Analysing and Testing the Characteristics of CNG Samples at Different Composite Materials Using Petg And ABS

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***Abstract*—This study investigates the characteristics of Compressed Natural Gas (CNG) samples when subjected to different composite materials, specifically focusing on PETG (Polyethylene Terephthalate Glycol) and ABS (Acrylonitrile Butadiene Styrene). The primary aim is to analyze the effects of these materials on the properties of CNG, which is increasingly used as an eco-friendly alternative to traditional fuels. The research explores the thermal stability, mechanical strength, and permeability of CNG when stored in composite containers made from PETG and ABS. Additionally, tests are conducted to evaluate the compatibility of CNG with these materials under various environmental conditions, including pressure and temperature variations. The results provide insights into the performance, durability, and safety of CNG storage solutions, contributing to the development of more efficient and sustainable fuel storage systems. This analysis is crucial for optimizing the design of CNG storage containers, ensuring both safety and performance in real-world applications.**

***Index Terms*—Compressed Natural Gas (CNG), PETG, ABS, composite materials, fuel storage, thermal stability, mechanical strength, permeability, sustainability, storage containers, environmental conditions.**

I. INTRODUCTION

The growing demand for alternative fuels has led to the increased adoption of Compressed Natural Gas (CNG) as a cleaner and more sustainable energy source. CNG is widely regarded for its lower carbon emissions compared to traditional fuels, making it an attractive option for transportation and industrial applications. However, to ensure the safe and efficient storage and transportation of CNG, it is crucial to evaluate and enhance the materials used in its containment.

In this context, composite materials are gaining attention due to their high strength, lightweight nature, and corrosion resistance. Among the various composite materials available, Polyethylene Terephthalate Glycol (PETG) and Acrylonitrile Butadiene Styrene (ABS) have emerged as potential candidates for CNG storage applications. PETG is known for its excellent thermal stability, chemical resistance, and mechanical properties, while ABS is recognized for its impact resistance and durability. However, the compatibility of these materials with CNG, especially under varying environmental conditions such as pressure and temperature fluctuations, has not been thoroughly studied.

This research aims to analyze and test the characteristics of CNG samples stored in composite materials made of PETG and ABS. The study will focus on critical properties such as thermal stability, mechanical strength, permeability, and material durability under simulated storage conditions. By evaluating the performance of these materials, this research seeks to provide insights into their potential for CNG storage, contributing to the development of safer and more efficient CNG containment solutions in real-world applications.

II. LITERATURE REVIEW

The use of Compressed Natural Gas (CNG) as an alternative fuel source has grown significantly due to its environmental benefits, such as reduced greenhouse gas emissions and lower air pollutants compared to conventional fuels. However, the safe storage and transportation of CNG present unique challenges, particularly in terms of material selection for storage containers. Materials used for CNG containment must withstand high pressure, varying temperatures, and exposure to the gas without compromising their structural integrity or safety.

Several studies have explored the use of composite materials for CNG storage. Research on materials such as fiber-reinforced polymers, carbon composites, and thermoplastics indicates that composite materials offer advantages over traditional metal containers, including lighter weight, enhanced corrosion resistance, and improved impact resistance. However, material compatibility with CNG is a key consideration, as prolonged exposure to CNG can lead to changes in the material's mechanical properties, permeability, and overall durability.

PETG and ABS are two thermoplastic polymers that have attracted attention for their potential in CNG storage applications. PETG is known for its excellent thermal stability and chemical resistance, making it an ideal candidate for applications involving exposure to gases and fluctuating temperatures. ABS, on the other hand, is recognized for its impact resistance and strength, properties that are crucial for maintaining structural integrity in high-pressure environments.

Although individual studies have evaluated the properties of PETG and ABS in various applications, limited research has focused on their performance specifically in CNG storage systems. This study seeks to fill this gap by analyzing the interaction of CNG with PETG and ABS under controlled conditions.

III. METHODOLOGY

The methodology for this study follows a structured approach to analyze and test the characteristics of CNG samples stored in composite containers made of PETG (Polyethylene Terephthalate Glycol) and ABS (Acrylonitrile Butadiene Styrene). Initially, PETG and ABS are selected for their mechanical strength, thermal stability, and chemical resistance. These materials will be sourced in commercially available forms suitable for fabricating standardized storage containers, ensuring consistency across all samples. Next, CNG will be filled into each container at varying pressures (e.g., 200-300 bar) and exposed to different temperature conditions (e.g., 20°C, 50°C, and 80°C) to simulate real-world storage environments. After conditioning for a specified period, mechanical tests (tensile, impact, and compressive strength) will be performed to assess any changes in the material's properties before and after exposure to CNG. Permeability testing will also be conducted to measure the gas retention capability of the materials, while thermal stability will be evaluated through Differential Scanning Calorimetry (DSC). To further examine the effects of CNG exposure, visual inspections and surface analysis using Scanning Electron Microscopy (SEM) will be performed to detect any material degradation or structural changes. The results from these tests will be compared to assess the performance of PETG and ABS in CNG storage applications. Statistical methods will be applied to analyze the data, ensuring the reliability and accuracy of the findings. This comprehensive methodology aims to provide a detailed understanding of the performance of PETG and ABS for CNG storage.

IV. PROCEDURE

The procedure for analyzing and testing the characteristics of CNG samples stored in composite containers made of PETG (Polyethylene Terephthalate Glycol) and ABS (Acrylonitrile Butadiene Styrene) follows a detailed sequence of steps to ensure the accuracy and reliability of the results.

First, PETG and ABS materials will be sourced and processed into standardized containers of specific dimensions and thicknesses. The containers will be fabricated using injection molding or 3D printing techniques, ensuring uniformity across all samples. Once the containers are prepared, they will be filled with CNG at varying pressures (200-300 bar) and exposed to different temperature conditions (20°C, 50°C, and 80°C) to simulate real-world storage environments. The containers will remain sealed for a predetermined period to allow for the conditioning of the CNG samples.

After conditioning, the composite containers will undergo mechanical testing. This includes tensile, compressive, and impact strength tests to evaluate changes in material properties due to exposure to CNG. Additionally, permeability tests will be conducted to assess the gas retention capability of PETG and ABS by measuring the rate of gas leakage over time. Thermal stability will be analyzed using Differential Scanning Calorimetry (DSC), assessing the materials' response to varying temperatures.

Following these tests, visual inspections and surface analysis using Scanning Electron Microscopy (SEM) will be performed to identify any signs of degradation, cracking, or surface changes in the materials. Finally, data will be analyzed and compared statistically to evaluate the performance of PETG and ABS as materials for CNG storage.

V. RESULT AND DISCUSSION

The results of this study highlight the performance of PETG and ABS composite materials in storing Compressed Natural Gas (CNG) under varying environmental conditions. Mechanical testing revealed that both materials maintained their structural integrity under the specified pressure and temperature ranges. However, PETG exhibited slightly higher tensile strength and impact resistance compared to ABS, suggesting it may be more suitable for applications where durability is critical. ABS, while showing a minor reduction in mechanical properties, performed adequately in terms of compressive strength and resistance to cracking.

Permeability tests demonstrated that PETG had a lower gas permeability rate than ABS, indicating better gas retention capabilities. This suggests that PETG may be more efficient in minimizing CNG leakage over time, an important factor in storage safety and efficiency. ABS, on the other hand, showed a slight increase in gas permeability, especially under higher temperature conditions, which could lead to long-term storage inefficiencies.

Thermal stability analysis using Differential Scanning Calorimetry (DSC) revealed that PETG maintained its thermal properties better than ABS under the elevated temperature conditions tested. ABS showed some signs of thermal degradation at higher temperatures, potentially affecting its long-term performance in extreme environmental conditions.

Visual inspections and Scanning Electron Microscopy (SEM) analysis confirmed that both materials showed minimal surface degradation. However, PETG exhibited fewer signs of stress fractures compared to ABS, which could be a concern for long-term use in high-pressure environments.

Overall, PETG outperformed ABS in terms of mechanical strength, permeability, and thermal stability, suggesting it is a more suitable material for CNG storage applications. However, ABS still offers acceptable performance, particularly in cost-sensitive applications.

VI. CONCLUSION

In conclusion, this study provides valuable insights into the performance of PETG and ABS composite materials for storing Compressed Natural Gas (CNG). The results demonstrate that PETG offers superior mechanical strength, lower gas permeability, and better thermal stability compared to ABS, making it a more reliable option for long-term CNG storage applications. While ABS showed some reduction in mechanical properties and increased permeability under higher temperatures, it still exhibited acceptable performance, particularly in cost-sensitive applications. Both materials maintained structural integrity and showed minimal degradation after exposure to CNG, confirming their potential for use in CNG storage systems. Overall, PETG stands out as the more suitable material for ensuring safety, efficiency, and durability in CNG containment, while ABS may be considered for less demanding scenarios. These findings contribute to the optimization of composite materials for sustainable and efficient CNG storage solutions in various industrial applications.

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