# INVESTIGATION OF DYNAMIC CHARACTERISTICS FOR FUEL CELL MOUNTED ON VEHICLE

Sangkeun Ahn

*Hanyang University, Mechanical engineering, Seoul, South Korea*
*email: ask9156@hanyang.ac.kr*

Hyeongcheol Koh

*Hanyang University, Mechanical engineering, Seoul, South Korea*
*email: a30821@naver.com*

Junhong Park

*Hanyang University, Mechanical engineering, Seoul, South Korea*
*email: parkj@hanyang.ac.kr*

The purpose of this study was to identify dynamic characteristics of PEMFC (Proton Exchange Membrane Fuel Cell). Fuel cell in the vehicle get damaged consistently in operating condition. The mode shape of the fuel cell was measured by impact test to find out global mode which affect fuel cell durability. The correlation between the torque of joint bolts and the global mode was investigated. The modal characteristics of fuel cell were compared with increasing bolt torque. To predict elastic properties of the fuel cell, the measurement method of effective dynamic properties was investigated. Structural features of cell stacked was considered when measuring properties. Consequently, the mounting conditions of fuel cell in vehicle were proposed considering predicted elastic properties. The result of this study improves the stability of the fuel cell on the vehicle in operating condition.
Keywords: Fuel cell, Modal characteristics, External vibration, joint bolt

## 1. Introduction

In order to cope with the climate change, the regulations of vehicle exhaust gas are introduced all over the world. The target of regulation is various such as a driving vehicle using an internal combustion engine and a special vehicle for a construction field. Fuel cell is more environment-friendly than conventional internal combustion engines. Due to fuel cells generate electricity from hydrogen, they do not produce pollutants [1-2]. Fuel cells applied to construction machinery and vehicles are exposed to impact signals by external impact or vibration. However, research for the dynamic characteristics of the fuel cells has not been progressed much [3-4].

In this paper, modal characteristics of the fuel cell was measured. Mode shapes of the resonant frequencies were visualized. Each mode shape was compared to identify effect on durability of the cell stack. The frequency responses of the cell stack was investigated with the torque applied to the joint bolts.

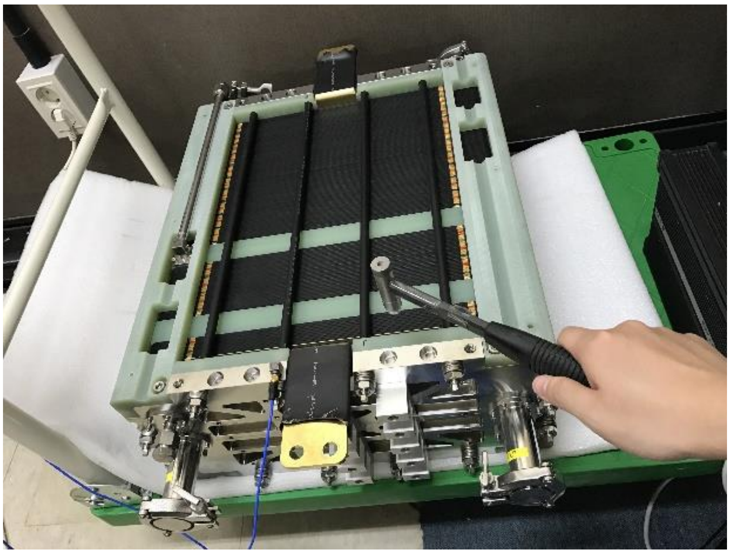

Figure 1: The impact test for dynamic response of the fuel cell

## 2. Body

### 2.1 Modal characteristics

The transfer functions of the fuel cell was measured by using 3-axis accelerometer and shaker shown as Fig. 1. To visualize the mode shapes of fuel cell continuously, about 70 measuring points were selected on the end plate, the cell stack and the joint bolts. Using the magnitude and phase of the transfer functions, the mode shapes of the fuel cell were identified. Low frequency responses below 500Hz were major component of the fuel cell vibration shown as Fig. 2. Especially, the phase of the transfer function on the end plate and the joint bolt were coincident at torsional vibration mode. This behaviour means the vibration is the largest at the torsional mode and the durability of the fuel cell is affected near this frequency range. For this reason, vibrational characteristics of the fuel cells is considered in design process of the mount for the vehicle.

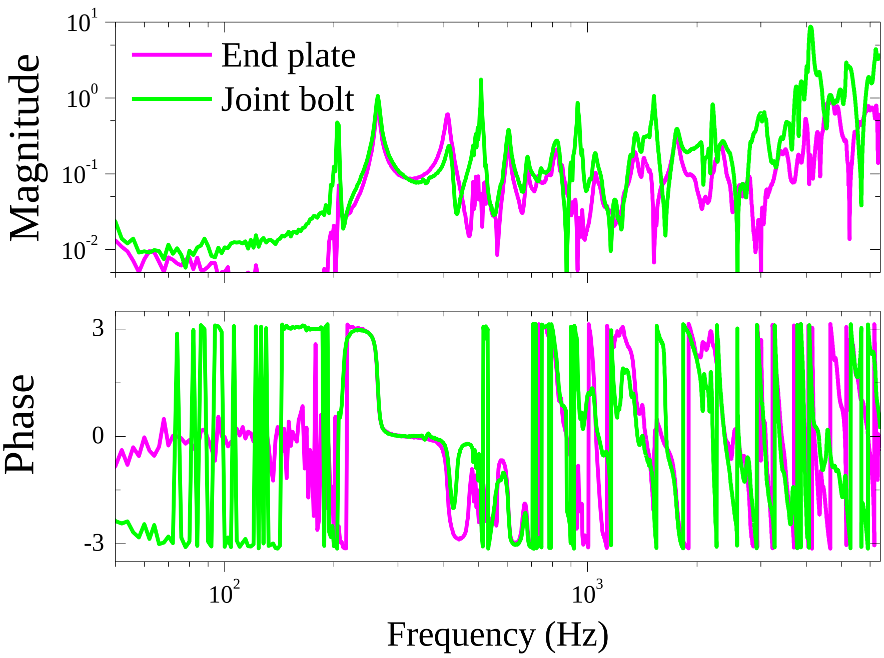


Figure 2: The measured transfer functions of the fuel cell

### 2.2 Property of the fuel cell stack

The fuel cell includes a stacked structure of the unit cells. The dynamic property of the stacked structures was investigated to estimate the dynamic behaviour of the fuel cell. The bending vibration responses of layered beam stacked dozens of aluminium blocks and single aluminium beam were compared. Due to the layered structure of the beam, the elastic modulus of the beam decreased about 50%. The torsional vibration of the layered beam was also investigated. Since the torsional mode of the fuel cell stack is dominant, it is important to identify the torsional behaviour of the stacked structure. The torsional vibration of the structure is affected by the shear modulus. Using the relation between the resonant frequency of the torsional mode and the shear modulus, the shear modulus of the layered structure beam was calculated.

## 3. Conclusion

In this paper, dynamic characteristics of the fuel cells for vehicle were investigated. Mode shapes of the cell stack and joint bolt were measured. Considering mode shape and frequency responses, the torsional vibration mode was significant mode for durability of fuel cell. By measuring dynamic properties of the layered beam, dynamic characteristics of the stacked structure was investigated. After splitting the single beam into dozens of pieces, the dynamic stiffness decreased. In the mount design process, preventing the torsional vibration is necessary point. The dynamic stiffness and damping ratio of the various fuel cell mount will be compared with various dimension to reflect its characteristics.

## 4. Acknowledgement

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20163010031980).

## REFERENCES

1 Chan C. C. The state of the art of electric, hybrid, and fuel cell vehicles, *Proceedings of the IEEE*, **95** (4), 704–718 (2007).

2 Nurettin D., John D. Hybrid Cars Now, Fuel Cell Cars Later, *Science*, **305** (5686), 974-976 (2004).

3 Chi P. H., Chan S. H., Weng F. B., Ay Su, Sui P. C. and Djilali N. On the effects of non-uniform property distribution due to compression in the gas diffusion layer of a PEMFC, *International Journal of Hydrogen energy*, **35** (7), 2936–2948, (2010).

4 Liu B., Liu L. F., Wei M. Y. and Wu C. W. Vibration mode analysis of the proton exchange membrane fuel cell stack, *Journal of Power Sources*, **331**, 299–307 (2016).