Hydrogen Fuel's Challenge to Lithium Batteries in Advancing Electric Aircraft

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Abstract. In today's modern society, more and more technologies are gradually emerging from the surface. Capitalists led by Musk have gradually embraced global technology. From electric vehicles to artificial AI, modern technology has gradually anthropomorphized. The most prominent is electric vehicles. With the rise of electric vehicles, it has brought not only the progress of science and technology, but also brought fresh blood to the automobile market. Electric vehicles have brought not only higher speed and efficiency, but more importantly, it has brought significant progress to environmental pollution and residents. Even if electric vehicles have become more popular cars on the market, the problems it faces are also challenging, because hydrogen fuel cells are gradually replacing lithium batteries. Although they cannot be surpassed in a short period of time, it is unknown whether more time and higher efficiency can surpass lithium batteries. This article will be compared through car brands, cost, market prices and environment. The main analysis is to compare the different materials and technologies used by different electric vehicles, and make a relatively important analysis and think about them from money and environment to determine whether hydrogen fuel cells can surpass lithium batteries or help each other in the future based on the results obtained.

Keywords: Hydrogen fuel, lithium batteries, electric vehicle.

1. Introduction

With the global focus on environmental issues and the need for sustainable transportation solutions, the aviation industry has been exploring new possibilities to reduce carbon emissions. Electric aircraft have emerged as a promising solution to eliminate emissions and reduce operational noise. While lithium batteries have been the main choice for electric aircraft propulsion systems, their long-term viability has been questioned due to limitations in energy density, weight and charging time. This paper will discuss hydrogen fuel as an alternative energy source for electric airplanes. The paper will begin with a comprehensive summary of the current state of electric aircraft technology and emphasize the role of lithium batteries. The paper will then delve into the science and benefits of hydrogen fuel cells, including their potential to significantly reduce carbon emissions and increase aircraft range. Challenges related to hydrogen storage, infrastructure development and safety considerations will then be assessed. In order to provide a comprehensive analysis, this study will also compare the performance, efficiency, cost, and environmental impacts of hydrogen fuel cells and lithium batteries. Factors such as weight, power output, energy density and refueling time will be examined to determine which technology offers the most promising future for electric aviation. The results of this study contribute to the current discussion and decision-making process surrounding the future development of electric airplanes. It will provide insight into whether hydrogen fuel cells can overcome the current limitations of lithium batteries and, if so, under what conditions they can be effectively implemented. In summary, this paper aims to address the question of whether hydrogen fuel can replace lithium batteries as the preferred power source for electric airplanes. By analyzing the advantages, challenges, and potential tradeoffs of both technologies, researchers hope to provide valuable insights to guide future research and development efforts in the electric aviation industry [1].

2. Lithium Batteries and the Challenges of Electric Aircraft

2.1. The Current Situation and Challenges of Electric Aircraft Technology

As of 2023, the current status of electric aircraft technology has made significant progress, and the technology is still developing rapidly. Electric aircraft has many advantages such as reducing operating costs, reducing environmental impact and reducing noise pollution. However, they still face some challenges and restrictions. As far as small electric aircraft (such as drones) are concerned, their technology is quite advanced. Many companies and start-ups have successfully manufactured and deployed electric drones for various applications such as aerial photography, parcel delivery and even urban passenger transportation. [2] The lithium batteries used by these small aircraft have been significantly improved, providing longer flight time and faster charging capacity. However, large electric aircraft such as commercial passenger aircraft are still in the early stage of development. Some companies and research institutions are actively developing branch electric jets that can carry dozens of passengers on short-haul flights. These aircraft use advanced battery technologies, such as lithium-sulfur batteries or solid-state batteries, to achieve a longer range and higher power density. The main challenges facing current electric aircraft technology include the limited energy density of the current battery, which may affect the range and payload capacity. In addition, the infrastructure for large-scale charging or replacing batteries has not been fully developed. However, efforts are being made to address these obstacles, including developing more efficient battery chemical components, innovative charging methods, and establishing charging networks at airports. Despite these challenges, many industry experts and researchers are optimistic about the future of electric aircraft technology. With the continuous progress of battery technology, power management systems and aerodynamic design, it is expected that in the next few years, electric aircraft will become an increasingly feasible and competitive alternative to traditional fossil fuel-powered aircraft [3].

2.2. Lithium Battery Hazards and Improvements

In terms of aircraft, lithium batteries play a vital role in electric aircraft technology. They are usually used as the main energy storage systems of electric aircraft propulsion systems. Lithium-ion batteries are widely used for their high energy density, lightweight design and ability to provide continuous power. However, there are still many challenges in using lithium-ion batteries in electric aircraft. One of the main obstacles is that compared with traditional jet fuel, lithium-ion batteries have a limited energy density, resulting in shorter flight distances and limited payload. In order to solve this problem, researchers and manufacturers are constantly improving battery technology, such as increasing energy density and reducing weight. Safety while developing batteries is another important issue. It is well known that lithium-ion batteries may overheat, leading to thermal runaway and fire risk. Appropriate battery management systems and thermal management technology, including active cooling and insulation, can ensure safety during operation. Despite these challenges, electric aircraft using lithium-ion batteries have been successful in short-haul flights and urban air transportation applications. With the continuous update of battery technology, [4] researchers aim to improve energy density, further strengthen safety measures, and expand the future flight range of electric aircraft in the process of research and development.

3. Advantages and Disadvantages of Hydrogen Fuel Cells

3.1. Advantages of Hydrogen Fuel Cells

In recent years, the hydrogen fuel cell has emerged as a device that converts hydrogen and oxygen into electricity through an electrochemical process. Although it covers a small area, this technology has several advantages if it is categorized among the technologies that are ahead of the benefits of lithium batteries: Clean hydrogen fuel cells do not produce any harmful emissions because the only by-product is water vapor. Water vapor is the water molecules formed when heated at high

temperatures, which helps to reduce environmental pollution. [1] Energy-efficient, hydrogen fuel cells are more efficient than traditional internal combustion engines. They can convert most of the energy stored in hydrogen into usable electricity, thus improving fuel economy. Multi-functional hydrogen fuel cells can be used in a variety of fields such as transportation, stationary power generation and portable devices, providing flexible and multi-functional energy solutions for different fields. Fast hydrogen refueling. Hydrogen fuel cell vehicles can be refueled with hydrogen in minutes at the same rate as gasoline-powered vehicles. This solves one of the main challenges of electric vehicles which usually require longer charging times. Hydrogen fuel cell vehicles have a longer range than battery electric vehicles. This is particularly beneficial for heavy-duty applications such as buses, trucks, airplanes and coaches. Quieter operation. Hydrogen fuel cells run quieter than conventional internal combustion engines, reducing noise pollution. Despite these advantages, there are still challenges to overcome, such as the high cost of hydrogen production and infrastructure development. However, continued research and technological advances will continue to improve the viability and scalability of hydrogen fuel cells as a clean energy solution [5].

3.2. Disadvantages of Hydrogen Fuel Cells

The main disadvantages of hydrogen fuel cells include hydrogen fuel being used as a clean energy source, and while hydrogen fuel cells have many advantages, they have disadvantages that are hard to go over. The main disadvantages of hydrogen fuel cells include: Infrastructure challenges, the establishment of a comprehensive hydrogen infrastructure, including production, storage and distribution facilities, is still at an early stage. For example, in a hydrogen refueling station, a typical car takes 3 to 5 minutes to complete charging in commercial operation, while a hydrogen refueling station costs more than 10 million dollars this is a huge challenge for a country. Building the necessary infrastructure requires significant investment and time, which limits the widespread use of hydrogen fuel cells. [2] Hydrogen fuel can be stored in two ways, the first is gaseous storage, which has a small storage capacity and poor safety; liquid storage of hydrogen requires a large number of compression workers in the liquefaction process, which consumes high energy and requires high adiabatic performance of the container, and if people want to apply hydrogen to automobiles people will need a complete set of supporting facilities. [3] Hydrogen transportation vehicles are not perfect. This is because first of all hydrogen survives as a gaseous state in the environment, because the difficulty of transportation is a small challenge, although in some developed countries they have hydrogen transportation pipelines that can reach up to 16,000 kilometers, but in China, if people want to transport hydrogen, it is certainly a huge challenge. [4] Hydrogen fuel cell technology is currently very costly compared to other alternatives such as lithium batteries. The reason for the high cost is that hydrogen fuel cells are not yet comparable to conventional energy sources in terms of cost. Therefore, hydrogen fuel cells are not yet comparable to conventional energy sources in terms of cost. Limited availability because pure hydrogen is not readily available on Earth and needs to be extracted from other sources such as natural gas or water through energy-intensive processes. The challenges associated with the extraction of hydrogen from its sources are exacerbated by the substantial costs involved, often compounded by reliance on non-renewable energy sources. These factors collectively impinge upon the overarching environmental benefits that hydrogen fuel cells seek to offer. The extraction processes, albeit indispensable for harnessing hydrogen's potential, necessitate intricate procedures that demand substantial energy inputs, frequently derived from non-renewable sources. This dichotomy presents a conundrum wherein the pursuit of cleaner energy is paradoxically entwined with energy generation methods that are incongruous with sustainable ideals. Furthermore, the inherent flammability of hydrogen engenders a pressing need for meticulous handling and stringent safety protocols. This vital aspect cannot be understated, as mishandling or inadequate safety measures can precipitate catastrophic consequences. While earnest endeavors are underway to enhance safety mechanisms, the complexities of hydrogen's nature pose ongoing challenges. The deployment of hydrogen, particularly in applications involving storage, processing, and utilization, warrants a comprehensive understanding of its volatile properties. To ensure a holistic comprehension

of the risks inherent in hydrogen usage, it is imperative to acknowledge the evolving nature of safety protocols. While substantial advancements have been made, lingering concerns persist. The mitigation of hydrogen-related risks necessitates an interdisciplinary approach encompassing engineering, materials science, and chemistry, among other disciplines. By fostering a comprehensive understanding of the intricacies associated with hydrogen fuel utilization, stakeholders can collaboratively engineer solutions that enhance safety thresholds. In conclusion, the intricate facets tied to the extraction, handling, and safety of hydrogen as a fuel source are pivotal to realizing the potential of hydrogen fuel cells. The dual challenges of extraction costs and reliance on non-renewable energy sources underscore the imperative for holistic evaluations of the environmental sustainability of hydrogen-based solutions. Simultaneously, the criticality of implementing stringent safety measures to mitigate the inherent flammability of hydrogen is paramount. The pursuit of hydrogen fuel cell technologies mandates persistent research, technological innovation, and interdisciplinary collaboration to surmount these challenges and foster the integration of hydrogen as a pivotal element of the future energy landscape.

4. Lithium Battery and Hydrogen Fuel Cell Comparison

After understanding the hazards and advantages of hydrogen fuel cells and lithium batteries, it is necessary to compare the two through a number of aspects in order to determine which battery will be more popular with the general public. In the comparative analysis, people chose to use a purely electric vehicle and a hydrogen fuel cell vehicle to compare the three aspects of performance, price and environmental impact. First of all, performance, the Passat as a hydrogen fuel cell car test, through the experiment found that a charge can run 300 kilometers, energy conversion reached 60% to 80%, in contrast to the ordinary internal combustion engine efficiency is only 25%; pure electric car choose BYD F6DM, its energy conversion efficiency is also as high as 80%, but it can only run 100 kilometers by electric power, and then run through the fuel power after 330 kilometers. 330 kilometers, from the performance point of view of pure electric car is higher than a hydrogen fuel cell car.[6] Second is the price, the public demand for vehicles is the lower the price the better, but if you only discuss the cost of the battery, hydrogen fuel cells than lithium batteries are much higher, or choose the Passat and BYD comparison. Passat's hydrogen fuel cell up to 1.5 million RMB, more than 5 times more expensive than an ordinary sedan; BYD's lithium battery cost is relatively cheap, only 40,000 yuan more expensive than an ordinary internal combustion engine car, and if the production increases the price will be cheaper. [7] The third is the impact on the environment. Hydrogen can be produced from a variety of renewable energy sources, such as wind, solar and hydropower. If hydrogen is produced using renewable energy sources, the environmental impact of hydrogen fuel cells is further reduced. Combining hydrogen with renewable energy sources, provides an opportunity to realize a sustainable energy system, whereas lithium batteries used in electric vehicles cannot be a renewable source of energy, which greatly contributes to environmental damage; The second is the impact on the environment. Hydrogen can be produced from a variety of renewable energy sources, such as wind, solar and hydropower. If hydrogen is produced using renewable energy sources, the environmental impact of hydrogen fuel cells is further reduced. Combining hydrogen with renewable energy sources, it provides an opportunity to realize a sustainable energy system, whereas lithium batteries used in electric vehicles cannot be a renewable source of energy, which greatly contributes to environmental damage; at the same time, purely electric vehicles operate with essentially no emissions, which helps to reduce air pollution and dependence on fossil dyes. Hydrogen fuel cell vehicles emit only water vapor. While water vapor has no impact on the environment, the production of hydrogen may have an impact on the environment, depending on how the hydrogen is produced. Finally, it affects the residents. The noise pollution of hydrogen fuel cell vehicles is similar to that caused by pure electric vehicles, but in terms of use, pure electric vehicles are still more convenient than hydrogen fuel cell vehicles, because pure electric vehicles only need to be charged, even if the charging efficiency brought by different charging piles is different. [8] But if all of them are fast

charging, it only takes about 30 minutes, which greatly reduces the efficiency of the public. [9] In contrast, hydrogen fuel cell cars need hydrogen refueling stations. Its cost is high and its penetration rate is far less than that of charging piles, so even if hydrogen fuel cell vehicles appear in the future, it still can't help. To summarize, according to tests, electric cars still dominate the market, but if hydrogen can be used safely and stably in automobiles, it will overtake lithium batteries [10].

5. Summary

In the backdrop of escalating global energy shortages and mounting environmental concerns, the imperative for innovative and sustainable solutions is more pressing than ever. Despite concerted efforts by nations to mitigate these challenges, the transient impact of individual measures underscores the need for transformative breakthroughs. The emergence of new energy vehicles, particularly hydrogen fuel cell electric vehicles (FCEVs), has garnered substantial attention as a potential remedy. However, the path to widespread adoption of FCEVs is strewn with multifaceted challenges that extend beyond technological considerations. While the concept of purely electric vehicles has gained traction, it is acknowledged that they alone cannot fully address the complex energy and environmental issues at hand. In this context, hydrogen fuel cells emerge as a compelling alternative due to their potential to significantly mitigate pollution. However, the viability of hydrogen fuel cells hinges not only on their environmental benefits but also on their economic feasibility, presenting a formidable hurdle. Manufacturing hydrogen at scale remains an expensive endeavor, compounded by challenges in its efficient collection. The financial burden this places on manufacturers is substantial and necessitates governmental intervention to surmount this impediment. Notably, countries like Japan have pioneered initiatives to propel the adoption of hydrogen-powered vehicles. Despite its relatively small size, Japan has established itself as a technological frontrunner in this domain. The nation's proactive promotion of hydrogen-fueled vehicles, coupled with augmented subsidies to incentivize consumer adoption, serves as a poignant example of how governments can galvanize transformative changes in the automotive landscape. Esteemed automotive manufacturers like Audi, Mercedes-Benz, and BMW are also investing in hydrogen fuel cell technology, emphasizing its potential to complement and eventually compete with conventional battery electric vehicles (BEVs). In juxtaposition to BEVs, FCEVs offer distinctive advantages that can reshape the electric vehicle landscape. Characteristics like high energy efficiency, superior energy density, shorter refueling times, and extended driving ranges have the potential to bridge the existing gaps in BEVs. The symbiotic relationship between these two technologies becomes evident, as FCEVs can offset certain limitations of BEVs, while BEVs offer advantages such as charging convenience. However, this interplay assumes optimal charging infrastructure development for BEVs. The pace of charging infrastructure establishment bears substantial implications for the trajectory of FCEVs. If the deployment of charging stations lags, FCEVs could emerge as formidable contenders, potentially displacing BEVs. This underscores the significance of strategic and coordinated efforts in infrastructure development to ensure the harmonious coexistence of both technologies. In summation, the prospects of hydrogen fuel cells as a catalyst for sustainable transportation are undeniable. The challenges encompassing their adoption extend beyond technical realms, spanning financial viability, government support, and infrastructural development. FCEVs hold the potential to not only mitigate environmental concerns but also revolutionize transportation efficiency. As the globe seeks to reconcile energy demand, environmental stewardship, and technological advancement, hydrogen fuel cells offer a promising avenue. Governments, industries, and academia must collaboratively navigate these challenges to expedite the transition to a cleaner and more efficient transportation paradigm. Through meticulous research, technological innovation, and steadfast commitment, the realization of hydrogen fuel cells as a pivotal element of the global energy solution is within reach.

References

[1] Ceav. Electrical Engineering and Computer Science. Stefan cel Mare University of Suceava, 2022.

[2] Xu Hong. Comparison of electric vehicles and hydrogen fuel cell vehicles. China New Energy, 2010.

[3] Yin Yilin. Present Situation and Prospect of Hydrogen Energy Industry. Chemical Industry and Engineering, 2021, 38(4): 78-83.

[4] Xu Hong. Comparison of electric vehicles and hydrogen fuel cell vehicles. China New Energy, 2010.

[5] SHAO Zhigang, YI Baolian. Developing Trend and Present Status of Hydrogen Energy and Fuel Cell Development. Bulletin of Chinese Academy of Sciences, 2019, 34(4): 469-477.

[6] Xu Hong. Comparison of electric vehicles and hydrogen fuel cell vehicles. China New Energy, 2010.

[7] Xu Hong. Comparison of electric vehicles and hydrogen fuel cell vehicles. China New Energy, 2010.

[8] Chen Wan. Hydrogen-fueled vehicles will complement pure electric vehicles in long-term coexistence. Environmental Economics, 2019, 33(8): 22.

[9] HE Jintao, ZHENG Chuanpen. Analyzing the development trend of hydrogen fuel cell vehicle. Heavy Duty Vehicles, 2019, 68(4): 3.

[10] SUN Tiantian, WANG Lin, GUO Qiaoqiao, et al. Development status and prospects of pure electric vehicles and hydrogen fuel cell vehicles. Science and Technology Perspectives, 2016, 56(4): 2.