수소 상용차 부품 원가절감 및 안전성 향상 기술 개발

수소저장용기 및 고정장치 성능과 가격경쟁력 확보를 위한 특성 분석 및 최적 설계

김건우* · 김혜원** · 박한민** · 정경현** · 최인호** · 김한상***

Characteristic Analysis and Optimal Design for Securing Performance and Price Competitiveness of Hydrogen Storage Tank and Mounting Block

Gunwoo Kim*, Hyewon Kim**, Hanmin Park**, Kyunghyun Chung**, Inho Choi**, Hansang Kim***

Key Words : Hydrogen storage tank (수소저장용기), Mounting block (고정장치), Performance (성능), Cost reduction (가격 저감), Structural analysis (구조해석)

ABSTRACT

As environmental issues such as carbon emissions resulting from the use of fossil fuels continue to be raised, public interest in eco-friendly energy has increased, and research in the hydrogen field is also being actively conducted in major countries. Accordingly, as Korea has also proposed the production and expansion of hydrogen vehicles for carbon neutrality, there is a need for research to improve the safety of hydrogen storage tanks and mounting block for hydrogen storage, transportation, and use. This study attempted to improve safety compared to existing products by conducting a study to analyze the effects of each layered structure of the Type 4 hydrogen storage tank composite material and the characteristics of the mounting block according to the direction of vehicle travel. To this end, this study performed FE modeling WoundSim and ABAQUS, commercial structural analysis software. In addition, the test was simulated analytically to predict the maximum fiber direction tensile stress of composite, Von mise stress, and failure area. Afterwards, by selecting design variables and analyzing the safety of each model, we attempted to lay the foundation for securing technology to improve performance and reduce costs.

본 연구는 산업통상자원부(MOTIE)와 한국에너지기술평가원(KETEP)의 “신재생에너지핵심기술개발사업”의 지원을 받아 연구한 과제입니다. (No. 2022303004020A)
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고압 가스 저장 실린더의 누출 진단에 대한 음향방출의 응용

김광복* · 김봉기** · 김운경*** · 김상원**** · 박성훈***** · 강준길******

Application of Acoustic Emission to the Diagnosis of Leaks in High-Pressure Gas Storage Cylinders

Kwang-Bok Kim*, Bong-Gi Kim**, Woon-Kyung Kim***, Sang-Won Kim****, Sung-Hoon Park*****, Jun-Gil Kang******

Key Words : Acoustic emission(음향방출), Leakage(누출), Fluctuating Reynolds stress(레이놀즈 응력 변동), Pinhole leakage source(핀홀 누출 소스), Analytical modeling(분석 모델링)

ABSTRACT

Reliable maintenance of high-pressure gas vessels, especially those containing fuel gases, has increased exponentially over the past decade, because the gases are extremely hazardous under conditions that can cause them to ignite. The most important way to prevent disasters caused by gas leak fires is to detect leaks and their leak location and make subsequent repairs. Recently, acoustic methods have proven to be very effective in detecting leaks by eliminating disturbing signals through time and frequency domain analysis and characterization of acoustic emission parameters. We conducted an extensive experimental investigation to characterize the AE signals caused by a pinhole gas leak in a cylinder. The artificial leak system was constructed with a commercial N_2 gas cylinder with a pinhole-type leakage source plugged into the cylinder's wall. The AE parameters such as frequency, mean amplitude and RMS were measured as a function of pressure and pinhole size. The resonant frequency distribution was obtained by decomposing the observed AE signal by the FFT method. Furthermore, analytical modeling for an AE due to leakage through a circular pinhole in a gas storage cylinder was performed by solving the Navier–Lamé equation with the concentrated force (CF) associated with fluctuating Reynolds stress, and spatial Green's function. The main advantage of this study is that it provides an accurate solution for the AE characteristics due to leakage in cylindrical geometries. In the near future, this mathematical model will be used to locate leakage sources with more experimental data.

본 연구는 산업통상자원부(MOTIE)와 한국에너지기술평가원(KETEP)의 "신재생에너지핵심기술개발사업"의 지원을 받아 연구한 과제입니다. (No. 2022303004020A)

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수소저장용기 성능 및 가격경쟁력 확보를 위한 공정 개선 및 설계검증 기술개발

윤수진* · 윤영길** · 김종열***

Process Improvement and Design Verification Technology Development to Secure Hydrogen Storage Tank Performance and Price Competitiveness

Sujin Yoon*, Younggil Youn**, Jonglyul Kim***

Key Words : Hydrogen storage tank(수소저장용기), Hydrogen commercial vehicles(수소 상용차), Productivity improvement (생산성 향상), Cost reduction(원가 저감), Non-destructive test(비파괴 검사)

ABSTRACT

Recently, environmental problems, such as carbon emissions resulting from the use of fossil fuels, have gained increased attention, leading to a growing interest in eco-friendly energy among the public. Research in the field of hydrogen is actively being conducted in response to environmental regulations in many countries. In line with this, the government has proposed expanding the production and distribution of hydrogen vehicles and enhancing the technological and development infrastructure as a strategy to transition towards carbon neutrality within the next 50 years. However, challenges such as increased costs associated with developing systems that offer improved performance and safety compared to previous models have surfaced. To address these issues, this study aims to secure technologies that enhance performance and reduce costs. This will be achieved through research on process optimization, optimal design techniques to minimize carbon fiber usage, high-speed winding processes, and the development of curing processes to improve productivity. Additionally, non-destructive inspection techniques will be explored. By leveraging these development technologies, we intend to establish a foundation for market expansion by entering overseas markets early and gaining a competitive edge in Europe, the United States, Japan, and China.

본 연구는 산업통상자원부(MOTIE)와 한국에너지기술평가원(KETEP)의 “신재생에너지핵심기술개발사업”의 지원을 받아 연구한 과제입니다. (No. 2022303004020A)

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수소저장용기 플라스틱 라이너 수소차단성능 향상에 대한 연구

장보애* · 박진호**

A Study on Enhancing Hydrogen Barrier Performance of Plastic Liners in Hydrogen Storage Tank

B.A. Jang*, J. Park**

Key Words : Hydrogen barrier(수소차단), Plastic liner(플라스틱 라이너), Hydrogen tank(수소저장용기)

ABSTRACT

Recent research on hydrogen fuel cell vehicles has gained momentum in pursuit of carbon neutrality. As a result, there is a growing interest in enhancing the performance and safety of hydrogen storage tanks. Particularly, research aimed at improving the hydrogen barrier properties of plastic liners without materials change. In this study, we conducted research to enhance the hydrogen barrier properties through heat treatment under varying conditions, i.e., at 120 °C, 150 °C, and 180 °C. We carried out analyses of the hydrogen barrier properties, physical properties, thermal characteristics, and crystalline structure of the liner material after heat treatment. The results showed that the hydrogen barrier properties varied depending on the heat treatment conditions, with a notable increase of over 15% observed under the conditions of 180 °C for 90 minutes. In future research, we plan to investigate whether there is an improvement in the hydrogen barrier performance of hydrogen storage tank when subjected to heat treatment of plastic liners.

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수소 상용차용 충전구 및 분배기 성능에 대한 연구

박신규* · 심인선*

Reserch on the Performance of Receptacle and Manifold for Hydrogen Heavy Duty Vehicle.

Insun Shim*, Shinkyu Park*

Key Words : Receptacle(충전구), Manifold(분배기),

ABSTRACT

This study identifies key design factors to improve the performance and durabillity of receptacle and manifold which are parts of hydrogen heavy duty vehicle. Due to environmental regulations around the world, automobile manufacturers are accelerating the development of hydrogen vehicle that are environmentally friendly and have the advantages of fast charging times and long mileage. Accordingly, it is necessary to develop vehicle parts that combine excellent performance and durability to take the lead in technology in competition with overseas parts companies.

This study studied material selection, precision machining and component assembly tolerances to improve the leakage performance and durability of receptacle and manifold, which are parts of hydrogen heavy duty vehcle. Based on the research results, parts will be manufactured to verify leakage and durability, and it is expected that parts with better performance and durability than those of advaced overseas companies will be produced.

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수소상용차 구성 합금 소재의 가공 전후 기계적 물성 비교 및 개선안 제시

심준석* · 최이정* · 강승균**

Comprehensive Analysis of the Mechanical Properties of Hydrogen Vehicle Alloy Materials Before and After Processing, Offering Valuable Insights into Potential Enhancements

Junseok Shim*, Yi-jeong Choi*, Seung-kyun Kang**

Key Words : Indentation test(압입 시험), Hardness(경도), Yield strength(항복 강도), Tensile strength(인장 강도), Microstructure(미세 조직)

ABSTRACT

In this study, we aim to address design-related issues arising from differences in the mechanical properties of alloy materials used in hydrogen fuel cell vehicles before and after processing. To achieve this, we plan to compare the mechanical properties of the materials before and after processing using indentation tests, which have minimal impact on the material's specifications. Additionally, we intend to analyze and clarify the microstructure both before and after processing to identify the underlying causes of these mechanical property changes. Furthermore, we seek to provide solutions on how to modify the processing methods to meet the required mechanical property targets at the component level.

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수소 배관의 원가 절감 및 성능 개선

우대호*

Cost Reduction and Performance Improvement of Hydrogen Piping

Daeho Woo*

Key Words : Hydrogen Commercial Vehicle(수소 상용차), Cost Efficiency(가격 저감), Hydrogen Storage System (수소저장시스템)

ABSTRACT

The hydrogen tube has the same inner diameter and reduced thickness and outer diameter compared to the existing one. However, it was developed to a strength that has the same performance.

The hydrogen tube's sealing mechanism was developed using a metal sealing method to improve leakage performance.

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수소저장시스템 기능부품 내구성 및 신뢰성 확보를 위한 기술 개발

노의동* · 설정용** · 이승범*** · 이경원****

Develop Technology to Enhance Reliability and Durability For Parts of Hydrogen Storage Tank System

Euidong Ro*, Jeongyong Seol**, Seungbeom Lee***, Gyeongwon Lee****

Key Words : Hydrogen Commercial Vehicle(수소 상용차), Cost Efficiency(가격 저감), Hydrogen Storage System (수소저장시스템)

ABSTRACT

The first purpose of the research is to Development of hydrogen supply system technology applicable to high flow rate and Cost Efficiency. The second is the Development of technology to improve durability of hydrogen storage system functional parts(hydrogen tank valve, regulator, receptacle). Third is the Reliability evaluation of hydrogen high-pressure functional parts and development of suitability test mode.

Research progress and results include improving the airtight performance by increasing the spring load by 40% by improving the design of the hydrogen tank valve, and magnetic force was improved by 40% as compensation. Additionally, we designed a Temperature Activated Pressure Relief Device that can forcibly discharge the hydrogen inside the tank in the event of a fire. And core components are applied to satisfy airtightness performance under high pressure and low temperature conditions.

High flow rate application and durability performance are satisfied by expanding the cross-sectional area of the regulator's internal flow path.

Strength verification and differential pressure performance were satisfied for the receptacle and manifold.

Through analysis and testing, mechanical properties, flow increase factors were derived, and failure mechanisms were confirmed.

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고유량 레귤레이터의 원가절감 기술

김구호* · 신용섭** · 정석렬***

Development of Cost Reduction Technology for High-Flow Regulator

Guho Kim*, Yongseob Sin**, Seokryeol Jeong***

Key Words : Hydrogen commercial vehicle(수소상용차), High pressure regulator(고압레귤레이터), High flow(대유량), Durability(내구성), Price reduction(가격절감), Cost reduction(원가절감),

ABSTRACT

Domestic hydrogen electric vehicles, which began mass production for the first time in the world in 2013, are currently applying the system to various passenger and commercial vehicle types 10 years later. In particular, in the case of commercial vehicles, systems and tank capacities exist in various forms, and high flow rates are required due to the high output of the stack. Accordingly, the flow rate of the regulator, which reduces the pressure to a certain pressure in order to supply the hydrogen stored in the hydrogen storage container to the stack, is required to be up to three times that of a passenger vehicle, and the severity of durability is higher.

Through this research, we secured performance by increasing the diameter of the pressure reducing part of the regulator and increasing the valve stroke, optimizing the balance structure, developing products at a level that ensures durability, improving the materials and construction methods for the parts applied to them, and improving the manufacturing process. It was possible to reduce the price compared to before.

This research was conducted with support from the Ministry of Trade, Industry and Energy's New and Renewable Energy Core Technology Development Project (2022303004020B, Technology Development to Secure Durability and Reliability of Functional Parts of Hydrogen Storage Systems).

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예냉가스 공급장치의 테스트 모드 설계 및 검토

장재열* · 조성철* · 이주희** · 정재헌*

Design and Review of a Test Mode of a Pre-Cooled Gas Supply Device

Jaeyeol Jang*, Sungchul Cho*, Juhee Lee**, Jaeheon Jung*

Key Words : Hydrogen commercial vehicle(수소 상용차), Cost efficiency(가격 저감), Save testing days(시험 소요일), Pre-cooled gas supply device(예냉기체 공급 장치)

ABSTRACT

Development of a device that satisfies extreme temperature and maximum flow rate (more than 2.0 times the supply flow rate compared to 45g/s of a general vehicle) through the design and review of a test mode of a pre-cooled gas supply device that simulates the charging environment of a Hydrogen commercial vehicle.
Simultaneous testing of two key hydrogen charging components (receptors, manifolds, hydrogen pipes, etc.) that satisfy safety and durability can save testing days & Cost Efficiency.

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수소상용차의 수소저장용기용 솔레노이드 밸브 설계에 관한 연구

남충우* · 김재광** · 김구호** · 이경원*** · 노의동***

A Study on Solenoid Valve Design for Hydrogen Commercial Vehicle Hydrogen Tank System

Chungwoo Nam*, Jeakang Kim**, Guho Kim**, Gyeongwon Lee***, Euidong Ro***

Key Words : Hydrogen Commercial Vehicle(수소 상용차), Solenoid valve(솔레노이드 밸브), Hydrogen Storage System(수소저장시스템)

ABSTRACT

With the increasing demand to find new energy resources instead of using fossil fuels, for the protection of the environment, one of most attractive areas in renewable energy is hydrogen. Hydrogen gas related technology has become one of the most attractive and has great potential in next generation vehicles. The conventional states of hydrogen in which it is normally stored are compressed hydrogen, liquid hydrogen and cryo-compressed hydrogen with a storage pressure of 350 to 700 bar. Nevertheless, considering expansion due to temperature increases, the pressure of the reservoir needs to be able to rise to 1050 bar (700 bar, NominalWorking Pressure) safely. Moreover, the development of a hydrogen cell system including a control valve is difficult in ensure safety and stability, and little research into testing systems has been reported.

The solenoid valve controls the amount of ultra-high pressure hydrogen gas released from storage and sends the gas to the depressurizing valve to charge.

We carried out performance tests by applying voltage with wide ranges of input pressure, response time and output flow rate and pulsation repetition tests considering increases in temperature, etc. Moreover, the results indicated good potential for application in fuel charging and transporting commercial hydrogen vehicles.

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ANSYS를 이용한 상용차 수소저장시스템 구성요소의 진동에 대한 해석적 연구

이정호* · 임한석* · 이창열** · 김지영** · 한정옥*** · 심정연****

An Analytical Study on the Vibration of Hydrogen Storage System Components for Commercial Vehicle Using ANSYS

Jungho Lee*, Han-Seuk Lim*, Changryeol Lee**, Jiyoung Kim**, Jeongok Han***, Jeongyoen Shim****

Key Words : Combined Temperature and pressure sensor(온도압력복합센서), Controller(제어기), Fuel cell vehicle (수소연료전지 자동차), Hydrogen detection sensor(수소감지센서), Hydrogen storage system(수소저장시스템), Shut-off valve(차단밸브), Structural analysis(구조해석), Vibration(진동)

ABSTRACT

Recently, in the automotive industry, studies on eco-friendly cars are being conducted. Fuel cell vehicles are one of these eco-friendly vehicles, and a hydrogen storage system must be established to drive them. The hydrogen storage system consists of components such as a hydrogen detection sensor, a controller, a combined temperature and pressure sensor, and a shut-off valve. These components require verification of vibration characteristics for the safe use. Therefore, this study is performed to confirm the vibration characteristics of hydrogen storage system components by structural analysis using ANSYS. Derived results can be used for research and development of fuel cell vehicle technology.

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유압시스템 결함 판단을 위한 압력 센서 기반 데이터 전처리 다변화를 통한 정확도 향상 연구

이동희* · 김병우**

A Study on Improvement of Accuracy with Diversification of Pressure Data Processing for Fault Detection of Hydraulic System

Dong hee Lee*, Byeong woo Kim**

Key Words : Deep learning(딥러닝), Fault detection(결함 검지), Data processing(데이터 가공), Hydraulic system (유압 시스템), Pressure sensor(압력센서)

ABSTRACT

Fault detection is an essential field that can be used in various industries. In particular, safety such as a vehicle should be secured, so it should be designed to diagnose and cope with failures in advance. Data processing is required to deal with data that reflects unpredicted characteristics rather than specific repetitive data. Deep learning, one of the most promising research fields, has a clear difference in accuracy depending on what input is injected. In this study, we considered detection model for a hydraulic line through the representative network MLP (Multi-Layer Perceptron). The dataset utilized hydraulic pipeline-based pressure sensor measurement data provided by Texas A&M University. It contains data that causes leakage due to cracks or fastening abnormalities in the object. We performed data processing to extract feature points reflecting the flow characteristics of the hydraulic line. In addition to the representative features (maximum, average, variance, and effective value) of time series data, statistical features (distortion, kurtosis) and sinusoidal-related features (Crest factor, Shape factor, Impulse factor) were included. We performed accuracy evaluation by applying the extracted feature points to the defect diagnosis algorithm. The detection accuracy using four input data of existing time series features based on a specific dataset was 85.28%, compared to 88.14% using input data with five additional proposals, confirming an improvement in accuracy within 3%. The results of this study can help to develop a fault detection technology that may be caused by unpredicted characteristics such as vehicle driving in advance.

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수소저장시스템의 멀티 및 싱글제어를 위한 차단밸브 & 매니폴드 기술개발

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Develop Technology to for Shut Off Valve and Manifold of Hydrogen Storage Tank System Capable of Multi and Single Control

Young ki Kim*, Hyo jin Lee**

Key Words : Hydrogen commercial vehicle(수소상용차), Shutoff valve(차단밸브), Manifold(매니폴드), Normally open type(상시개방형), Cost efficiency(가격저감)

ABSTRACT

Developing a Normal Open type Shut off valve to shut off the vehicle when an abnormal signal is detected during charging, and a manifold to improve charging speed through simultaneous charging with multiple channels. How to protect Oring from high-pressure hydrogen environment by applying packing ring structure and A double sealing structure was applied to improve internal airtightness.

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