C2Po2B-04 Development of a cryogenic performance experiment system for centrifugal cold compressors

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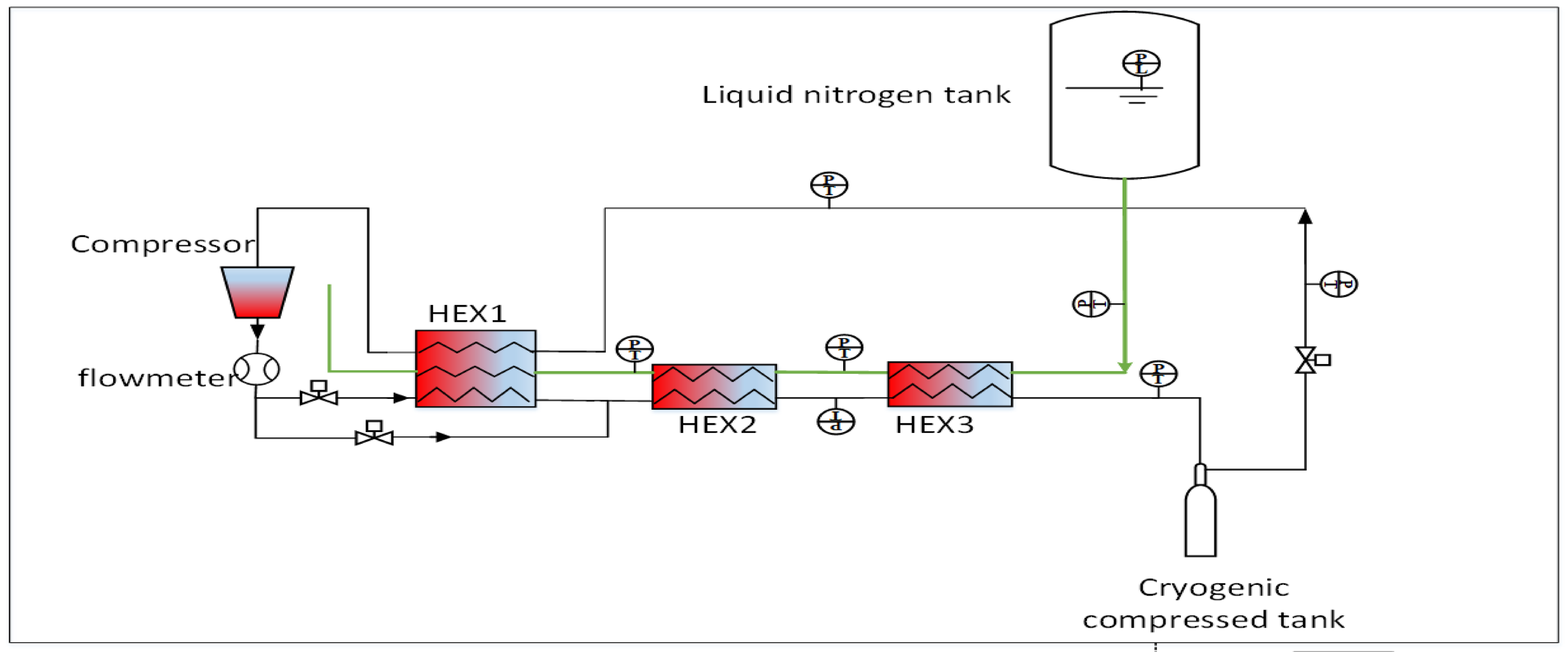
Background

Cryogenic compressed hydrogen technology is a newly high-density hydrogen storage method, which provides a new and promising solution for achieving economical and efficient hydrogen storage. In the future, it will be widely used in aerospace, transportation, energy storage systems, etc. The proposed refueling process, which involves generating hydrogen at 80K and 35MPa using liquid nitrogen cooling is being constructed to validate the feasibility and dependability.

Objectives

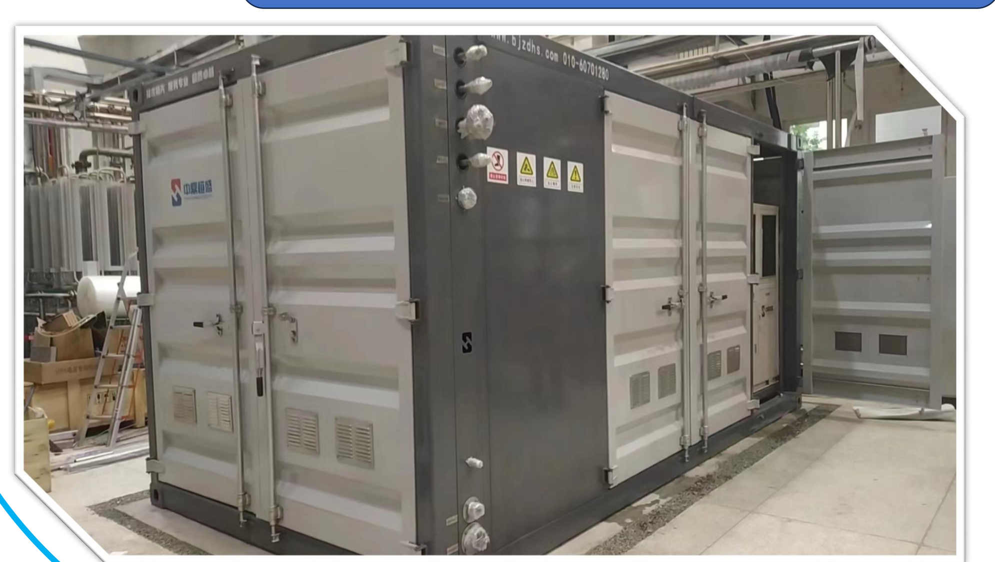
- ◆ A new gas refueling process , with the characteristics of no emissions, safety, and efficiency, has been designed to adapt the randomness of the refueling process for fuel cell vehicles.
- ◆ Considering laboratory safety, the cryogenic refueling system used the helium as the working medium to study the performance of cryogenic compressed hydrogen during the precooling and refueling modes.
- ◆ The state of the gas in the outlet of the system is 35MPa@80K.
- ◆ The experience and experiment results will provide the guide in the future design.

Flow scheme of cryogenic compressed gas refueling system



- ➢ The experimental system included the vacuum insulated cold box, the cryogenic compressed tank, liquid nitrogen tank, the compressor, the control system and other auxiliary facilities.
- ➢ The cold box is composed of three heat exchanger HEX1-HEX3, the cryogenic valves, etc.
- ➢ In the pre-cooling process,HEX1-3 are used simultaneously. In the filling process, HEX 2-3 are used at the same time.
- ➢ The design refilling rate is 1 kg/min

Main system units

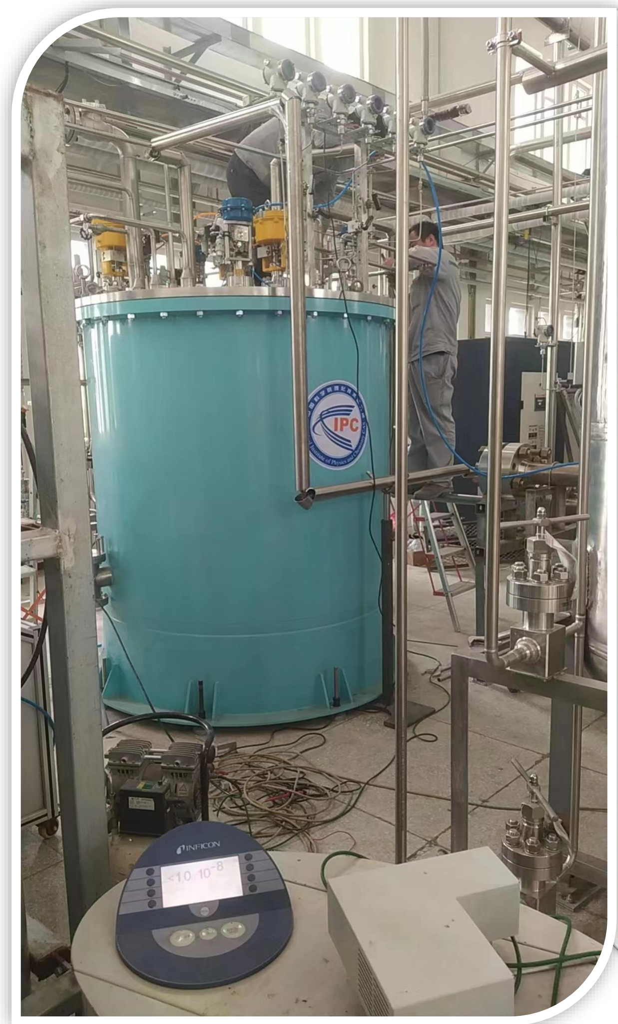


Compressors station

- ➢ In order to prevent the system from being polluted, the compressor adopts oil-free diaphragm compressor, the inlet pressure is 5-12.5MPa, and the outlet pressure is ≤35Mpa.
- ➢ The compressor can be used for pre-cooling and filling processes. In the pre-cooling process, it is used as a circulating compressor with a operating pressure of 10Mpa, and in the filling process, it is used as a booster compressor with a maximum outlet pressure of 35MPa.

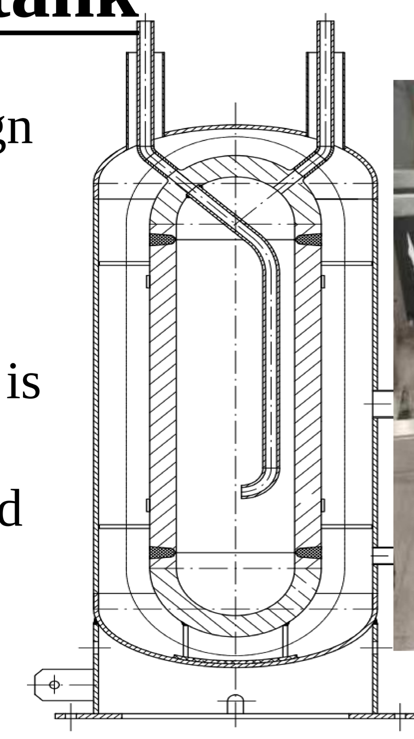
Cold box

- ✓ The shape and internal structure diagram of the cold box are shown on the right.
- ✓ The cold box is composed of an upper flange and a cylinder body, and HEX1-3 is installed inside the cold box; The actuator and control elements of valves, pressure gauges, thermometers, etc are installed on the upper flange cover of the cold box.
- ✓ All the pipes in the cold box are welded by argon arc welding, and each welding joint has been treated by liquid nitrogen cold shock at least 3 times.
- ✓ After cold shock, the leakage detection rate of the welding joint by helium mass spectrometry is better than 1x10-11 Pam³/s.
- ✓ High vacuum multi-layer insulation material is arranged on the surface of the internal equipment.
- ✓ The integrated leakage rate of the whole cold box is better than 1x10-10Pam³/s.

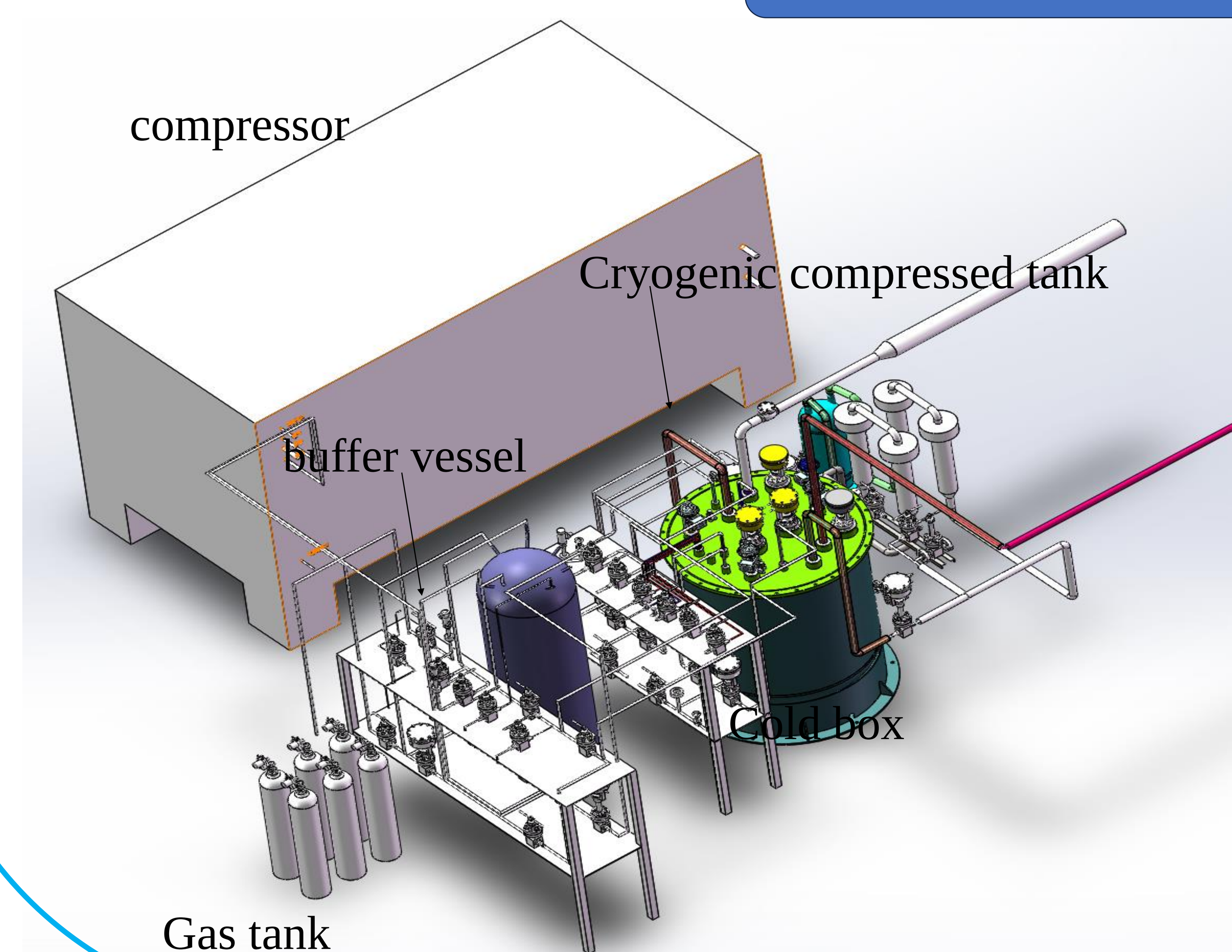


Cryogenic compressed tank

- ✓ The cryogenic compressed tank adopts the traditional cryogenic tank design method. It has a capacity of 10L and is made of stainless steel. The inner tank is wrapped with multiple layers of insulation material and placed within a vacuum chamber.
- ➢ To ensure rapid cooling of the storage tank, a specialized structural design is implemented for the inlet pipe section.
- ➢ In order to facilitate future widespread application, a cryogenic compressed storage tank with an aluminum alloy-wound carbon fiber inner tank is currently under development.



Conclusion



The current experimental system has been fully integrated and has completed pressure testing. Under a pressure of 43.76 MPa, the pressure drop of the system over a 24-hour period is far less than 0.2%. In the future, the system will be filled with liquid nitrogen for testing its low-temperature performance and getting experimental experience to guide future design and measurement.