POWERFUL PISTON DESIGN

Joe Salinas, Global Compression Services, USA, highlights how a customised approach to piston service and upgrades can provide refineries with time-saving solutions, improved value, and greater convenience.

Packing cases play a critical role in compressor operation, sealing the compressor cylinder that carries gas through the system. However, many original equipment manufacturer (OEM) packing case designs are 40 - 50 years old, which may limit their efficiency and environmental compliance. To address this, Global Compression Services (GCS) is involved in the manufacturing and supply of both OEM and aftermarket parts, components, and engine accessories for reciprocating compressors and ignition and control systems, and is developing a zero emission packing case, designed to help refineries meet modern environmental regulations. When a packing case vents to the atmosphere, upgrading to a steel packing case and installing a specialised zero emission packing to prevent any gas leakage is preferable.

Traditionally, packing cases are made from cast iron, a porous material that allows process gases like hydrogen and methane to permeate the packing case, complicating reconditioning efforts. Replacing cast iron packing cases with cases made from 1045 or 4140 steel, which are machine-lapped to a precise 7 - 8 RMS finish, creates a highly smooth, sealed surface that effectively prevents gas leakage.

Unlike cast iron, which can 'sweat' or release retained gas due to its porosity, steel cases with a perfect RMS finish provide a robust barrier, preventing gas from escaping into the atmosphere. This not only enhances the packing case's durability but also contributes to zero emission standards, supporting refineries in achieving stricter environmental compliance.

Unique piston design

In January 2023, two custom-designed 27.75 in. pistons were delivered to a refinery's reciprocating compressor in Corpus Christi, Texas, US. These featured a unique three-piece configuration with two aluminium halves and a steel centre section. Custom-built for the refinery's specific operational requirements, each piston took approximately six to eight weeks to manufacture. Produced on CNC machines, the pistons achieved high precision and efficiency, allowing for reduced labour and quicker turnaround times.

Originally, the compressor had hollow cast pistons, which were prone to failure under the extreme temperatures (200 - 500°F) encountered in refinery operations. A solid piston design with a steel core and aluminium ends can withstand such temperature fluctuations without failure. This solid design provides greater durability and reduces the risk of compressor shutdowns at high temperatures, addressing a major limitation of the OEM's original cast pistons.

Designed specifically for oilfield and refinery environments, pistons are also built to resist sour gas, which can severely corrode pistons and valves. In the custom design, anodised aluminium is used to prevent gas penetration, offering an ideal solution for South Texas operations where sour gas is prevalent.

Utilising steel vs cast iron

On a new project, GCS first retrieves a gas analysis from the refinery. The gas analysis reveals the composition of the gas that the piston is going to be pumping. Based on the gas analysis, engineers will recommend the material for that piston in that operation. If the wrong material is used in combination with an abrasive and/or corrosive gas, the metal will degrade over time and the piston will fail. Using the proper material with the right gas ensures a long run time.

Figure 1. Piston steel centre section.

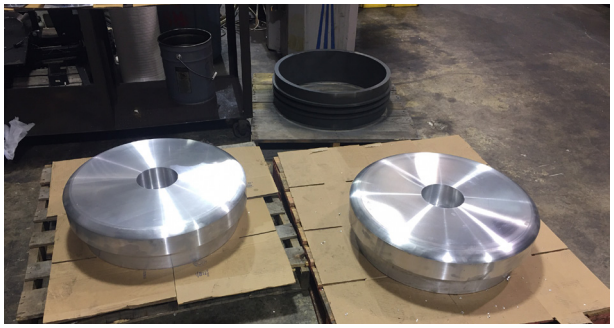

Figure 2. Two aluminium piston halves.

The design process begins with obtaining a piston sample or print, which is carefully measured and assessed by engineers. Based on these measurements, they either refine the existing design or create a new one. In many cases, the piston requires aluminium, for which GCS uses aircraft-grade 6061 T6 aluminium for optimal durability. For the centre section, cast iron or steel is selected according to the application's specific requirements, with a three-piece piston design being the most common. In some situations, a solid cast iron piston is required, which limits upgrade options.

While high-grade aluminium is resistant to corrosive gases, it will eventually degrade over time. To address this, pistons are designed with a modular structure: a durable steel or cast-iron centre section flanked by aluminium ends. This design enables efficient recycling and repair. If the aluminium ends become unusable, they can be replaced while reusing the centre section, or vice versa. The worn part can be swapped out without needing to replace the entire piston, as would be required with an OEM piston. This modular approach supports both sustainability and cost-efficiency in piston maintenance and replacement.

Case studies

Hydrogen non-lube system

A refiner operating a pure hydrogen non-lube system with specific cylinder frames was experiencing significant wear issues with piston ring and rider bands, which required replacement every two months. GCS recommended a specialised polymer material for the rings and rider bands, custom-engineered for durability in non-lube systems. They overhauled and upgraded the entire piston assembly, implementing a tailored Teflon-based design that could withstand the demands of hydrogen service without lubrication. Since the upgrade, the refiner has achieved a runtime of over two years, surpassing previous performance.

Valve upgrade

Another refiner required a valve upgrade for compressors handling gas with high liquid content. Originally using steel rings, the compressors were updated by GCS with high-performance peak rings and entirely new valve assemblies. To reduce liquid presence in the compressors, the refiner also implemented separators and dryers in the system. GCS recommended switching from cast iron to steel valves, which improved durability and performance. This upgrade extended the valve lifespan to over a year initially, and the design was subsequently standardised across all the client's compressors. The new valves now operate for up to two years without issues, offering robust leak protection even in liquid-rich environments.

Refineries often purchase frame packages from OEMs and then turn to companies like GCS for maintenance and repair services. Valves can be reverse-engineered and repaired to meet specific operational needs, providing an alternative to OEM replacements. Computer numerical control machines are used for precise repairs, with programming tailored to each valve's specifications to ensure accuracy.