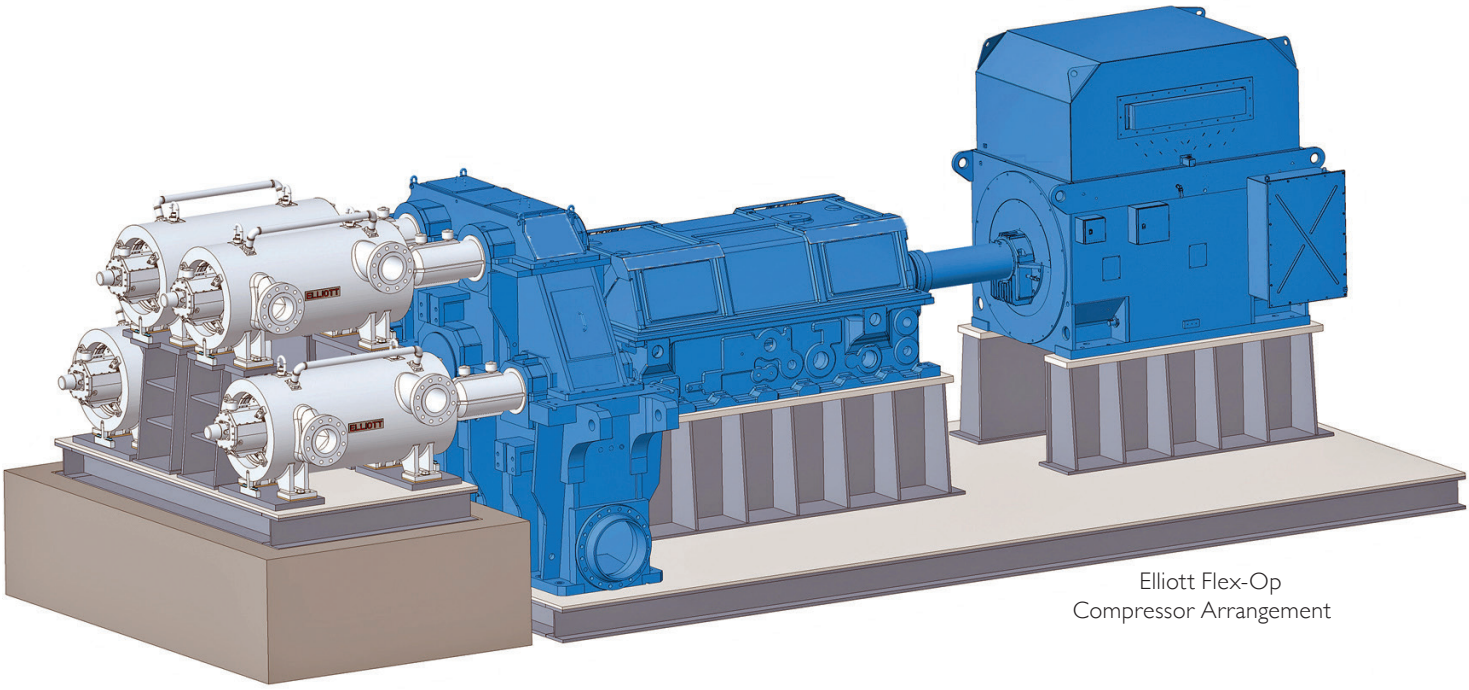
HYDROGEN H_2 REPORT

BY BRENT HAIGHT

FLEXIBLE HYDROGEN COMPRESSION

ELLIOTT INTRODUCES FLEX-OP HYDROGEN COMPRESSION ARRANGEMENT



Elliott Flex-Op Compressor Arrangement

Elliott Group has developed a configurable compressor arrangement designed to enhance operational flexibility in hydrogen applications. Drawing from the company's 70+ years of hydrogen compressor experience, Flex-Op uses currently available technology to make a more versatile solution for hydrogen compression.

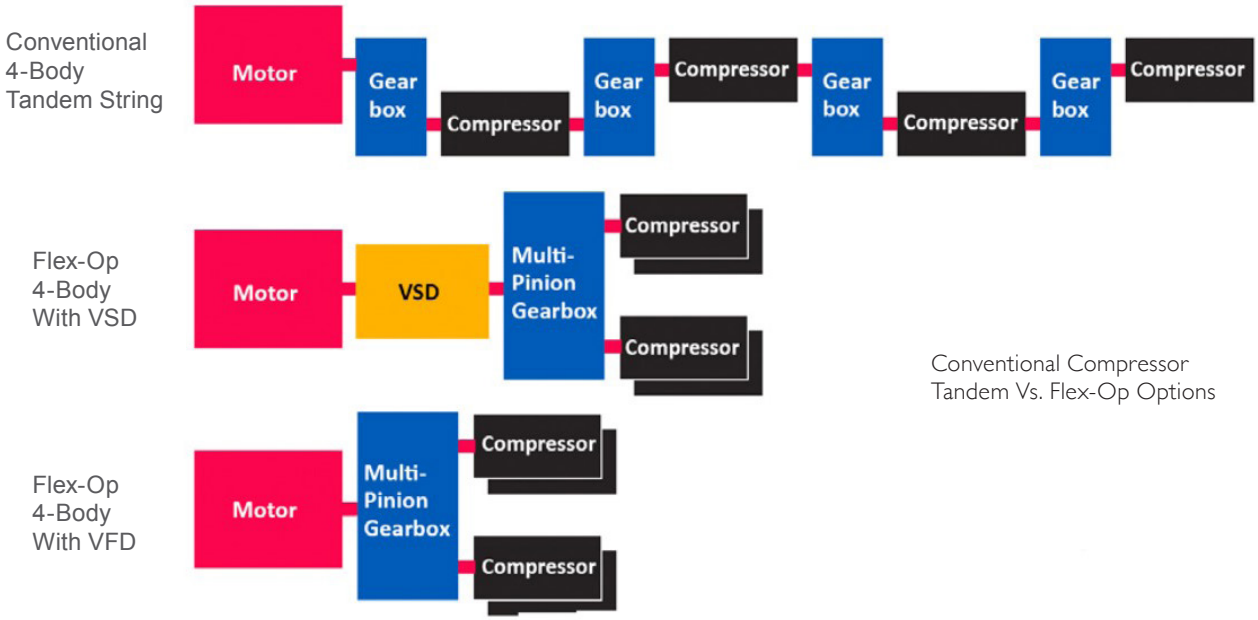
"Hydrogen compression requires a large number of compression stages to achieve a reasonable head for a very light gas," said Klaus Brun, director of research and development at Elliott. "With the Flex-Op arrangement of three to four casings, up to 44 impeller stages can fit into a footprint that traditionally only fit up to 10 stages. This shrinks the linear footprint of the compressor section from 60 ft. [18 m] or more to about 20 ft. [6 m] and offers up to four times the compression capability within the approximate linear footprint of one compressor."

According to Brun, the primary goal behind the Flex-Op is to have a product that can meet hydrogen market compression demands, which requires a pressure ratio between 2.5 and 3 for many key applications, with low-risk, currently available technology. "We're seeing that there will be industrial-sized hydrogen production facilities within two or five years coming onto the market," said Brun. "They will need this compression. Running lots of reciprocating compressors in parallel is not an efficient solution and until now, there was not a viable centrifugal compressor solution."

DESIGN FLEXIBILITY

Elliott developed the Flex-Op compressor design to improve operational flexibility in hydrogen applications, including increased head and flow capabilities. The arrangement allows for improved reliability and accessibility to the rotating components. "The Flex-Op design is efficient, with many advantages over reciprocating compressors or extremely high-speed centrifugal compressors. It uses standard design compressors and impellers. The arrangement is compact and easy to maintain and repair. It is operationally flexible, with the potential to engage/disengage individual compressors, to switch between series and parallel operation, and to run each compressor at different speeds," said Brun. "Also, very important for pure hydrogen compression, the process gas is safe from risk of oil contamination, unlike with a standard reciprocating compressor."

In the Flex-Op arrangement, individual compressors can be run in series, in parallel, or both. This is achieved with three to four centrifugal compressors arranged about a single multi-pinion gearbox. Each rotor is connected to its own pinion via a flexible shaft coupling to the central bull



Conventional Compressor Tandem Vs. Flex-Op Options

gear, which means the rotor speeds can be individually optimized for highest aerodynamic efficiency. Elliott's barrel casing configuration, coupled with the multi-pinion gearbox, allows the entire assembly to be powered by a motor with a variable frequency drive (VFD) or a motor in conjunction with a variable speed drive (VSD) for speed control.

"There's nothing in Flex-Op, as far as technology is concerned, that has not already been done in some form," said Brun. "The gearbox, the pinion, the compressors themselves — having an 8- to 11-stage compressor on the flex coupling — we've done that many times. The Flex-Op development project made sure that there's nothing in here that is high risk. We looked at the torsional analysis, support structure, flange loads, etc. We looked at the entire packaging of the Flex-Op compressors utilizing existing technology to minimize design risk."

A SOLUTION FOR NOW

As the hydrogen economy continues to evolve, so will compression technology. However, action must be taken now to make hydrogen scalable and more affordable.

"Hydrogen is the lightest gas that exists, and therefore it is relatively hard to compress," said Brun. "To compress it to a pressure ratio of 2.5 with a conventional compressor, you end up with a compressor that requires about 40 stages. That is a lot of stages and requires an enormous footprint. Another option for hydrogen compression is operating at a very, very high speed, but this technology does not yet exist. Elliott is working on it. Our competitors are working on it. In the long term, 7 to 10 years for example, we'll be using ceramic impellers and/or carbon-wound fibers — things that can run 50,000 rpm. We've done testing on these technologies, but with what is currently available today, nobody is going to accept that into the market."

"Flex-Op is available now," said Brun. "It is available in industrial scale. Since each rotor is connected to its own pinion via a flexible shaft coupling to the central gear, the rotor speeds can be individually optimized for the highest aerodynamic efficiency. We are taking technology that's available today and offering a better solution for hydrogen compression right now." GCM

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