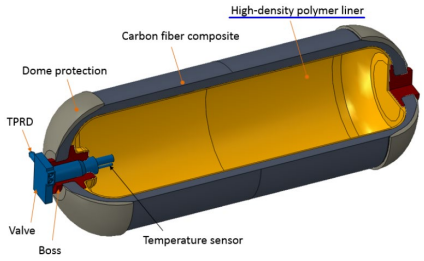
Visit Report

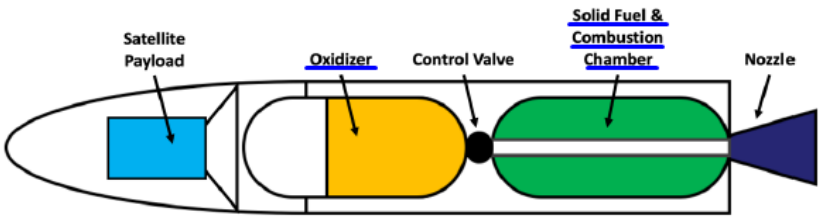
To : CHAA
Cc : CAAG, FNM, WNGJ, GUOS, LIAW,
GUOC, ZHAI, LINR, XUEA, FUJT, WANS
From : HAJU

Date of visit: 10 July. 2023
Date of report: 21 July. 2023

TI SPACE

Participants	:	TI SPACE : Ph.D Chieh Yu *(Manager)*
		EMS : J. Ha. A.Chang
OEM	:	Interspiro
Sales responsible	:	CHAA
Distributor	:	N/A
Location	:	Taiwan
Application	:	Hydrogen/Oxidizer tank liner of a rocket
Segment Code	:	210
Project number	:	N/A(New customer, PDS will be raised after a feasibility)
Material	:	Grilamid L25A NZ
USP	:	Better H2 permeability of PA than XLPE (Cross-linked polyethylene)
Potential	:	30 t/a
SOP	:	3Q.2024





1. Target of visit

Check application information and project status.

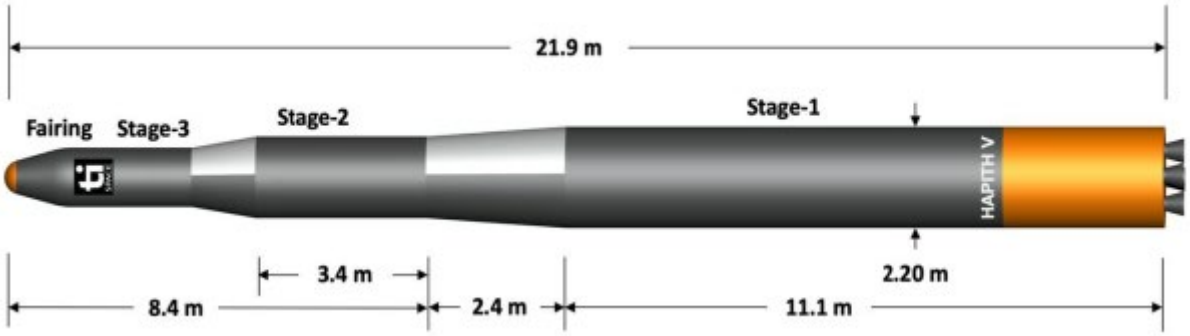
2. Summary

- TI SPACE is interested in PA12 which has less hydrogen permeability than HDPE and PA6.
- Specimens made of L25G for checking the bonding strength with CFRP have been delivered, and verification of bonding with TPRD for airtightness and hydrogen permeability will be carried out
- Blow moulding for hydrogen tank is not a problem with exist products, but rotational moulding for oxidizing tank require a powder
- Will check a powder supply is available and a powder product

3. Details

Customer & Project information

- Target application is oxidizing tank plastic liner of Stage-2, 3 and hydrogen tank plastic liner.
  * Oxidizing tank liner of Stage-1 is a metal, not plastic.



- HDPE(High density polyethylene) is used as the first choice for the liner material of hydrogen tanks. In addition, polyamide polymers are gradually being accepted because of good gas barrier properties and PA12 has better the hydrogen permeability than PA6.
- The hydrogen permeability of PE100 with a crystallinity of 60% was actually higher than that of PA11 with a crystallinity of 20% for PE100
- The hydrogen permeability coefficient of PA12 is 5 times that of PA6, as high as $3.42x10^{-15}$ mol(Pa.m.s)
- EMS doesn't have H2 permeability of PA12, it would cost several 1000 EUR per material.
- Hydrogen tank is manufactured via blow molding, oxidizing tank is manufactured via rotational molding and a powder of material will be required for rotational molding.

- To check a bonding with CFRP, tensile bar specimens made of L25G was provided.

Part & Test Requirement

- Good bonding with CFRP(Carbon Fiber Reinforce Plastic)
- Good bonding with TPRD(Thermally activated Pressure Relied Device) for airtightness
- The hydrogen permeability coefficient of the liner material is less than $1.24*10^{-15}$mol m^{-1} s^{-1} Pa^{-1}(ISO 19881-2018)

4. Actions

No.	Action	Resp.	Due date
1	Check a bonding test result between L25G and CFRP, power product.	HAJU	30.08.2023
2	Check 3rd party to measure the hydrogen permeability	HAJU	30.08.2023
3	Check a powder supply is available in Taiwan via 3rd party.	CHAA	30.09.2023

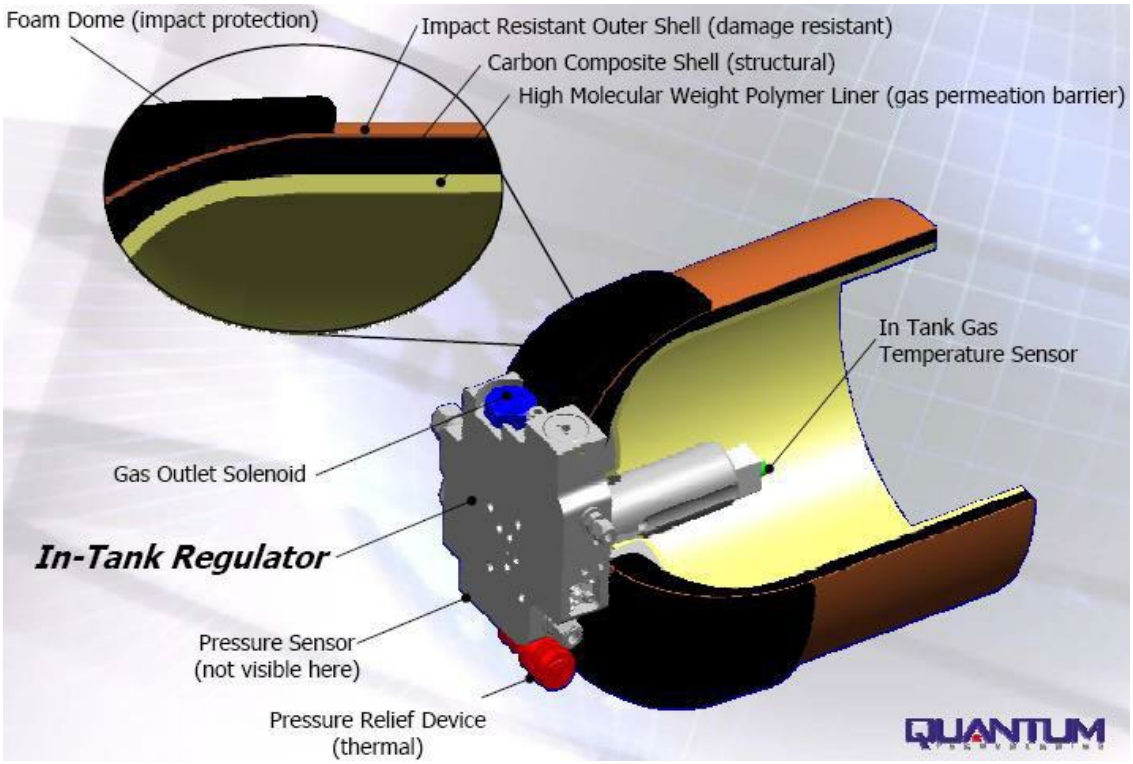
5. Attachments

#1 Hydrogen storage tank structure
#2 Market info. of the hydrogen tank
#3 Rotational moulding

Best regards,

Jun Ha

#1 Hydrogen storage tank structure



#2 Market info. of the hydrogen tank

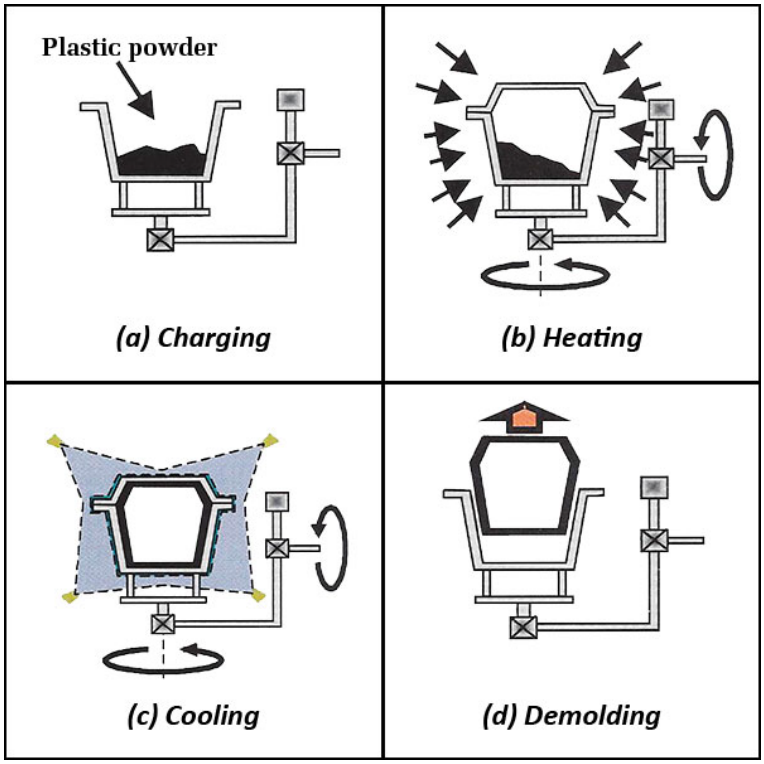
Green hydrogen in China

By 2030, China's industrial demand for green hydrogen will be 25 million tons/year, in the fields of chemical industry, construction, transportation, and steel production.
In the field of transportation, including hydrogen stations and hydrogen vehicles, the annual demand for green hydrogen is about 3 million tons. It can be seen that the demand for green hydrogen in the industrial sector is 10 times that of all transportation sectors (Fuel-cell vehicles).

Hydrogen storage tank
The demand for carbon fiber for hydrogen storage tank will increase in the future.
Compared with the traditional steel hydrogen storage tank, the new high-strength carbon fiber hydrogen storage tank overcomes the problem of hydrogen embrittlement, greatly improves the safety and reduces the weight, and becomes an important hydrogen storage tool for fuel cell vehicles. As the hydrogen storage bottle is a special equipment with high safety requirements, the carbon fiber hydrogen storage bottle uses T700 high-end carbon fiber, accounting for more than 60% of the total cost.

With the increase of the demand for hydrogen storage bottles and the increase of the unit consumption of carbon fiber, the demand for carbon fiber for hydrogen storage will usher in an explosive growth. It is estimated that the demand for carbon fiber for hydrogen storage will exceed 34000 tons by 2025.
Current companies in fast progress for Hydrogen tank: **BOSCH, Plastic Omnium, Shenyang Silinda.**

#3 Rotational mouding
<Process>



<Key advantages>

- Low tooling costs. As this is a casting process there is no pressure. This means moulds are inexpensive and low volume can be economic. If you have a great idea for a new product but don't know how many you'll sell or simply want a low volume production run, rotomoulding's low initial investment makes it particularly attractive.
- It's easy to make complicated shapes. Rotomoulding readily accommodates production complexities such as stiffening ribs, moulded inserts and different surface textures.
- Uniform wall thickness. Rotomoulding achieves consistent wall thickness with corners tending to be thicker. This increases product strength and integrity. Other processes such as blow moulding stretch the molten material at corners or sharp edges creating potential thin spots and weaknesses.
- Rotational moulding machine costs are low compared to other processes and the investment required is small. There is great production flexibility with the process.
- There is almost no limit to the size of products and several different products can be moulded at the same time.

<Products>

- Tanks for storing water and chemicals – up to 50,000 litres
- Material handling products such as containers, crates, pallets and insulated fish and cooler boxes.
- Environmental products which include litter bins, road cones, bollards, traffic dividers and road signs.
- Floats, buoys and pontoons.
- Automotive products such as truck mudguards, ducting, diesel fuel tanks, toolboxes and tractor dashboards.
- Kayaks, canoes and boats
- Products for the outdoors such as garden planters, water butts and furniture.
- Toys and playground equipment.