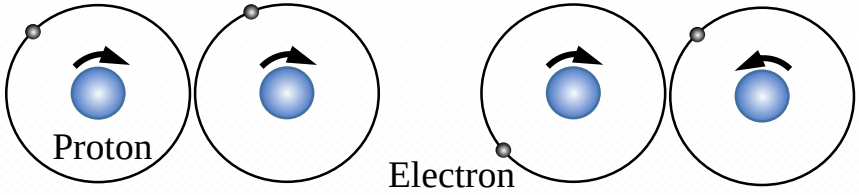
Ortho-Para hydrogen convertor design for a 0.5 TPD scale of hydrogen liquefaction plant

M.K GONG [1], H.M. LIM [1,2],J. PARK [1], and S.W. KARNG [1,*]

[1] Korea Institute of Science and Technology, Republic of Korea
[2] University of Seoul, Republic of Korea

[*] Corresponding author, email : libra@kist.re.kr

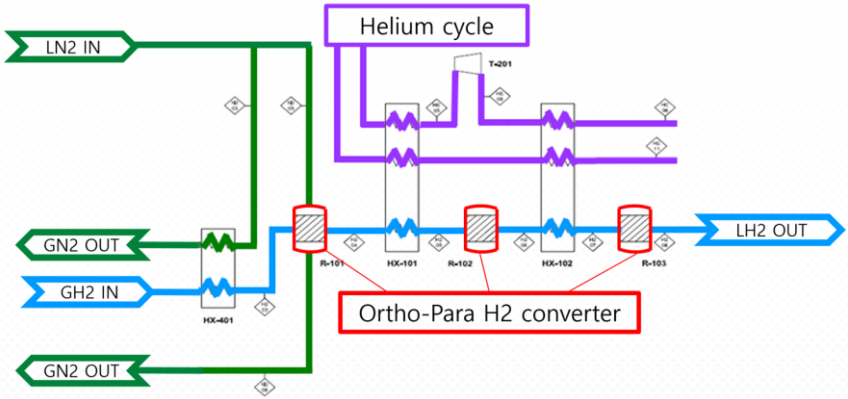
1. Hydrogen prospects in Korea



<Ortho hydrogen> <Para hydrogen>

- ✓ 7 billion tons of hydrogen will be expected to be needed a year in Korea, 2030 (Hydrogen Council).
- ✓ Because liquid hydrogen-based hydrogen infrastructure is needed to meet the demand, a 0.5 TPD scale of hydrogen liquefaction plant is to be constructed in Korea, 2021.
- ✓ Without ortho-para hydrogen conversion during the hydrogen liquefaction process, the conversion with an exothermic reaction will take place due to ortho-para hydrogen equilibrium on temperature.

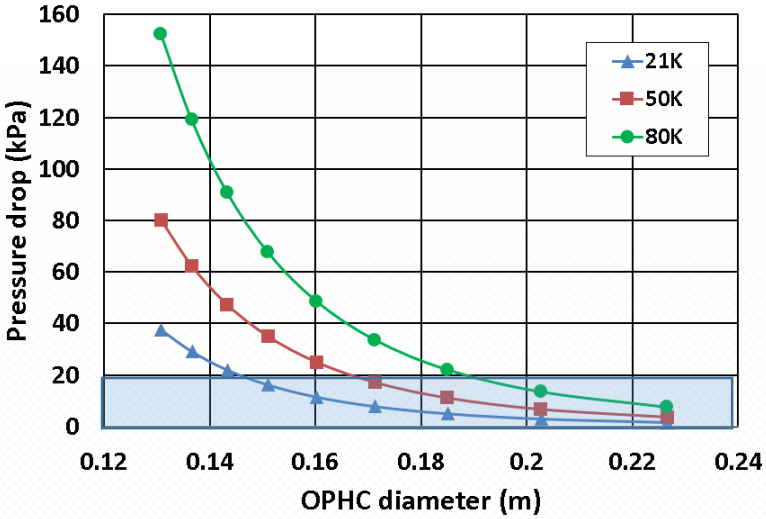
2. Ortho-para hydrogen conversion



Temp. (K)	Equilibrium Para Hydrogen (%)	Heat of Conversion (kJ/kg)
20	99.821	527.138
50	77.054	526.845
80	48.537	513.932
150	28.603	322.495
300	25.072	27.562

- ✓ Three of Ortho-Para Hydrogen Converters (OPHC) will be installed separately in the liquefaction process.
- ✓ The inlet temperatures to the OPHCs calculated by using Aspen HYSYS V11 with REFPROP V10 from NIST were 80K, 50K, and 21K at three consequent steps.
- ✓ Ergun's Correlation was used for estimating the pressure drop in the OPHC.
- ✓ Space velocity and rate constant was used for calculating the amount of catalyst and reacting time.

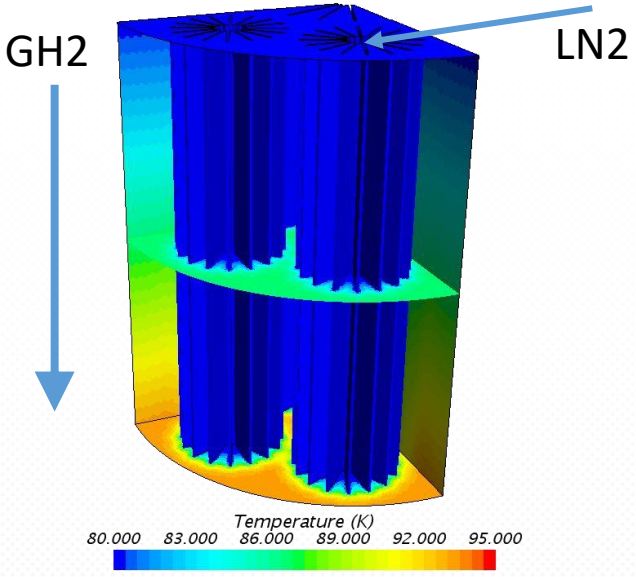
3. Results

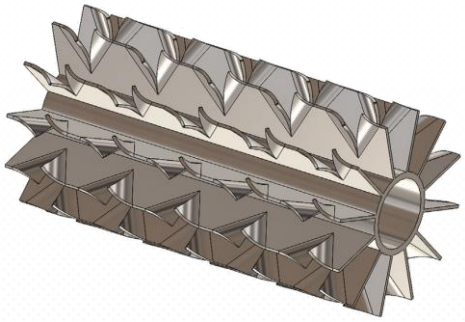


Temperature (K)	300	80	50	21
Mole Fraction of Ortho-H2 (%)	74.9	51.5	22.9	0.18
Conversion heat (kJ/kg)	-	161.7	201	159.8
Reacting time (s)	-	0.071	0.153	0.919

- ✓ The shapes of the three proto-type OPHCs were selected cylindrical container. Pressure drops (<20 kPa). through the OPHCs were calculated on various of inlet temperatures and diameters.
- ✓ Because the mole concentration of ortho hydrogen decreases as the ortho-para hydrogen conversion progresses, longer reaction times are needed.

3. Results





※ P. Stehlík et al., Possibilities of intensifying heat transfer through finned surfaces in heat exchangers for high temperature applications, 2014

- ✓ The structure of LN2 tube with longitudinal plain fin through the packed catalyst was considered to reduce pressure drop in a cylindrical shape of the 1st OPHC.
- ✓ Thermal analysis was carried out by using Siemens Star-CCM+ V13.06 .
- ✓ Because the environment in which the catalyst is filled is difficult to convective heat transfer by hydrogen and the thermal conductivity of hydrogen is also low, thermal stagnation is concentrated in far areas from fins.