The Development of Fuel Cell Scooters in Taiwan

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1. Introduction

Taiwan has the highest scooter density area in the world. There are 11 million scooters for over 23 million residents in the 36 thousand square kilometer area. On average, every two people own one scooter and 88% of families have at least one scooter. Scooters are very convenient for commuters, students and small businessmen. However, internal-combustion-engine scooters cause serious environmental pollution. According to the Taiwan Environmental Protection Administration's statistical data, all scooters emit 330 thousand tons of CO and 90 thousand tons of HC every year, making up 12% and 8% of the total pollutants. Furthermore, scooters emit 1.8 million tons of CO2 each year. Therefore, the environment is severely polluted by scooters should be improved immediately. To solve the serious pollution problem caused by engine scooters in Taiwan, there is an urgent need to apply environmentally friendly technologies to power the two-wheeled--as well as four-wheeled--vehicles. Fuel cell technology is a potential solution with the brightest prospects for Taiwan and elsewhere.

2. The Progress of Fuel Cell Scooters in Taiwan

To promote fuel cell scooters in Taiwan, the Taiwan Institute of Economic Research (TIER) and other related organizations have been working together for more than four years. In 1998, TIER collaborated with local motorcycle manufactures as well as its partner in the USA, the W. Alton Jones Foundation, to promote fuel cell technology for scooters. Through their sponsorship and efforts, the world's first fuel cell scooter prototype--Zero Emission Scooter (ZES I; see Figure 1)--was built by Desert Research Institute (DRI), USA. ZES I was remodeled from an existing battery powered scooter. All fuel cell engine components were purchased from commercially available sources. Obviously, almost all components, including the 2kW PEM fuel cell stack, were bulky and not designed for optimal scooter integration. ZES I was tested at the Automotive Research and Testing Center (ARTC) in Taiwan and, as expected, its performance was not spectacular, mainly due to low stack output power. Nevertheless, ZES I fulfilled its purpose of demonstrating the applicability and feasibility of fuel cell technology for scooters.

In October 2000, Asia Pacific Fuel Cell Technologies Ltd. (APFCT),in collaboration with Kwang-Yang Motor Co., completed the second generation Zero Emission Scooter (ZES II; see Figure 1), which was exhibited during the 2000 Fuel Cell Seminar conference on October 30, in Portland, Oregon. ZES II was equipped with a specially designed ambient pressure PEM fuel cell stack and metal hydride hydrogen supply system. Although ZES II did not achieve an

objective function equal to internal–combustion-engine scooters, its purpose for serving as a test bed for verification of the fuel cell engine system concept and integration was successful. ZES II also showed commercial potential. ZES II was a conversion electric scooter powered by the APFCT fuel cell engine and metal hydride hydrogen storage system. The ZES prototype has since been through several developmental generations as a test bed to verify improvements in fuel cell engine components.

In June 2001, the developmental scooter ZES II.5 (see Figure 1) was unveiled. It embodies an improved cooling system and fuel cell stack for higher performance and thermal management. Developmental scooter ZES II.6 (see Figure 1) was produced in December 2001 and incorporates the most advanced fuel cell stack and on-board hydrogen supply systems.

Development of the third generation fuel cell scooter, ZES III (see Figure 1) began in December 2000 and was completed in June 2002. ZES III (see Figure 1) is a totally new integrated fuel cell/chassis scooter designed from the ground-up. Its modern European styling compliments its advanced fuel cell engine technology. It rationally matches the fuel cell engine with the drive train. However, the performance doesn't match the expected targets, especially for over 100kg. Moreover, it's durability remains to be tested.

The creation of the commercial model of fuel cell scooters, ZES IV, and a factory for fuel cell engines is projected to commence in 2004. When annual output reaches 100,000 scooters, the estimated selling price for each fuel cell scooter will be about US$2,200. As output doubles, the estimated price will drop to about US$1,730, roughly the current market price of a 125 c.c. scooter. The scooter's design and performance will be comparable to conventional gasoline engine scooters and it will be competitively priced. (APFCT, 2002)

Figure 1. Fuel Cell Scooters

Source: APFCT, 2002.

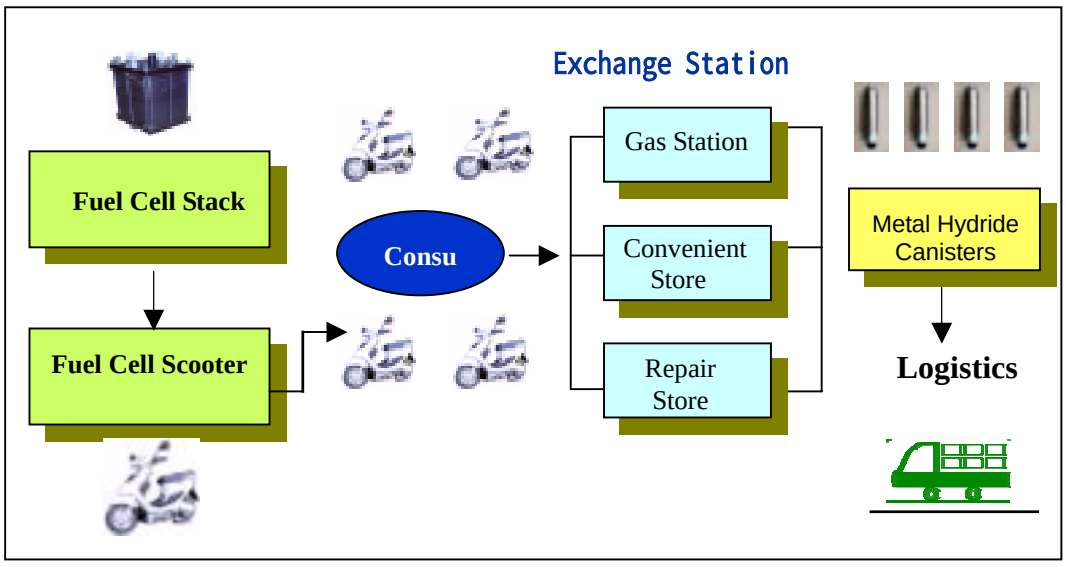
3.Hydrogen Fuel Supply System of Fuel Cell Scooters

In terms of storage density, convenience, safety and cost, the hydrogen storage alloy metal, which uses FeTi as its main material, is the best way to store hydrogen currently. In addition, the metal hydride hydrogen storage canisters can be designed with quick disengagement connectors, like an interchangeable one for exchanging when the vehicle cover is opened, for easy replacements. Consumers do not need to be in direct contact with hydrogen when replacing their hydrogen canisters.

If fuel cell scooters are to be accepted by the consumer market, a hydrogen fuel distribution supply system has to be set up to avoid pitfalls, such as Taiwan's past failure in developing liquified petroleum taxis and promoting recharged-battery driven scooters.

From the hydrogen distribution system shown in Fig 2 we can see that when fuel cell scooters need to refill with hydrogen fuels, the scooter drivers can drive to fuel stations, scooter repair centers or convenient stores and exchange empty metal hydride canisters with filled ones. Logistics companies will circulate the empty metal hydride canisters. This means the empty metal hydride canisters can be delivered to and replaced at the exchange stations, which in turn the empty metal hydride canisters are delivered back to the factory.

Figure 2. Industry Infrastructure of Fuel Cell Scooters



Source: TIER

4. Taiwan Fuel Cell Partnership

To develop the fuel cell industry in Taiwan, the Taiwan Fuel Cell Partnership (TFCP),was established in July 2002. The purpose of TFCP is to integrate the development of fuel cell technology with the capabilities of industry, government, and academic research. There are six subcommittees-fuel committee, fuel cell committee, vehicle committee, generator and other application committee, code & standard committee and industrial development committee. Each of the committees has its own mission to promote the fuel cell development. The mission of the Taiwan Fuel Cell Partnership is as follows:

a. to develop the standards and regulations of fuel cells, fuel supply systems, and fuel cell scooters;
b. to test and verify fuel cell scooters;
c. to demonstrate the fuel cell scooter fleet; and
d. to hold the domestic fuel cell forum and the international fuel cell conference.

Among these tasks, promoting fuel cell scooters will be the most important objective in the beginning phase.

The website of "Taiwan Fuel Cell Information (http://tfci.org.tw) was established in September 2002. There is a substantial amount of information about fuel cells, the introduction of fuel cells, news, papers, periodicals, and an area belonging to partnership members to communicate messages. There is only a Chinese version now. There will be an English version in the near future.

For this year 2003, TFCP is focusing on studying and drafting the fuel cell codes and standards, especially related to the fuel cell scooters. Evaluating a proper place to hold the demonstration fleet is another priority for TFCP. According to the evaluation for the time being, Green Island, a tourist islet off the east coast of Taiwan, is the most proper place to demonstrate the fuel cell scooter fleet. In addition, education and conservancy awareness is important as well. TFCP is planning to make a set of teaching materials about fuel cells to spread this technology to elementary students.

5. Conclusion

Air pollution in Taiwan is rapidly increasing to dangerous levels. A major source of emission comes from the exhausts of gasoline scooters. Therefore, the government and the technological industrial fields are making an effort to apply new technology, fuel cell technology, for developing environmentally friendly scooters.

References

Journal Articles:

1. Bruce Lin, "Conceptual Design and Modeling of a Fuel Cell Scooter for Urban Asia", Journal of Power Sources 86(2000) 202-213.
2. James H. Wang, Wei-Li Chiang, Jet P.H. Shu, "The Prospects - Fuel Cell Motorcycle in Taiwan", Journal of Power Sources 86(2000) 151-157.
3. Whitney G. Colella, "Market Prospects, Design Features, and Performance of a Fuel Cell-powered Scooter", Journal of Power Sources 86(2000) 255-260.
4. Tso, C. and Chang, S., "A viable niche market - fuel cell scooters in Taiwan" , International Journal of Hydrogen Energy, 2003, Vol.28, issue 7, pp.757-762

Reports:

1. "Asia Pacific Fuel Cell Technologies Ltd. (APFCT) Introduction", Taiwan, 2002.
2. Chang, S., "Oncoming Vehicles-Fuel Cell scooters", Taiwan Economic Research Monthly, November 2000.

3.“Electric Motorcycle Development Action Plan”, Environmental Protection Administration (EPA), Executive Yuan, R.O.C., March 1998.
4.“Fuel Cell Technologies for Use in Transportation Applications-With the World First Zero Emission Scooter Demonstration”, Conference Proceedings, Taiwan Institute of Economic Research (TIER), Taiwan, April 1999.
5. Tso, C., “Characteristics and application of fuel cells”, National Science council, the Executive Yuan, January 2001.
6. Tso, C. and Chang, S., “Technical Feasibility and Market Potential for Fuel cell Scooters in Taiwan”, Proceedings of Fuel Cell 2001 Seminar, Tokyo Japan, July 2001.
7. Yang, J., “PEM Fuel Cell Power for Electric Scooters”, YS Power Company, September 1999.
8.Yang, J., Tso, C. and Wu, K., “Fuel Cell Powered Scooters in Taiwan” Proceedings of Fuel Cell 2000 Seminar, Portland, Oragon, USA, November, 2000.