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Extended Abstract

An Oxygen Balance Method: Fuel Consumption Measurement for Fuel Cell Vehicles based on Exhaust Emissions with No Vehicle Modification

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Abstract

For the measurement of fuel consumption of fuel cell vehicles (FCV), ISO 23828 and SAE J2572 standards recommend three methods, the gravimetric, pressure and flow methods. These methods can measure with a high accuracy and have proven its practicability in the fuel economy test, but require the test vehicle to be modified to supply hydrogen from an external, rather than the on-board fuel tank. As these vehicle modifications necessitate technical assistance of the vehicle manufacturer, a simpler no-modification method such as the carbon balance method for gasoline- and diesel-fuelled vehicles is desired. Therefore, the authors have developed new method using only FCV exhaust emissions. This paper describes the principles behind the new method as well as test equipment and results, influence factors in error and issues. As a result, its real-time fuel consumption measurement characteristics were improved by reducing the volume of the gas sampling system and by correcting the time lag in oxygen concentration analysis. Error of the new method was from -3% to +1% as compared with the flow method for the fuel cell system operating in JC08 test cycle.

Keywords:

Fuel consumption; Hydrogen; Exhaust emission; Fuel cell vehicle

Introduction

Efforts are being made to increase the fleet of hybrid, electric and other next-generation vehicles for addressing the issues of global warning and energy conservation. In particular, the fuel cell vehicle (FCV), powered by hydrogen available from a variety of primary energies, is receiving a great deal of attention as a vehicle emitting no air pollutants or CO_2, boasting a long travel distance per fuelling comparable with conventional vehicles, and thus most befitting to future low-carbon society. Japan's first commercial hydrogen station was opened at Amagasaki city, Hyogo in July 2014,and in December of the same year the world's first mass production FCV model was put on sale in Japan. Currently a project is underway to establish at least 100 commercial hydrogen stations in four big city areas and along the expressways connecting these megacities, while the second mass production FCV model has been placed in the market since March 2016. Wider presence of FCVs is expected as automakers are planning to accelerate FCV production

In step with the intensifying efforts for FCV development and commercialization, there is growing importance of developing evaluation techniques for comparing and analyzing the performances of FCVs. While fuel consumption is an essential test item for vehicle registration, the existing carbon balance method is applicable only to internal combustion vehicles and stakeholders have striven to develop a practical fuel consumption measurement method for FCVs. For example, using an external compressed hydrogen cylinder attached to the test FCV, the authors of this paper previously developed the mass method of measuring hydrogen mass variation inside the compressed hydrogen cylinder the pressure method of measuring hydrogen temperature and the flow rate method of measuring hydrogen flow quantity. Those methods were reported for discussions at ISO and SAE.

Results and Discussion

Effect of pipe volume reduction

We verified the effect of reducing the exhaust pipe volume between exhaust outlet and flow meter on the improvement of time lags. Figure 7a and 7b shows the real time fuel consumption measurements for exhaust pipe volumes 9 L and 3 L, respectively,

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each comparing measurements between the oxygen balance method and the hydrogen flow method, the latter method employing a hydrogen flow meter. In Figure 7b with a smaller exhaust pipe volume, the results obtained by the oxygen balance method more closely approximated the hydrogen consumption waveform recorded by the hydrogen flow meter.

Conclusion

We devised an oxygen balance method for calculating the amount of FCV fuel consumption on the basis of the chemical composition of exhaust gas from its tailpipe. The oxygen balance method gives reliable data comparable with those of other fuel consumption measurement methods without necessitating vehicle modifications. Also we developed an exhaust gas flow meter, derived the amount of intake air, and examined the applicability of the oxygen balance method using a fuel cell system. As a result its real time fuel consumption measurement characteristics were improved by reducing the volume of the gas sampling system and by correcting the time lag in oxygen concentration analysis.

Additionally the measurement of a fuel cell system's hydrogen consumption by the oxygen balance method under the JC08 driving cycle gave errors of -3% ~ +1% as compared to the data obtained by a hydrogen flow meter, thus substantially improving from the error level recorded in 2007.

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