation.

Integrally geared compressors

Integrally geared compressors have a large bull wheel with multiple pinions driving up to 10 centrifugal impellers. The design speed of each pinion and the diameter of each impeller can be optimised to meet the process duty with high overall efficiency. It is possible to drive the compressor either via the bull wheel or via a pinion, meaning either high speed or low speed drivers can be used.

With a large number of impellers, it is possible to compress across high pressure ratios, with multiple intercoolers. Integrally geared compressors are, for example, commonly used in compression of CO_2 from atmospheric pressure to very high pressure. Integrally geared machines are a good fit for process facilities with multiple streams that either need to be compressed separately or join as side streams at different pressures.

Variable inlet and/or diffuser guide vanes can be used for capacity/suction pressure control. Depending on the compressor design, these can achieve turndown to as low as 30% of design capacity before recycle is needed, without affecting other process stream/impeller conditions. The flexibility to have multiple side streams, with potential access to each impeller, minimises the need to throttle high pressure streams.

As there is pipework between each impeller in an integrally geared compressor, it is possible to include more stages of intercooling than is practical with a barrel compressor. This means that the load on the driver, and hence operating cost, can be reduced, although there is a trade-off with the complexity and associated pressure loss of multiple coolers.

In a UK gas processing plant removing nitrogen from natural gas[2], a compression system consisting of four parallel integrally geared centrifugal compressors is used to compress process gas from multiple pressure levels to the high pressure needed for delivery to the gas transmission system.

Product gas enters each compressor at three pressure levels, between 7 and 25 barg and is compressed to 55 – 75 barg. Each compressor comprises six compression stages on three pinions around a single helical spur gear connected directly to a fixed speed 4 MW electric motor. Product gas is introduced to stages 1, 2 and 4, with variable guide vanes on the inlet providing suction pressure control. Cooling is provided after stages 3 and 6. With four parallel compressors, each sized for 25% of the total throughput, with provision for recycle and sequence control, high efficiency operation is achieved over a wide range of flows.

Screw compressors

For an environmentally driven project at a UK oil refinery, Costain engineered a compression system for the recovery of

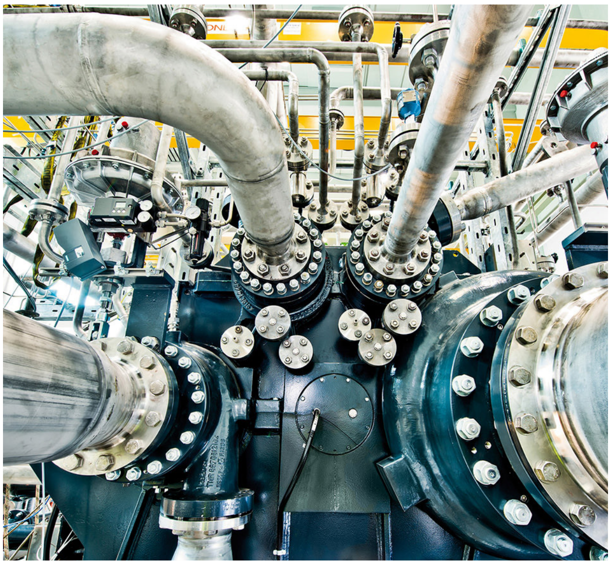

Figure 4. GT type compressor (source: Atlas Copco).

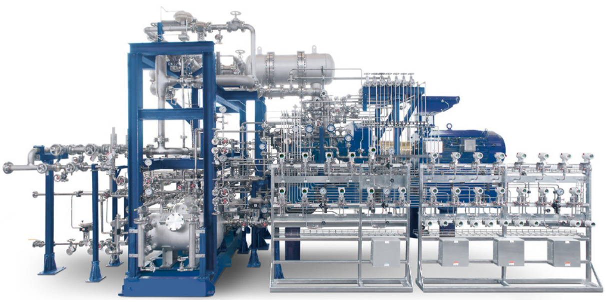

Figure 5. Dry screw compressor (source: Aerzen).

low pressure gas that would otherwise be flared. A screw compressor was the appropriate selection for this application, as the suction pressure and volumetric flow rates were low and the duty relatively constant. A reciprocating compressor could also have achieved the required duty, but the high reliability of the screw compressor, of up to 99.7%, with fewer moving parts and mechanical seals made it a good choice.

Both dry and oil lubricated screw were considered, but the risk of contamination of lubricating oil by the process gas was considered too great. As contamination can cause deterioration of the lubricant and failure of the compressor, and it would also not be possible to test with the operational gas to confirm appropriate oil selection before putting into service, a dry screw was ultimately selected. As dry screw compressors have no physical contact between the male and female rotor, small quantities of liquid carryover have minimal effect on compressor operation.

Given the high pressure ratio across the compressor of 8:1, there is a need for cooling to avoid high operating temperatures. The compressor design accounted for the process gas containing H_2S, and two compression stages with intercooling were used, as direct cooling of the rotors with water was not practical.

Conclusions

Proper specification and selection of compression equipment can have a major impact on life cycle costs, including capital cost and the operating cost for fuel/power and maintenance. Design of facilities around machinery capability, focusing on full life cycle requirements and operating range, rather than maximising peak efficiency at a single operating point at which the machine will operate for a limited time, leads to robust selection.

It is important for the design team to understand how the compressor fits into the overall facilities and all the conditions under which it will be required to operate. Poor understanding of how the reservoir, machinery, pipelines and processing plant will work together can lead to compression systems that are difficult to operate efficiently, are prone to degradation, or are unreliable.

An increasing choice of compressor technologies, offering improved efficiency, lower maintenance, and reduced life cycle cost, and a continued focus on environmental performance means compressor selection considering all project delivery, technical, and operational criteria, is very important. In a low energy price environment, the incremental returns from field gas compression projects can be more marginal, and compression system specification and selection can influence project viability.

Acknowledgements

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