AMMONIA ENERGY SYSTEM

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Contents

Summary

Merits of an ammonia energy system can be summarized as follows. Nitrogen as a carrier of hydrogen can be obtained infinitely. Ammonia synthesis is an established technology. It is free from CO_2 problems because carbon is not used in the whole system. The yield rate of energy at arrival port is high.

The disadvantages are as follows. Ammonia is poisonous and has an unpleasant smell. It has a large energy loss because of ammonia thermal decomposition and through the decomposed gas separation after arrival. Direct use of ammonia will be necessary. One is a direct combustion without high NOx emission, and another is direct ammonia supply for fuel cell.

1. Features of Ammonia Energy

For the establishment of a global hydrogen energy system, a serious bottleneck for global transportation is that hydrogen, either gas or liquid, has a very low energy density.

A plan called the ammonia energy system is being proposed. The feature of this system is the use of nitrogen as a carrier of hydrogen by the following synthetic reaction of ammonia.

$$3H_2 + N_2 \rightarrow 2NH_3 + 92 \text{ kJ/2mol-}NH_3$$
$$3 \times 285.7 \text{ kJ} \quad 2 \times 381 \text{ kJ}$$

About 11% of calorific value/mol that hydrogen for a source owns is lost by the exothermic reaction at synthesis. As a result, 89% of calorific value moves into ammonia as a theoretical value. Thus, in the course of making the energy density nearly as high as fossil fuels, by converting hydrogen to ammonia that can be easily liquefied, that makes it possible to transport hydrogen remotely by tanks. The merit of an ammonia energy system is that nitrogen as a carrier of hydrogen can be obtained any place in the world because it is the main component of air.

2. Tanker Transportation

Performance of energy carrier in tanker transportation generally depends on the energy density per capacity. The liquefied ammonia has a lower energy density than hydrocarbons (Table 1). However, among the nominees of alternative fuels, ammonia has a much higher energy density than liquid hydrogen. It also has the advantage of the mild handling at low temperature.

In Table 1, liquid natural gas is shown as LNG, liquid hydrogen as LH_2, liquid petroleum gas as LPG, capacity correcting coefficients as A (correcting coefficient by insulation volume), and B (correcting coefficient by spherical tank).

Fuel species	**Energy density for volume**		**Specific gravity**
	10^6cal/ι	A B result	
Liquid Ammonia (–33°C)	3.0	÷1.1; ÷1.54 → 1.8	0.68
LPG (–42°C)	6.5	÷1.1; ÷1.54 → 3.8	0.58
LNG (–161°C)	5.7	÷1.2; ÷1.54 → 3.1	0.43
LH_2 (–253°C)	2.2	÷1.3; ÷1.54 → 1.1	0.07
Methanol	4.2	—	0.79
Heavy oil	9.5	—	0.95

Table 1. Energy densities of various cargo-fuels.

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Biographical Sketch

Hirosi Sano graduated from Chemical Division, Faculty of Science, Niigata University (March 1955); joined GIRIO (Government Industrial Research Institute of Osaka JAPAN) Chemistry Section (April 1955); moved to Osaka Gas Co., Ltd. Research Center (February 1992); moved to Lab. Office of Global Energy System (to follow up to RITE, CO_2 chemical recycling project); Project and Theme: Dr. Engineering at Kyoto University (1978); Sunshine Project (Hydrogen Energy System) (1974–1990); awarded “Approach toward Compatible Solution for Energy & Global Environmental Problems” by Japan Society of Energy & Resources (1989); RITE Feasibility Study “CO_2 global recycling system Using by Natural Energy” (1990–1993); RITE Project “CO_2 chemical recycling system” (1995–).