수소 저장 안전성 향상

수소전기차 내압용기 안전성 강화를 위한 검사 결과분석

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Analysis of Inspection Results for Reinforcement of Safety of Hydrogen Electric Vehicle Pressure Vessels

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Key Words : Hydrogen(수소), A hydrogen electric vehicle(수소전기차), Pressure-resistant container(내압용기) Safety (안전성), Inspection facility(검사시설), Inspection results(검사결과), Nonconformity(부적합), Gas leak (가스누출), Corrosion(부식), Defect(결함), Composite(복합재)

ABSTRACT

As investment in hydrogen electric vehicles to solve environmental pollution problems such as global warming increases, the importance of inspection systems and inspection infrastructure to ensure the safety of hydrogen-resistant containers is increasing as the number of hydrogen vehicles supplied increases. Therefore, the Korea Transportation Safety Authority (TS) introduced dedicated inspection technology and advanced equipment for hydrogen vehicle inspection, and established an inspection center dedicated to hydrogen electric vehicles in Ulsan as one of its strategies to expand related inspection facilities. This study analyzed 13.7 % of the nonconformities found in the inspection results of hydrogen-electric vehicles and examined technologies and facilities related to the inspection. As a result, it is expected that emphasizing the importance of inspecting internal pressure containers and continuously expanding the inspection infrastructure for internal pressure containers of hydrogen vehicles will contribute to strengthening the operational safety of hydrogen-electric vehicles as the supply of hydrogen vehicles expands.

지구 온난화 등 환경오염 문제를 해결하기 위한 수소전기차의 투자가 확대되면서 수소차 보급 대수가 증가함에 따라 수소 내압용기의 안전성을 확보할 검사제도와 검사 인프라의 중요성이 높아지고 있다. 수소차 검사를 위한 전용 검사 기술과 첨단 장비를 도입하고 관련 검사시설 확충을 위해 울산에 수소전기차 전용 검사센터를 구축하였다. 본 연구는 수소전기차 수검 차량을 대상으로 검사 결과 나타난 부적합 13.7 %를 분석하고 검사 관련 기술이나 시설을 살펴보았다. 그 결과 내압용기 검사의 중요성을 강조하고 수소차 보급이 확대되는 만큼 수소차 내압용기 검사 인프라를 지속적으로 확충하는 것이 수소전기차의 운행 안전성 강화에 기여할 것으로 기대된다.

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GTR 13 개정에 따른 내압용기 및 용기밸브 검사 개정 방향

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Direction of Inspection Revision of Cylinder and Cylinder Valve for Hydrogen Vehicles According to GTR 13 Phase 2

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ABSTRACT

As UN GTR No.13, the global test standard for cylinders cylinder valves and pressure safety devices as CHSS used in hydrogen vehicles was revised in 2022, some test methods were changed. As global test standards change as UN GTR 13, we plan to establish a direction for revising the Ministry of Land, Infrastructure and Transport's regulation, which is the domestic inspection standard, by checking necessary changes in manufacturing, such as the design of cylinders and cylinder valves for vehicles, and whether domestic test standards are performed.

수소전기차에 사용되는 용기 및 용기안전장치의 글로벌 검사표준인 UN GTR No.13이 2022년 개정됨에 따라 검사방법이 일부 변경되었다. 글로벌 검사표준이 변경됨에 따라 용기 및 용기밸브의 설계 등 제작의 변경의 필요한 부분과 국내 검사수행 여부를 점검하여 국내 검사기준인 국토교통부 고시의 개정방향을 설정하고자 한다.

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FEA활용한 수소저장용기의 안전성 평가 프로세스 설계에 관한 연구

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A Study on the Design on the Safety Evaluation Process of Hydrogen Storage Vessel Using FEA

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Key Words : Hydrogen storage vessel (수소저장용기), Finite element analysis(유한요소해석), Safety evaluation (안전성 평가), Composite (복합재), Time reduction (시간 저감)

ABSTRACT

To ensure the safe storage and transportation of high-pressure hydrogen gas, evaluating the strength and integrity of hydrogen storage vessels is essential. However, conducting actual safety assessment tests consumes significant time and cost. To address this, the study designed a process to evaluate the safety of hydrogen storage vessel using Finite Element Analysis (FEA), aiming to reduce future development time and costs by assessing safety under various test conditions. Using ABAQUS, FEA models of hydrogen storage vessels were constructed, and safety and key influencing factors for different tests were analyzed. By designing and analyzing this series of processes, a foundation for evaluating the safety of hydrogen storage vessels using FEA was established, leading to cost and time savings in development.

본 연구는 산업통상자원부(MOTIE)와 한국에너지기술평가원(KETEP)의 “신재생에너지핵심기술개발사업”의 지원을 받아 연구한 과제입니다. (No. 2022303004020A)
본 연구는 산업통상자원부 (MOTIE)와 한국산업기술평가관리원(KEIT)의 “소재부품기술개발사업”의 지원을 받아 연구한 과제입니다. (No. 20022511)

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수소저장용기 기밀용 오링의 수소가스 영향 유한요소해석 연구

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Finite Element Analysis Study on the Effect of Hydrogen Gas on the Sealing O-ring of a Hydrogen Pressure Vessel

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Key Words : O-ring(오링), Hydrogen gas(수소 가스), hydrogen diffusion(수소 확산), Finite element analysis (유한요소 해석)

ABSTRACT

Rubber O-rings installed in hydrogen pressure vessels are exposed to high pressure hydrogen gas. Due to the effects of high pressure and temperature as well as the penetration and diffusion of hydrogen gas into the material, rubber O-rings experience mechanical damage such as extrusion failure and blister failure. To prevent such hydrogen gas leaks, we conducted a suitability analysis of the material using the commercial finite element analysis software Abaqus. This study confirmed the effects of the ambient temperature during charging and discharging as well as the penetration and diffusion of hydrogen gas. We performed heat transfer analysis and mass diffusion analysis, and developed a coupled thermal-hydrogen diffusion and structural analysis that linked these results with structural analysis to examine the overall behavior of the O-ring according to the operating environment.

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Type 4 수소저장용기의 축소 시제를 활용한 가속화 충전 모사 해석 및 원 시제와의 비교

정경현* · 박규환** · 김한상***

Accelerated Charging Analysis for Type 4 Hydrogen Vessel Using Reduce Scaled Model and Comparison with the Original Model

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Key Words : Type 4 Hydrogen Vessel(Type4 수소저장용기), Accelerated Charging(가속화 충전), FSI-Analysis Method(유체-구조 연성 해석 기법), Structural Similarity(구조적 유사성), Ansys CFX(유동해석S/W)

ABSTRACT

Testing and evaluation of gas charging and discharging cycles of high-pressure hydrogen vessel consume considerable time and cost. Consequently, there is a demand for testing and evaluation methods using scaled-down prototypes to accelerate the process. In this study, computational fluid dynamics (CFD) analysis using ANSYS-CFX was performed to predict the temperature changes of gas, liner, boss, and CFRP layer during charging for both reduce scaled and original models. Subsequently, a one-way fluid-structure interaction (FSI) analysis was conducted using ABAQUS by mapping the temperature data obtained from CFD analysis onto the finite element model of the vessel. Based on the results, it was confirmed that the maximum temperature and fiber direction stress distribution and magnitude during charging were similar between the reduce scaled and original models. Through these studies, using CFX and ABAQUS, a methodology for one-way FSI analysis of hydrogen vessel, was proposed, validating the reliability of accelerated testing and evaluation using reduce scaled models.

본 연구는 산업통상자원부(MOTIE)와 한국산업기술평가관리원의 "자동차산업기술개발사업"의 지원을 받아 연구한 과제입니다. (NO. 20015346)
본 연구는 산업통상자원부(MOTIE)와 한국 에너지 기술 평가원(KETEP)의 "에너지기술개발사업" 지원을 받아 연구한 과제입니다. (NO. 20203010040010)

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