OPTIMIZED SUSPENSION SYSTEM FOR A SOLAR POWERED ELECTRIC FORMULA CAR

ANALYSIS OF HYUNDAI MOTOR COMPANY ELECTRIC VEHICLE RECALLS

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

The transportation sector accounted for the largest portion of total greenhouse gas emissions in the United States in 2022 (EPA, 2024). The traditional internal combustion engine that currently dominates the transportation industry is the primary contributor to this relatively large level of greenhouse gas emissions. Electric and hybrid vehicles offer a more sustainable alternative to internal combustion engine vehicles and have become significantly more popular in recent years. Globally, electric car sales grew by 3.5 million vehicles from 2022 to 2023 (IEA, 2024). Despite the considerable size of this growth, internal combustion engine vehicles still account for 84% of light-duty vehicle sales in the U.S. as of 2023 (Dwyer, 2024). To accomplish the goal of reducing greenhouse gas emissions from the transportation industry, it is crucial to develop new sustainable technologies to power electric vehicles and promote the transition away from internal combustion engines. Harnessing solar energy to power an electric vehicle is an emerging avenue that offers a purely sustainable method to accomplish this goal.

In view of the potential for solar energy to play a role in advancing electric vehicle technology, I propose the development of an advanced suspension system for the University of Virginia (UVA) Solar Car Team that will increase mechanical efficiency of the car and contribute towards the advancement of the team as a whole. In addition to technical considerations, there are also social, political, and financial factors that influence the development of solar vehicle technology. To analyze the relationship between these various factors, I will use the STS framework of actor-network theory to investigate how a rapidly growing environmental movement and government policy influenced manufacturing decisions and design choices that contributed to widespread recalls on Hyundai electric vehicles. If electric vehicle manufacturing companies focus only on quickly advancing electric vehicle technology, but fail to address the cultural and policymaking aspects of this rapid transition, then they risk facing setbacks in public and government confidence in the technology, leading to continued excessive emissions from the transportation sector. Because the challenge of reducing carbon emissions by developing solar vehicle technology is socio-technical in nature, it requires attending to both its technical and social aspects to accomplish successfully. In what follows, I set out two related research proposals: a technical project proposal for developing a new suspension system for the UVA Solar Car Team and an STS project proposal for examining the social, political, and financial factors that led to the widespread recalls on Hyundai electric vehicles.

Technical Project Proposal

Universities around the world offer solar car programs that provide students with hands-on experience developing solar powered vehicles. At the University of Virginia, the Solar Car Team is dedicated to designing, manufacturing, and testing a solar powered electric formula car to race in an intercollegiate competition. The team strives to improve the following primary systems: the chassis, energy harvesting, energy storage, aeroshell, and suspension (Carroll, 2003). In particular, the suspension system is a critical component as it facilitates the efficient movement of the vehicle (Goodarzi & Khajepour, 2017). Additionally, an effective suspension protects the fragile solar technology components from the harsh forces encountered while the vehicle is driving in competition.

In the previous model of the UVA solar car, the suspension system was a rudimentary double wishbone system. It consisted of a clunky aluminum upright, two aluminum wishbones, and a spring mounted directly to the bottom wishbone. The upright and wishbone arms were too heavy, mating joints were comprised of metal-on-metal contact, and the shock absorber was incorrectly rated leading to inefficient translation of forces. The culmination of these factors resulted in an overdamped suspension that inhibited the travel around corners, produced extreme forces and vibrations, and caused a lack of control over steering.

The aim of this technical project is to design a new suspension system that efficiently transfers and dampens shock impulses and works seamlessly with the steering and braking systems to maximize handling of the car. The system will be constructed such that weight is minimized through thoughtful material selection and a methodical geometry. Additionally, every joint within the system will be crafted using high-grade bearings to allow for a smooth transfer of forces (Adams, 2017). Lastly, the shock absorber will be carefully selected such that it critically dampens the transferred forces and creates a smooth ride (Dixon, 2007).

There are four major tasks the team will undertake in redesigning the solar car suspension system: designing, prototyping, manufacturing, and testing. First, the task of designing will be to create detailed engineering drawings and designs of our approach using geometric dimensioning and tolerancing. To analyze potential designs, the team will utilize the computer-aided design (CAD) software SolidWorks, and the finite element analysis (FEA) software Ansys (Bhatt, 2002). The final design will adhere to a set of strict boundary conditions and limitations set out by the American Solar Challenge as well as the dimensional constraints of the current chassis (American Solar Challenge, 2024). Next, the prototyping task will be to iteratively prototype the design components using fused deposition modeling (FDM) and scaled models to test joint fittings and other mating tolerances (Shahrubudin, N., Lee, T. C., & Ramlan, R., 2019). Additionally, we will use an Instron machine to perform a compression tesAst on the shock absorber to ensure that it is the optimal selection for the car (Instron, 2024). The manufacturing task will consist of machining the uprights from stock aluminum, cutting and welding one inch steel tubing into wishbones, creating mounts and tabs out of steel sheet metal to mount individual components together, and assembling all of the components together onto the chassis of the car (Harvey, 2013). The fourth and final task will be to test the system as a whole to verify the suspension accomplishes its intended goal, and to make adjustments as needed.

Initial design data for the system will be obtained from scholarly articles pertaining to the construction of suspension systems as well as models of existing systems such as Formula 1 race cars. As the proposed system develops through an iterative design approach, each iteration will supply more information and understanding for further development of the system. As for demonstrating the value of the system, a test will be performed when the suspension system is finalized and mounted to the chassis of the car to prove that it accomplishes its intended goal of safely mitigating impacts and facilitating efficient movement of the vehicle.

STS Project Proposal

Hyundai Motor Company, a leading South Korean automaker, is one of the largest automotive manufacturing companies in the world, and a key contributor to the growing electric vehicle industry. With several different models in their electric vehicle lineup, Hyundai is one of the top companies in electric vehicle sales in the U.S (Daly, 2024). Despite being a prominent company in the electric vehicle industry, Hyundai has had widespread recalls on many of their electric vehicles due to potential safety issues. In 2024, Hyundai recalled over 147,000 electric vehicles in the U.S. due to issues with the vehicles' integrated charging control units (ICCU) (Osho-Williams, 2024). Multiple incidents in which the ICCU stopped charging allowed for a sudden loss of power while the car was in use, which is a significant safety concern.

Commonly cited reasons for these issues that led to recalls focus on technical issues by the manufacturing companies. The issue with the ICCU in 2024 was attributed to design issues of the unit. More specifically, it was a manufacturing glitch that allowed for potential malfunction of the ICCU (Stotz, 2024).

Although these technical challenges played a role in the Hyundai electric vehicle recalls, they do not fully explain why the recalls occurred. The issues faced by electric vehicle manufacturers like Hyundai exist in part due to societal forces rapidly accelerating the growth of the electric vehicle industry. Customers with minimal understanding of electric vehicle technology, regulatory bodies, manufacturing companies with minimal electric vehicle experience, and a general societal push for a rapid transition towards environmentally sustainable goods all play a role as well (Bayless, 2023). The individual contributors are not solely responsible for the recall issues, but also the interactions between all of the factors. The combination of each of these factors allows for a more comprehensive view of the societal developments that led up to the problems faced by Hyundai's production of electric vehicles.

Common explanations for the cause of the electric vehicle recalls do not consider the network of factors that have developed and led up to the complications that initiate the widespread recalls. For this reason, I argue that manufacturing inexperience, regulatory bodies, customer unfamiliarity, and a rapid environmental movement gave way to the rise of technical issues in electric vehicles that ultimately led to widespread recalls. More specifically, I believe that the interactions between these factors led to mass electric vehicle production without sufficient understanding of the potential challenges and difficulties that could arise.

To frame my analysis of the Hyundai electric vehicle recalls, I will draw on the science, technology, and society (STS) concept of actor-network theory (ANT). This framework suggests that a network of actors interact in a way that shapes social and technological outcomes. A key aspect to ANT is the idea that it examines how network builders construct heterogeneous networks comprised of human and non-human actors to solve a problem or accomplish a goal. The relationships between the various actors are fluid and are constantly being performed in new ways (Cressman, 2009). In addition, I will utilize the concept of punctualization, which is the idea that an entire complex actor-network can be linked with other actor-networks to create an even larger network. For example, the entire Hyundai electric vehicle recall network can be considered a single point in a larger sustainable transportation network. The evidence I will draw on to support my argument will primarily be news media articles, technical reports, consumer reviews, and official statements released by Hyundai regarding the recalls.

Conclusion

The technical design of creating a new suspension system for the UVA Solar Car Team will improve on the existing design, and allow for the vehicle to operate in a manner that is both mechanically efficient and optimal for the solar technology. The STS project will provide a better understanding of the various social factors that contributed to the issues faced by Hyundai Motor Company's production of electric vehicles. Knowledge of the relationship between cultural and governmental aspects surrounding electric vehicles will allow for well-informed development of electric vehicle technology. The technical challenge of creating a suspension system to advance the progress of the UVA Solar Car Team coupled with the insights gained from the actor-network theory in the STS research will allow for a further understanding of how solar technology can be incorporated into the electric vehicle industry to address the challenges faced by electric vehicle manufacturers.

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