6–5 R&D on CO_2-Free H_2 Production by the IS Process

— Progress from Lab Stage to Industrial-Material-Facility Stage —

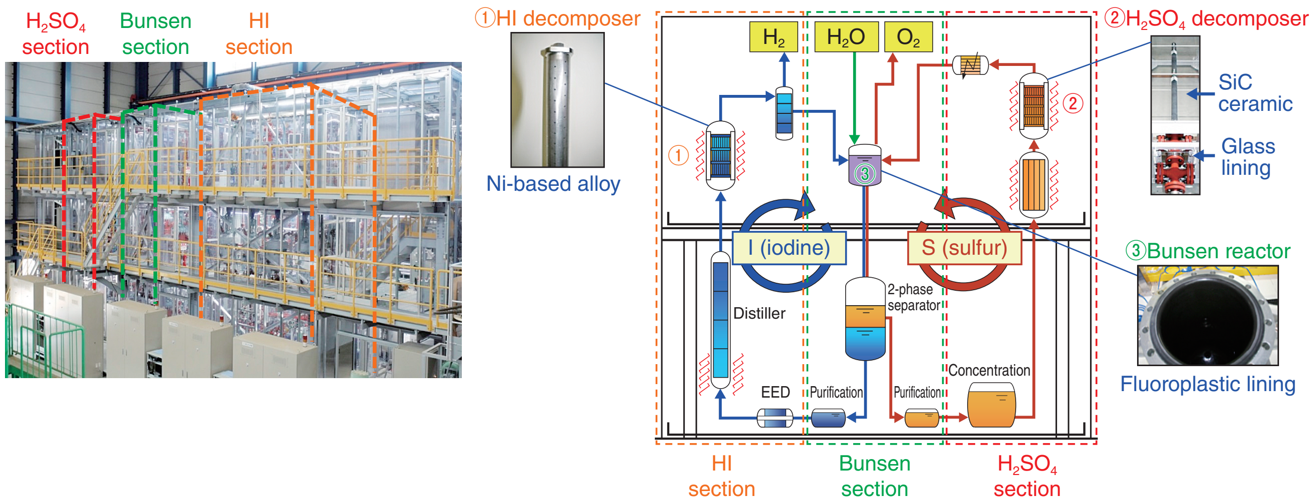

Fig.6-10 Continuous-H_2-production test facility
(Left) Photo of the facility: Size, 18.5 m (W) × 5.0 m (D) × 8.1 m (H). (Right) Structure and reactor components: Materials used for liquid-phase components not shown in the figure include impervious graphite for electro-electrodialysis (EED) HI concentrators and heat exchangers, as well as fluoroplastic- and glass-linings for other components and lines.

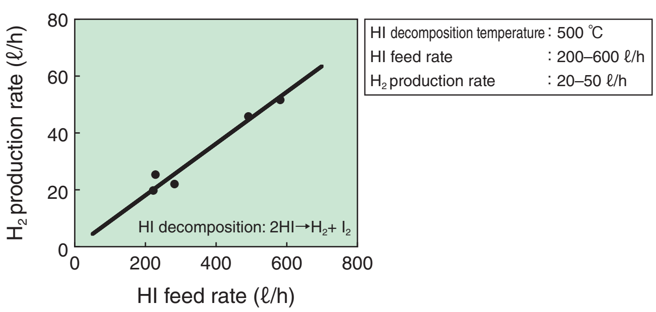

Fig.6-11 Effect of HI feed upon H_2 production in a HI decomposer
The H_2-production rate is controllable by changing the HI-feed rate because the one is proportional to the other.
Reprint from Takegami, H. et al., 2016 Annual Meeting of AESJ, 2N23 (in Japanese), (partly modified)

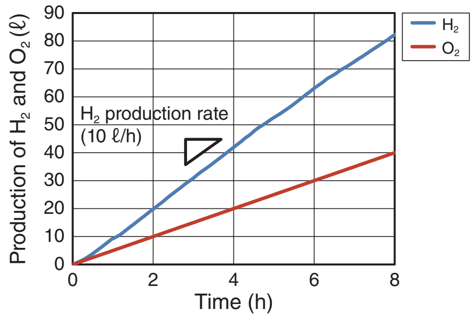

Fig.6-12 Total H_2 and O_2 production in a process demonstration
H_2O is decomposed at a constant rate and H_2- and O_2-production rates are balanced by considering a constant gradient and H_2/O_2-production ratio that is constant at 2.

We have performed R&D on thermochemical hydrogen (H_2)-production using iodine-sulfur (IS) process as an application of High Temperature Gas-cooled Reactor (HTGR) heat. The IS process consists of Bunsen reaction to produce hydrogen iodide (HI) and sulfuric acid (H_2SO_4), HI decomposition to produce H_2, and H_2SO_4 decomposition to produce oxygen (O_2). Overall, H_2O is decomposed into H_2 and O_2. The IS process is expected to offer CO_2-free H_2 production because carbon is neither in the material nor in the energy source.

We succeeded in conducting a one-week continuous H_2 production using a lab-scale facility in FY2004. Components in the facility was made of glass. Corrosion- and heat-resistant components of industrial materials are required for commercialization because large-scale structures cannot be made of glass.

We constructed a test facility in FY2013 by applying corrosion- and heat-resistant materials to the whole process (left in Fig.6-10). Reactors were developed and integrated into each section (right in Fig.6-10). The designed H_2-production rate was 100 ℓ/h. The functionality of individual sections was verified in FY2015. Process-rate control in reactors, such as control of H_2 production by HI feeding (Fig.6-11), and phase separation (such as HI distillation) were verified. Then, a demonstration was performed by coupling the 3 sections. An 8-h continuous H_2 production at 10 ℓ/h was achieved in February 2016 (Fig.6-12). By checking the facilities after operations and performing operational-data analysis, we found that clogging prevention and Bunsen-solution-composition control were important for longer-term operation.

We plan to improve the facility based on these findings for longer-term operations to verify the technology and integrity of the facility.

Reference

Kasahara, S. et al., Current R&D Status of Thermochemical Water Splitting Iodine-Sulfur Process in Japan Atomic Energy Agency, International Journal of Hydrogen Energy, vol.42, issue 19, 2017, p.13477-13485.