Sagebrush
EXPERTS IN ENERGY EQUIPMENT

The Sagebrush H2NG Blender: Pioneering the Future of Hydrogen Blending

As global energy producers increasingly shift towards cleaner and more sustainable solutions, hydrogen is emerging as a key fuel in the pursuit of worldwide decarbonization. Blending hydrogen with natural gas (H2NG) offers a viable strategy for increasing sustainability for utility, power generation, and industrial applications. This practice, which is available and implementable now, could become a core element of the green energy transition, reducing carbon emissions while leveraging existing infrastructure. Sagebrush, LLC, established leaders in engineered equipment for the energy industry, has developed a state-of-the-art H2NG blending system designed to meet the increasing demand for precise, efficient, and scalable hydrogen blending solutions.

The Sagebrush H2NG Blender has undergone rigorous testing to confirm its performance characteristics, providing insight into how it addresses the unique challenges posed by hydrogen integration into natural gas networks.

Introducing the Sagebrush H2NG Blender

Answering The Need for Accurate Hydrogen Blending

To start, it's vital to acknowledge that Hydrogen is the lightest and most energetic element, aspects that contribute to it being a potent fuel source. However, it's also these properties that present significant challenges when hydrogen is blended with natural gas for traditional fuel pipeline distribution. Hydrogen's small molecular size leads to higher risks of leakage and requires more transport energy per unit of calorific value compared to natural gas. This means that hydrogen and natural gas blending has to be very precise to maintain the safety, efficiency, and reliability of the fuel mix in pipeline systems.

The Sagebrush H2NG Blender was designed with these challenges in mind. The H2NG not only ensures an accurate and stable hydrogen-natural gas mix but also operates efficiently across a wide range of blending ratios—from 0% to 100% hydrogen. The Blender was tested at the University of Tulsa Fluid Flow Loop Test Facility, at the McDougall School of Petroleum Engineering, in order to evaluate its accuracy and performance under varying natural gas (NG) and hydrogen blend and flow rates.

Compact, Modular, and Scalable: A Flexible Solution

One of the key advantages of the Sagebrush H2NG Blender is its compact, modular design, engineered for easy installation and setup. This design approach was to make the technology suitable for utilities, power generators, and industrial facilities seeking to decarbonize by integrating hydrogen into their energy mix. The modularity of the system means it can be scaled to meet specific project requirements, whether for small-scale test or pilot operations or larger full-scale infrastructure applications.

This design flexibility, combined with its stainless steel construction, robust engineering, and precision blending programming, allows the Sagebrush blender to fit seamlessly into existing infrastructures, providing a future-proof solution as the demand for hydrogen increases. Moreover, it is a self-adjusting, automated device, capable of making real-time adjustments based on downstream (on-board or remote) hydrogen analysis and diagnostics. These features ensure that the blend ratio remains precise and consistent, even under fluctuating operating conditions.

Precision and Accuracy: Introduction to Our Rigorous Testing Conditions

The design of this system prioritized the importance of precision and reliability in hydrogen blending. To achieve the highest standards of accuracy, the H2NG blender was tested under rigorous conditions, with sufficient third-party inputs to guarantee reliable results. Our collaboration with the University of Tulsa's (TU) McDougall School of Petroleum Engineering provided a platform to evaluate the system's performance in a controlled environment, equipped with vessels, compressors, mass flow meters, density measuring devices, and a blending skid. Sagebrush provided a fully integrated skid-mounted H2NG blender with flow meters, control valves, pressure and temperature instruments, and a hydrogen analyzer. TU provided the flow loop infrastructure, gas compression and test facility, including verifying measurements and thermal fuel destruction.
With all of this at our disposal and hydrogen from Airgas, various natural gas flow rates and hydrogen blend ratios were simulated for testing.

Consistently Accurate Results

During the tests, which took place over two months, the H2NG blender demonstrated remarkable accuracy in maintaining the desired blend ratios. Hydrogen was blended at rates between 10% to 25%, increasing in 5% increments. The system performed consistently throughout the process, with variations between the set points and actual blend ratios falling within a margin of less than 2% of the total flow, with many results better than that. This level of precision is critical for utilities and industries that depend on stable and reliable fuel sources.

Evidence of Self-Adjustment

In addition to hydrogen blend accuracy, the system's aforementioned self-adjusting capabilities were highlighted during the testing process. By continuously analyzing hydrogen levels and making real-time adjustments, the Sagebrush H2NG Blender was able to maintain optimal performance throughout all test phases. Adjustments to blend ration inputs were accomplished in less than 20 seconds. This feature is particularly vital in applications or projects where gas demand and flow rates may vary, ensuring that the hydrogen-natural gas mix remains within safe and efficient limits.

Built for Decarbonization

Decarbonizing the world isn't something that's going to happen overnight, with industries and governments all required to contribute in a worldwide push. Hydrogen blending and hydrogen fuel stations present an immediate and practical solution to reduce emissions without overhauling existing natural gas infrastructure. The Sagebrush H2NG blender is designed to support these efforts by offering a reliable, precise, and scalable system that can blend hydrogen with natural gas to create a cleaner, more sustainable energy mix.

Our system is equipped with all necessary components, including mass flow meters, hydrogen analyzers, control valves, and pressure monitoring devices, ensuring it is ready to operate upon adoption and installation. This turnkey solution simplifies the process for our clients, allowing them to focus on their broader decarbonization goals while the H2NG blender seamlessly handles the technical aspects of hydrogen blending.

We believe that the Sagebrush H2NG blender represents a cutting-edge solution for hydrogen blending in natural gas networks. Throughout this paper, we're going to explore the results of the testing process in more detail, demonstrating why it's a valuable asset for utilities, power generators, and industrial users aiming to reduce their carbon footprint.

Coriolis Meters for Precision Hydrogen Injection

The Coriolis flow meter, known for its precision, was used extensively in our system to manage hydrogen injection into the natural gas stream. Coriolis meters, measuring mass flow so that pressure and temperature adjustments are not necessary, are highly accurate across a range of hydrogen blends, from 0% to 100%, making them well-suited for hydrogen injection applications. While Coriolis meters tend to be more expensive and bulky for larger pipelines, their performance in smaller bore pipes, such as those used for hydrogen injection, provided ideal accuracy during our tests.
In our trials, the combination of the mass flow readings, PLC algorithms, and the control valve adjustments allowed for rapid system response times to changes in set points, achieving stability within 20 seconds.

Consistency in the Systems

Throughout the trials, TU's flow meters and the SB H2NG Blender demonstrated Coriolis meters good correlation, particularly when it came to monitoring and controlling the blend ratios of natural gas and hydrogen. The consistency between the two datasets was encouraging, especially as we move forward to scaling up hydrogen blending technologies.

The Sagebrush H2NG Blender's ability to maintain consistent hydrogen flow rates, even in lower concentrations, suggests that the technology is ready for more complex applications. To further this effort, Phase 2 of the testing will be conducted.

The Next Steps to Explore During Phase 2 Testing

The next phase of testing will dive deeper into this correlation, focusing on longer-duration tests and a broader range of hydrogen blend ratios—requiring an increased quantity of hydrogen. Future tests should also include strengthened controls, such as H2 analyzer calibration including zero, purge, and reset techniques. We will also aim for more consistency between regulators. All of this will allow us to further validate the system's accuracy and robustness under more dynamic conditions.

The Value of System Response and Reaction Time

Testing revealed that a standout feature of the SB H2NG Blender is its rapid response time. During the initial testing phase, the system was able to adjust its blend ratios in response to changes in the set point within 20 seconds—remarkably fast for hydrogen blending. This quick reaction time is critical, particularly for industrial applications where operational conditions can change rapidly, and maintaining the correct blend ratio is essential for both safety and efficiency.

When hydrogen is blended with natural gas, the blend ratio must remain precise to ensure proper combustion, avoid pipeline integrity issues, and meet safety regulations. The ability of the SB H2NG Blender to quickly and accurately adjust the blend in response to changing conditions demonstrates a level of control and flexibility that is highly valued in such applications.

Future Testing for Response & Reactions

Future iterations of testing could potentially aim to reduce the reaction time even further, potentially down to 10-15 seconds. This will allow for even more responsive control over the blending process, particularly in high-pressure situations where rapid fluctuations in gas demand or pressure may occur. Achieving such performance enhancements will likely involve further fine-tuning the PID Loops within the controls to best match system parameters.

In addition, this system's real-time monitoring capabilities demonstrated that operators were able to observe performance metrics instantly. This showed that the technology could help address any potential issues before they escalate into potential problems. The confirmation of the blend ratios in real time increases the confidence of the system operators. As we know, a high-speed response time of the SB H2NG Blender is essential for maintaining a safe and effective balance between hydrogen and natural gas in real-world operations.

Precision of the Initial Trials

As touched on earlier, the results from the initial trials of the SB H2NG Blender indicate that the system performs exceptionally well under controlled conditions. However, there were some moments where precision was compromised, which is to be investigated in the Phase 2 of testing. During the first round of testing, the system consistently maintained blend ratios with a precision of within 1% of the set point, except at the 20% blend ratio, where the deviation was slightly higher, at 2%, with some clear fluttering displayed in our readings.

This was likely because we started to deplete our H2 bottles, which also reduced the inlet pressure.

Maintaining precision, especially when dealing with the low molecular weight and high diffusivity of hydrogen, is vital for the pursuit of incorporating hydrogen blending in power production. This is particularly important when blending gasses through existing natural gas pipelines, where small deviations in blend ratio can result in significant operational issues downstream.

How Precision Declined Throughout Testing

It's essential to note that as the trials progressed, the precision of the system began to decrease. This drop in accuracy, both at the 20% blend ratio and further down the testing line, can likely be attributed to several factors, including the failure to recalibrate the system, prior to each trial, not purging the gas lines between tests, and not re-zeroing the hydrogen analyzer between tests.

These procedural missteps likely introduced measurement errors, which resulted in the increased deviation from the set points during later trials. Another additional control to be applied would be testing each blend ratio within clearer, more specific, and wholly consistent time parameters. The early precision was definitely promising; however, greater care could be taken in future tests to guarantee more consistently accurate results in Phase 2 of testing.

Challenges Identified in Later Testing Phases

While the SB H2NG Blender performed well overall, some challenges emerged as testing continued into later phases, illuminating the need for more, increasingly controlled testing. The challenges and discrepancies shown in the tests are valuable learning points for the system's future development and refinement.

The Need for Recalibration & Re-Zeroing

Because the system was started and stopped (due to operational limitations with personnel and facility availability), with days between the trials, one issue was the need for more frequent recalibration in the H2% analyzer. Over time, as the system continued to operate without recalibration, the precision of the measurements decreased alongside the accuracy of the results. In particular, the hydrogen analyzer began to drift and flutter, resulting in less accurate readings. Re-zeroing the hydrogen analyzer is another critical control methodology for ensuring the system consistently provides accurate measurements over extended periods of operation. This is especially vital when handling variable blend ratios or transitioning between different test conditions.

The Impacts of Purging or Lack Thereof

Another factor contributing to the decline in precision was the lack of purging between tests. When transitioning between different blend ratios, residual gas from the previous test can remain in and back up the lines, affecting the accuracy of the next test's measurements. Purging the lines ensures that each test starts with a cleaner slate, eliminating any potential contamination from previous blends. This step is essential for readings to be as accurate as possible, particularly when testing across a wide range of blend ratios and with significant time periods between trials.

Moving forward, the next phase of testing will incorporate more stringent recalibration and purging protocols to ensure that the system operates at peak performance throughout the entire testing process. Similarly, future tests will require increased levels of H2, allowing for tests to expand into higher blend ratios to simulate wider ranging conditions. This step will also require setting each blend ratio for longer, more strictly set periods.

Next Round of Testing and Planned Improvements

Looking ahead to the next round of testing, several improvements will be implemented to address the challenges encountered in the initial trials, based on assessments of why those challenges arose. The goal is to enhance the accuracy, precision, and reliability of the SB H2NG Blender under a wider range of conditions, including higher hydrogen blend ratios and more dynamic operational scenarios.

Recalibration: One of the primary improvements will be implementing a more rigorous recalibration schedule, applied at every change in blend ratio. Recalibrating the hydrogen analyzer and flow meters at regular intervals will help maintain the high level of precision seen during the early phases of testing, avoiding the flutters seen later down the line.

Purging the Lines: Strictly purging the lines between tests will eliminate any residual gas that could affect subsequent measurements, ensuring more accurate and repeatable results across a range of blend ratios.

Hydrogen Analyzer Re-zeroing: The hydrogen analyzer will be re-zeroed before each test to ensure that the system starts from a known, accurate baseline. This step is crucial for maintaining precise hydrogen measurements, particularly when blending gasses at higher hydrogen concentrations.

Broader Range of Hydrogen Blend Ratios: The next phase of testing will include a broader range of hydrogen blend ratios, including blends exceeding 25%. This will provide valuable data on how the H2NG Blender performs at higher hydrogen concentrations, where issues such as gas diffusivity and pipeline integrity become more prominent. Testing at these higher concentrations will also help identify any potential limitations of the system, which can be addressed in future iterations.

Longer Duration & Strictly Timed Tests: To simulate real-world operational conditions more accurately, the next phase of testing will involve longer-duration tests, requiring increased quantities of H2. These extended tests will provide insights into how the system performs over time, particularly concerning maintaining accuracy and response time over prolonged periods of operation.

Future Implications for H2NG Blending Technology

The results of the testing conducted thus far provide a strong foundation for the future development and deployment of hydrogen-natural gas (H2NG) blending technology—specifically the SB H2NG Blender. As hydrogen earns a larger role in the global energy transition, accurate and reliable blending technology will be essential for safely and efficiently transporting hydrogen through existing natural gas infrastructure.

The SB H2NG Blender has demonstrated its potential as a leading solution for hydrogen blending, offering fast response times, high precision, and strong correlation with external measurement systems like those at the University of Tulsa. However, as we move forward, continued testing and refinement will be essential for ensuring that the system can meet the demands of large-scale projects.

Implications for the Energy Transition

As part of the broader energy transition, blending hydrogen into natural gas pipelines offers a relatively low-cost, low-disruption solution for increasing the use of clean energy. By integrating hydrogen into existing natural gas networks, we can reduce carbon emissions while utilizing infrastructure that is already in place. The results of this testing project will help inform the ongoing development of blending technology, paving the way for the safe and effective integration of hydrogen into the global energy mix.

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