NOV's first 3D-printed multistage choke trim withstands cavitation and optimizes flow in water injection line

Challenge

Several third-party, single-stage chokes experienced reduced run life on an operator's platform off the coast of Nigeria. The chokes were installed to step flowing pressures down from 3,000 to 30 psi in water lines feeding the platform's water injection wells. The produced water created cavitation and washout issues in the choke trims, which restricted water injection to below desired flow rates. The operator tried reducing flow rates into the chokes to minimize cavitation and washout—a solution that led to a lack of local flow control and unstable injection conditions.

The operator asked NOV to quickly devise a robust and reliable choke redesign that mitigated the cavitation challenge in the current single-stage chokes.

Solution

NOV's choke experts immediately went to work designing a multistage choke that effectively addressed the cavitation problem and maintained desired injection rates. An analysis of the flow conditions in the lines pointed to Kennametal's Stellite™ as the ideal trim material. A cobalt-based alloy, Stellite is widely used in the control valve market thanks to its proven combination of corrosion, impact, and abrasion resistance.

NOV decided to manufacture the multistage Stellite trim through a 3D printing method, marking the first time NOV applied 3D printing for choke trims. Compared to the traditional manufacturing method of sintering together stacked discs, 3D printing delivers the trim in less time and at a competitive cost. The 3D printing process creates the trim, including the complicated labyrinth of trim internals, in one solid body and one step.

This process delivers a more durable trim than stacked-disc sintering methods, which is particularly critical in production applications with a risk of vibration. And because the trim is a pressure-throttling rather than a pressure-containing member, it can be 3D printed without violating API requirements.

Case study facts

Location: Nigeria

Customer: Confidential

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Solution (cont.}

NOV previously designed and installed multistage chokes in gas lines for noise and vibration attenuation. But this application marked the first application of NOV's multistage choke in a water line for cavitation control. A detailed computational fluid dynamics analysis confirmed that the chokes fitted with 3D-printed trims would meet the operator's flow rate target at the required pressure differential.

NOV designed the choke with dual-range flexibility as an added benefit for this Nigerian application. At lower flow rates the choke runs in multistage mode, giving the operator greater flow control while mitigating cavitation effects. When higher flow rates are required, the choke operates in a full-open, single-stage mode.

Results

Satisfied with NOV's multistage choke design and 3D printing process, the operator ordered five chokes in June 2021. With dimensions provided by the operator, NOV quickly acquired all components to build the multistage choke bodies to seamlessly replace the single-stage chokes—without modifying the piping on the platform. The 3D printing process for the five Stellite trims took place simultaneously.

NOV delivered all five multistage chokes with Stellite trims in Q1 2022, just seven months after receiving the order. The chokes were installed quickly and have been in continuous operation for over a year—consistently delivering the required water injection rates with no cavitation or washout issues.

Pleased with these initial results, the operator ordered five additional multistage chokes to replace competitor chokes on a different platform. As of June 2023, the customer and NOV are in final negotiations for eight more chokes of the same design.

This first-of-its-kind installation convinced NOV of the multistage choke's applicability in both water and gas service. It also confirmed that 3D printing could reliably manufacture high-performance choke components at the required service specifications, saving the operator time and money in the process.