NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Hydrogen Compressor Reliability Investigation and Improvement

Cooperative Research and Development Final Report

CRADA Number: CRD-13-514

NREL Technical Contact: Danny Terlip

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Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI, A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: PDC Machines, Inc.

CRADA Number: CRD-13-514

CRADA Title: Hydrogen Compressor Reliability Investigation and Improvement

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1	$ 150,000.00
TOTALS	$ 150,000.00

Abstract of CRADA Work:

Diaphragm compressors have become the primary source of on-site hydrogen compression for hydrogen fueling stations around the world. NREL and PDC have undertaken two studies aimed at improving hydrogen compressor operation and reducing the cost contribution to dispensed fuel. The first study identified the failure mechanisms associated with mechanical compression to reduce the maintenance and down-time. The second study will investigate novel station configurations to maximize hydrogen usage and compressor lifetime. This partnership will allow for the simulation of operations in the field and a thorough analysis of the component failure to improve the reliability of diaphragm compression.

Summary of Research Results:

A PDC 4-Series compressor was installed at the NWTC at NREL as part of the Wind2H2 system. The compressor was operated at duty cycles up to 20 hours per day compressing hydrogen from ~100 psi to discharge pressures ranging from 3000 to 6000 psi for a total of ~800 hours. Data was collected on the compressor motor's power consumption, system pressures, temperatures and alarm conditions. Four key findings resulted from this CRADA work.

1. Compressor performance and reliability data was recorded and analyzed over 81 start-stop cycles. ~1800 kg of hydrogen was compressed at a calculated flow rate of 3.7 kg/hr. The average efficiency of the compressor system was 3.54 kWh/kg (including cooling pump and radiator at 1.86 kW). The mean time between failures was 49 days. Power consumption was found have a standard deviation of 600 W between discharge pressures of 3000 and 6000 psi. Power consumption was found to have a standard deviation of 500 W as ambient temperature ranged from 17 ^{0}C to -9 ^{0}C with discharge pressure kept nearly constant.

2. Seal weakness was found to be the main failure mechanism. Five seal failures occurred during the testing. Four were in the compressor head and one was on the check valve on the second stage discharge. This mechanism is consistent with field data on compressor failures shown in NFCTEC CDP24.
3. Major repair cost, time, parts and uncommon tools were documented during failures. This data, shown in Figure 1, informs hydrogen compressor operators of repair costs and can be used to reduce downtime.

Failure	Repair Time	People Required	Parts Cost	Parts Lead time	Uncommon Tools Required
CV Seal	<1 hour	1	$20	3 weeks	Torque wrench, long pick
1st Stage Seal	3 hours	2	$1000	6 weeks	Torque wrench, breaker bar, hoist, lint free wipes
2nd Stage Seal	4 hours	2	$1,200	6 weeks	Large torque wrench, large breaker bar, hoist, lint free wipes
Minor Leaks	<1 hour	1	N/A	N/A	Torque wrench, leak detector

Figure 1 - Hydrogen compressor repair burdens

4. Significant downtime can be avoided by monitoring the leak detection circuit. Compressor manufacturers often set a limit on the amount of pressure allowable on the leak detection circuit. Pressures below this level (typically 15 psi) do not send an alarm to compressor operators, yet can be a precursor to seal failure.

In addition to these four key findings, NREL recommends monitoring the overpump valve setting and using a non-Siloxane based lubricant on compressor seals. The settings of overpump valves can change over time resulting in pressure or temperature being too high in the compressor head. Components, such as seals, can be damaged as a result. The pressure setting can be checked using a CV and gauge on the test port of the valve. NREL sampled a non-native coating found on the interior wall of the compressor process tubing and identified Siloxane as a major component. Siloxane was found to be harmful to fuel cells and is found in some commercial vacuum grease. There are other commercial vacuum greases available that do not contain Siloxane.

Subject Inventions Listing:

None

Report Date:

19 January 2016

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