Hydrogen Blending in Natural Gas Pipelines

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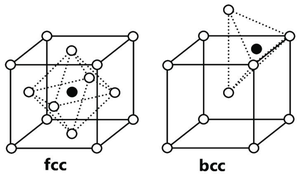
Abstract

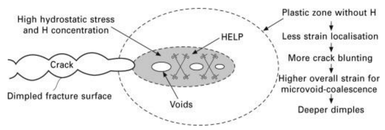
Using hydrogen (H_2) gas as a sustainable fuel presents many challenges, especially in its transportation and storage. The purpose of this project is to determine the effect of hydrogen blended natural gas (H_2/CH_4) on existing pipeline infrastructure. Our focus will be quantifying levels of corrosion and changes in metal crystallinity in static pressure testing. We are also interested in hydrogen diffusion into and out of our plastic & metal sample pieces. We will be using XPS, XRD, SEM, TGA and DMA to characterize our samples before and after exposure to determine the long-term effects of our H_2/CH_4 blend on the lifespan of our pipeline material samples.

Background

- In response to rising greenhouse gas emissions, the demand for more sustainable fuels has greatly increased[1]. Hydrogen is currently considered to be one of the leading fuels for reducing greenhouse gas emissions[3].
- A major issue in using hydrogen gas is the transportation of the fuel. When hydrogen is added to pipeline networks, it may react with the metal or polymer pipeline material, causing hydrogen embrittlement (HE) or hydrogen-induced cracking (HIC) which can severely damage the pipeline network[2].
- The impact of hydrogen blending w/ natural gas within pipeline networks must be studied further to assess this damage.



Octahedral and Tetrahedral Interstitial Sites[2]

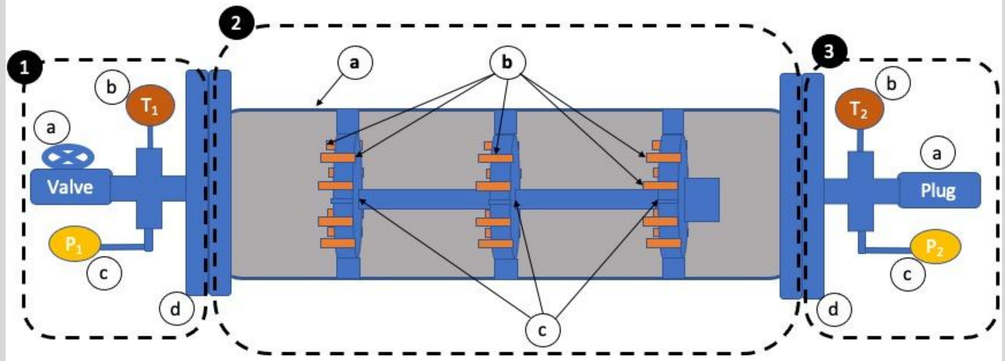


Hydrogen Embrittlement HELP Mechanism[2]

Objectives

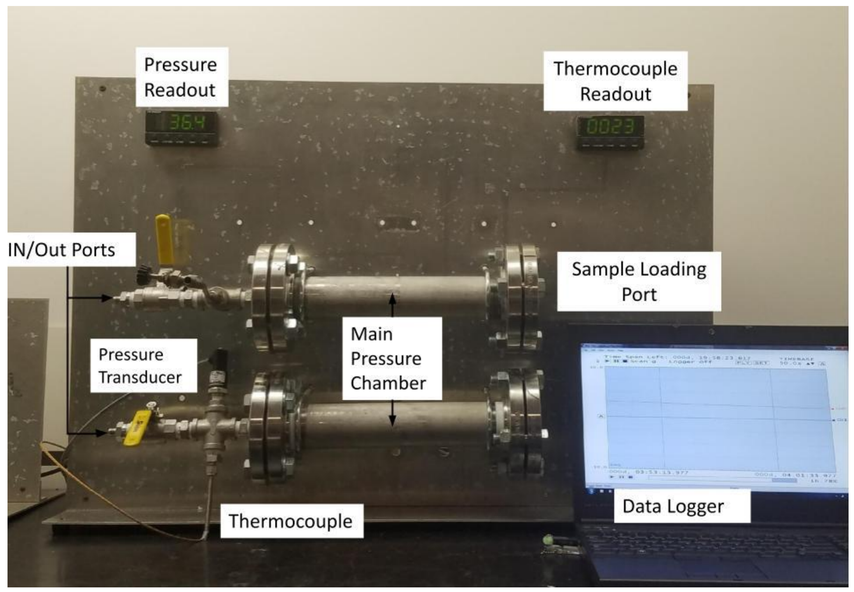
- HyBlend Unit Commissioning: Leak tests will be conducted to ensure that our unit can operate under high pressure.
- Hydrogen Exposure Runs: The inner surface of our pipeline materials will be tested by exposing our samples to our H2/CH4 blend.
- Spectroscopic Characterization: Spectroscopic characterization will be conducted to examine the surface chemistry of our samples and determine the long-term effects of hydrogen on the pipeline materials'; confirm if any metal hydrides form on the metal surface when in presence of hydrogen.
- Long-term Storage: Determine the effects of long-term storage of hydrogen and methane.

Materials and Methods



1. Inlet Section
   - (a)Inlet valve; to pressurize and depressurize the cell
   - (b)Temperature measurement 1
   - (c)Pressure measurement 1
   - (d)Removable flange connection
2. Exposure Cell and Sample Holder
   - (a)Exposure Cell
   - (b)Coupon samples for testing
   - (c)Annular sample holder
3. Outlet/Sample Recovery Section
   - (a)Plug or outlet valve
   - (b)Temperature measurement 2
   - (c)Pressure measurement 2
   - (d)Removable flange connection for sample recovery

Reactor Setup



HyBlend Static Pressure Hydrogen Exposure Cell; experimental setup for testing pipeline coupon samples for degradation from hydrogen exposure over time

Future Research

Future testing will involve continuous flow and dynamic pressure testing of the HyBlend fuel mixture. The flowing mixture may cause flow-accelerated corrosion (FAC), which can cause wall thinning. We will be monitoring the pipeline materials to determine the extent of corrosion that occurs.

Several gas flow issues may arise during dynamic pressure testing. We will have to assess the pipeline materials' integrity, gas flow heterogeneity, and H_2 pressure loss limits along the pipe length.

Acknowledgement

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References

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