수소버스 안전성 평가기술 및 장비개발 연구

THz wave 검사 및 딥러닝을 활용한 플라스틱 라이너의 내부 결함 확인

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Identification of Internal Defects Using THz Wave Inspection of Plastic Liner

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Key Words : Deep learning(딥러닝), C-scan(C-스캔), Non-destructive inspection(비파괴 검사), Hydrogen tank(수소용기), Plastic liner, Terahertz wave(테라헤르츠파)

ABSTRACT

Liquid hydrogen can be used not only as rocket fuel but also in various fields such as ships, drones, and more. Hydrogen tanks for storing liquid hydrogen are being manufactured and commercialized from Type 1 to Type 4. Type 4 hydrogen tanks are made by enclosing a non-metallic plastic liner with carbon fiber. It is challenging to detect defects during the manufacturing process. Therefore, a system capable of detecting defects in the plastic liner is needed.

Non-destructive testing methods available for the plastic liner include radiographic testing (RT), ultrasonic testing (UT), and acoustic emission testing (AE). In an effort to distinguish internal cracks with minimal harm to the human body, THz wave testing was attempted. THz waves use less energy than radiation, making them less harmful to humans. Flat specimens of the plastic liner were created with defects of sizes 1x1, 2x2, 3x3, 4x4, 5x5, and 6x6 [mm^2] and depths of 0.2, 0.4, 0.6, and 0.8 [mm] for testing. Testing was conducted over an area of 60x60 [mm^2] with a 0.2mm interval, and data was acquired. The acquired data was visualized to separate normal and defect areas, and thickness was compared based on the signals in each area.

Since it is difficult for inspectors to check every time, an attempt was made to implement deep learning based on THz wave inspection data. THz wave inspection data was trained as sequence data using video-based LSTM, rather than image-based CNN. Labeling of the areas was performed, and deep learning was conducted using MATLAB programming. The results showed an accuracy of approximately 96%.

If this research technology is applied to the inspection of plastic liners, it has the potential to prevent accidents caused by defects.

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수소버스 내압용기 결함 검출을 위한 LUT 시스템 구성

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Configuration of an LUT System for Detecting Defects in Hydrogen Bus Pressure Vessels

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Key Words : Carbon fiber(탄소섬유), Composite(복합재), Non-destructive inspection(비파괴 검사), Hydrogen tank (수소용기), Laser ultrasonic(레이저 초음파)

ABSTRACT

Hydrogen buses are gaining attention as environmentally friendly and sustainable public vehicles, and pressure vessels play a crucial role in hydrogen storage and supply systems. However, defects in pressure vessels can lead to serious safety and operational issues. Therefore, this study aims to design and implement a system for accurately identifying and efficiently detecting defects in hydrogen bus pressure vessels using Laser Ultrasonic Testing (LUT), one of the non-destructive testing technologies.

We have constructed a system for detecting defects in hydrogen bus pressure vessels using LUT. The system consists of components such as laser ultrasonic scanning, sensors for reading scanned data, signal processing and digitization algorithms, and subsequent data accuracy assurance through deep learning. As a result, this system can measure defects over a wide area. Moreover, the nature of laser technology may cause slight surface damage but is minimal in relation to the structure itself, maintaining the non-destructive testing safety feature. These results are expected to enhance the safety and reliability of hydrogen bus pressure vessels, and the LUT system is anticipated to be adopted as the standard defect detection method in the hydrogen vehicle industry.

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수소버스 실차 성능평가 기반 하이브리드 시스템 출력 시험법의 제안

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Proposal of Hybrid System Power Test Method Based on Fuel Cell Bus Performance Evaluation

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Key Words : Fuel cell bus(수소버스), Hybrid system power method(하이브리드 시스템 출력 시험법), Chassis dynamo test (샤시다이나모 시험), Fuel cell system(연료전지 시스템), GTR 21(GTR 21)

ABSTRACT

In order to reduce the emission of CO2, tremendous effort is being invested into fuel cell electric vehicles (FCEV). Vehicle safety test standards must also be optimized in line with the spread of FCEV. In order to amend the relevant regulation to reflect the reality of FCEV energy flow, this study experimentally investigates the fuel cell bus power systems.

Focusing on the South Korean power motor output test method and the revision of the UN GTR No. 21 system power test method, which is a system output test method that can be applied to FCEV based on the vehicle test results of fuel cell buses in South Korea proposed. The system power test method proposal uses the concepts of TP1 and TP2 defined in GTR No.21. The TP1 method, which calculates downstream from the output of the fuel cell and battery, measures the output of the fuel cell and battery, and for estimating the mechanical output of the motor, considers the loss up to the motor (K1) and adjusts the system. It is necessary to estimate the output, and we proposed an inverter supply power formula for fuel cell vehicles that can be applied to all system configurations of FCEV.

As for the TP2 method, which calculates upstream from the tire and wheel output, there are two methods, the chassis dynamo test and the wheel dynamo test. Since the rolling resistance of the tire fluctuates greatly depending on the temperature, the deviation of the K2 loss spreads. Therefore, when measuring TP2 in the chassis dynamo test, we proposed that it is necessary to measure the surface temperature of the tire and improve the accuracy of K2 in order to suppress fluctuations in rolling resistance.

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전기 트럭의 경사로 밀림 방지 안전 제어 시스템 분석 및 구현

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Analysis and Implementation of a Safety Control System to Prevent Sliding on Ramps for Electric Trucks

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Key Words : Saftety control system(안전 제어시스템), Prevent sliding on ramps(경사로 밀림 방지), Hill-start assist control (언덕 출발 보조 제어), Electric Trucks(전기 트럭)

ABSTRACT

Conventional vehicles are equipped with a safety system called HSA (Hill-Start Assist Control) that automatically maintains brake pressure during hill starts to prevent rolling backward and slipping on slopes while driving. This system uses brake pressure and slope sensors to adjust the brake pressure according to the situation, preventing the vehicle from slipping contrary to the driver's intentions. In this paper, we design a safety control system to prevent sliding on slopes for electric trucks. Utilizing torque control through current control of the AC motor in the electric truck, we implement internal speed and external angle controllers to realize the system. We present the system by applying it to an actual electric truck and conducting experiments to demonstrate the prevention of sliding on slopes during hill driving. Additionally, we propose approaches for more effective prevention.

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수소전기차용 타입Ⅳ 용기의 투과량 측정에 관한 연구

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Study on the Permeation Measurement of Type Ⅳ Hydrogen Fuel Cell Vehicle Tanks

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Key Words : Fuel cell electric bus(수소버스), GTR(국제기술기준), Compressed hydrogen storage system(수소 내압용기), Hydrogen permeation(수소투과), Real-time measurement(실시간 측정)

ABSTRACT

In pursuit of carbon neutrality, hydrogen fuel cell vehicles (HFCVs) play a crucial role as eco-friendly automobiles, and one of their key components is the hydrogen storage tank, responsible for safely storing high-pressure compressed hydrogen. Commercially available hydrogen storage tanks come in four types, ranging from Type I to Type IV, with Type IV tanks made of carbon composite materials and glass fibers being the lightest and most commonly used in HFCVs. Due to the need for safe hydrogen permeation, measurements of permeation rates are essential, especially when storing hydrogen with an atomic number of 1 at pressures exceeding 70 MPa. International standards, such as GTR No.13, and domestic regulations by the South Korean Ministry of Land, Infrastructure and Transport (standards under the Automotive Pressure Vessel Safety Regulation) govern the testing procedures for measuring the amount of hydrogen permeation.

The conventional method of hydrogen permeation testing involves sampling and capturing a portion of the hydrogen permeated from the compressed hydrogen container of the hydrogen fuel cell vehicle into a chamber. To analyze the sampled hydrogen, chromatography equipment is typically employed. However, this method is prone to variability between testing institutions and even within the same institution due to differences in temperature conditions and the proficiency of test personnel, necessitating various studies to enhance reliability. In this study, to address these issues, we propose a testing approach that directly connects the chromatography (GC) equipment, capable of analyzing the real-time flow of hydrogen, to the capture chamber.

The evaluation equipment and measurement method developed in this study enable real-time measurement of the hydrogen permeation of HFCV high-pressure storage tanks. By minimizing the influence of testing environments and test personnel on test results, we anticipate an increase in the reliability of the tests.

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175L급 압축 수소 용기의 수소 누출 평가를 위한 실험적 연구

양현석* · 공만식** · 전호병*** · 이동훈****

Empirical Study of Hydrogen Permeation Tests for 175L grade Compressed Hydrogen Storage System

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Key Words : Hydrogen permeation test(수소 투과율 시험), Hydrogen concentration(수소 농도), CHSS(압축 수소 저장 시스템), Hydrogen bus(수소 버스),

ABSTRACT

본 연구에서는 수소 버스에 사용되는 175L급 압축 수소 용기의 안전성 검증을 위한 방법의 하나인 수소 투과율 시험을 위한 시스템을 제작하였으며, 이에 따른 용기의 투과성 시험 절차 및 결과에 대한 분석을 제공한다. 국제 규정에 제시된 수소 투과율 통과 기준인 6cc/h/L를 용기에 10% 간격으로 주입하였으며, 각 주입량에 따른 투과된 수소 농도를 측정하여 실제 투과되는 수소량과 보정을 하였다. 실험 결과, 측정되는 값은 실제 투과량의 96%를 나타내었으며, 이는 국내 구축 중인 수소 버스 용기 투과율 시험 시스템의 기초 자료로 활용할 수 있다.

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수소상용차 측면충돌 가혹도를 반영한 최적 충돌시험방법 개발

인정민* · 한현민** · 마재홍*** · 김시우****

A Research Result about Developing the Optimum Evaluation Methods of Fuel Integrity System to Reflect the Side Crash Severity About Hydrogen HDV

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Key Words : Heavy duty vehicle(대형상용차), Full scale crah test(실차충돌), Post-crash safety(충돌 후 안전성), Sled test(충돌모의시험), Direct impact load(직접충돌하중), CHSS(Compressed hydrogen storage system, 수소내압용기)

ABSTRACT

Hydrogen heavy duty vehicles (HDV) are necessary to have large-capacity hydrogen tanks for long-distance driving. In addition, among all car-to-car collision accidents, heavy duty vehicles like large bus and truck are most likely to occur side collision types. The structure characteristic of both hydrogen buses and hydrogen trucks are possible to the higher fuel system risk on side collisions than in front and rear collision types because of occurring direct impact to fuel systems. Accordingly, it is necessary to develop new collision evaluation that can secure the fuel system safety in side collisions in HDVs equipped with large-hydrogen fuel containers. However, it is difficult to develop one evaluation methods representing fuel system risk on side collision because large commercial vehicles have various installation locations and structure about fuel system. So it is necessary to develop the optimum evaluation methods that can evaluate valid fuel system risks on side collision depending on the installation locations of the HDV fuel systems. The research aim to develop new evaluation methods to reflect fuel system severity equal to complete vehicles on full scale side crash test. Through this study, it will be used as reference data for developing new evaluation regulations that can accurately evaluate the fuel system safety of hydrogen HDV on side collisions.

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