Dynamics of Ammonia Combustion

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Abstract

Ammonia, which contains 18wt% hydrogen, is one of the hydrogen carriers in the hydrogen energy community. On the other hand, in the combustion community, ammonia can be considered as a potential carbon-free fuel when it is produced using renewable energy or even when it is obtained from natural gas or lignite with CCS. Ammonia has advantages in transportation and storage since its thermal properties are almost the same as those of propane in terms of boiling point temperature and pressure and also because the necessary infrastructure has already been established in the past 100 years. Although research on the practical use of ammonia as a fuel was performed in the 1960s, results were not sufficiently successful because of its very low combustion efficiency. Lately, utilization of ammonia as a carbon-free fuel is again of interest, and research projects on ammonia combustion have started in Europe and Japan.

The Cross-ministerial Strategic Innovation Promotion Program (SIP), 'Energy Carriers', in Japan, which was started in 2014, deals with ammonia combustion for gas turbine power generation, reciprocal engines, and industrial furnaces, as well as with pulverized coal power generation in which a certain amount of pulverized coal is replaced by ammonia. In the project, 41.5 kW power generation with a 100% ammonia fueled micro gas turbine succeeded in 2015 [1].

Challenges of ammonia combustion from the point of view of combustion fundamentals include low combustibility, i.e., low burning velocity of 7 cm/s at most, high ignition temperature, narrow flammable range, etc., and fuel NOx emission, as well as low radiation heat transfer when used for industrial furnaces. Research on combustion dynamics and the structure of ammonia flames combined with flame chemistry is essential to overcome these difficulties and to improve the design of systems using ammonia as a fuel. In this lecture, the characteristics of ammonia combustion in terms of flame dynamics and chemistry and recent progress in R&D of practical ammonia combustion systems are presented.

[1] O. Kurata, N. Iki, T. Matsunuma, T. Inoue, T. Tsujimura, H. Furutani, H. Kobayashi, A. Hayakawa, Performances and Emission Characteristics of NH_3-air and NH_3-CH_4-air Combustion Gas-Turbine Power Generations, Proceedings of the Combustion Institute, Vol. 36, (2017), pp. 3351-3359.

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