Steam generator for the future of crude oil extraction

Schubert & Salzer valves provide precise gas mixing across a wide control range

An application report by Alexander O'Neill and Mark King

Enhanced oil recovery (EOR) can significantly boost the yield of existing oil reserves. However, compared to traditional crude oil extraction methods, the processes involved – such as injecting steam into the reservoir – are much more energy-intensive and expensive. O'Neill Industries, an EOR specialist, has developed a steam generator that markedly improves energy efficiency and cost-effectiveness by using Schubert & Salzer control valves.

Gushing oil wells – those that flow to the surface naturally or are forced out by introducing water or natural gas – are becoming increasingly rare. Most of today's heavy oil is located in oil sands or other unconventional resources, making it too thick to be extracted using standard techniques. Enhanced oil recovery technologies help lower the viscosity of this oil, facilitating extraction from these reserves. In recent decades, methods like cyclic steam stimulation, steam flooding, and steam-assisted gravity drainage (see figure 01) have become common for recovering heavy, viscous crude oils.

Typically, conventional steam generators are used for these processes. However, they have their limitations: "Nearly 19% of all the heat generated in conventional steam generators is lost in the boiler stacks, and anywhere from 3-20% of the heat can also be lost in the flowline to the wells. On average, 32% of the generated heat could be lost by the time the steam is delivered to the wellhead", explains Alexander O'Neill, whose company, O'Neill Industries, specializes in EOR technologies.

Revitalizing an Old Concept with Sliding Gate Valves

The first companies began developing downhole steam generators in the 1980s, aiming to generate steam deep in the wellbore, closer to the reservoir, to shorten transportation distances and enhance efficiency. "However, the technology never made it past the experimental stage," O'Neill points out. "The combustion chamber of these early designs could not withstand the stresses of high-temperature differences and harsh conditions for long. Nevertheless, we took the underlying idea and, with Schubert & Salzer's help, developed it into today's Thermal Well Generator."

An innovative cooling concept ensures that high-temperature differences and the extreme thermal stresses that go with them are avoided: A rotating jacket of feedwater circulates around the flame in the combustion chamber. This effectively shields the outer walls, preventing them from becoming hotter than the water to be evaporated.

Cyclic Steam Stimulation (CSS): Steam is cyclically injected into a wellbore to heat the oil and reduce its viscosity. Following a period of soaking, the liquefied oil is extracted along with the vapor.

Steam Flooding: Continuous steam injection pushes the oil through the reservoir to another well to be extracted. The steam reduces the viscosity to improve the flow of the oil.

Steam-Assisted Gravity Drainage (SAGD): Steam is injected into an upper horizontal wellbore. The heated oil flows by gravity to a second, lower horizontal wellbore, where it is extracted.

Figure 01: Methods of thermal Enhanced Oil Recovery (EOR)

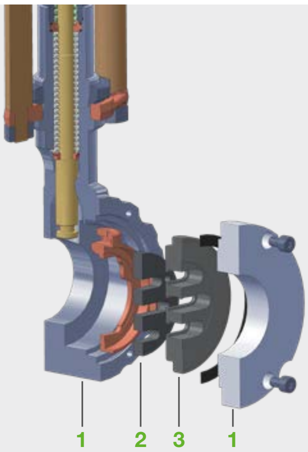
Schubert & Salzer sliding gate valves have been crucial in addressing one of the biggest challenges in developing this technology. “We only need a very small amount of combustible gas to ignite the TWG flame. As we continuously increase the power and switch on the feed water, we need very high C_{Vmax} values for air and methane and precise control over the mixing ratio. Most other valves we have sampled either will not go low enough to reach our minimal flow, or, if they can handle the minimum flow, they cannot reach the top end. Therefore, the first units we built were still equipped with double air and gas control valves from Schubert & Salzer to achieve the required control spread. Thanks to years of fine-tuning and optimization, we are now able to control gas and air with just one sliding gate valve each. We found the close cooperation and constant dialogue with Mark King and Doug Roy from Schubert & Salzer extremely valuable,” O’Neill notes.

Enhanced Energy Efficiency Above Ground

The advantages of this technology are not only interesting for underground use, reports O’Neill. Firstly, no elaborately treated water is needed for operation. Secondly, both the generated steam and the hot exhaust gases are completely fed back into the well. This increases energy efficiency and, with CO_2 and nitrogen, introduces two gases into the deposit that not only bind with the oil and reduce its viscosity, but also repressurize depleted zones. “These processes are usually done sequentially, but the Thermal Well Generator does it all in a single step,” O’Neill explains.

Moreover, the TWG is more compact than traditional steam generators, allowing it to be placed directly at the wellhead. The compact and lightweight design of the sliding gate valves is just one of the advantages; they only require about 10% of the actuating force required by comparable globe valves, allowing for significantly smaller actuators (see figure 03).

Figure 02: Due to the high rangeability of the sliding gate valve, the Thermal Well Generator now requires only one valve for gas and one for air.



The Sliding Gate Valve series controls liquid, vapor and gaseous media precisely, quickly and economically:

A sealing disc (**3**) fixed in the body (**1**) at right angles to the flow direction has a certain number of horizontal slots. A moving disc (**2**) with the same arrangement of slots moves parallel to the fixed disc (**3**), thereby changing the flow cross section. The prevailing differential pressure presses the moving disc (**2**) against the fixed disc (**3**) and seals it.

The low actuating force and short stroke (1/4“ to 1/2“) allow the use of smaller actuator. Coupled with the space-saving wafer construction, weight and installation dimensions are minimized, This translates into about 330 lbs for a flanged globe valve in 6“, whereas a sliding gate valve of the same nominal size weighs a mere 33 lbs!

Figure 03: Principle of the sliding gate control valve.

Figure 04: Multiple sliding gate valves by Schubert & Salzer are used in the Thermal Well Generator. (1) Fuel gas control valve (2) Air control valve (3) Well steam control (4) Vent steam control valve.

Figure 05: From concept to proven success – O'Neill's Thermal Well Generators revolutionize EOR operations.

A Vision for the Future: Downhole Steam Generation

For economic reasons, the Thermal Well Generator has primarily been used above ground. However, it has potential as a downhole steam generator, with O'Neill Industries already conducting trials. As energy prices rise, downhole applications are becoming increasingly appealing. With its technological edge and Schubert & Salzer valves, O'Neill Industries is well-prepared for the future: "We have been using multiple versions of these valves for 8 years. Of course, we have had some challenges in the past, but working with Schubert & Salzer a solution was always there. These valves have quite literally worked all over the world in some of the harshest conditions and have held up nicely."

About O'Neill Industries

O'Neill Industries develops technologies for enhanced oil recovery (EOR) including proprietary fluids and advanced well stimulation equipment. As an engineering company, O'Neill designs and builds equipment and machines for heavy oil recovery and oil sands extraction as well as mini-refineries for the economic and scalable processing of hydrocarbons.

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