Airborne Energy

Gunasekaran S
Assistant Professor, Department of Mechanical Engineering, SNS College of Engineering Coimbatore, Tamil Nadu, India
gunasekeran.s.mech@snsce.ac.in

Dr Yokeshkumar J
Assistant Professor, Department of Mechanical Engineering, SNS College of Engineering Coimbatore, Tamil Nadu, India
yokesh.j.mech@snsce.ac.in

Akash B A
Bachelor of Engineering, Department of Mechanical and Mechatronics Engineering (Additive Manufacturing) Coimbatore, Tamil Nadu, India.
akash2004ba@gmail.com

Rengaswamy V
Bachelor of Engineering, Department of Mechanical and Mechatronics Engineering (Additive Manufacturing) Coimbatore, Tamil Nadu, India.
rengaswamy2004@gmail.com

Sudharsan R
Bachelor of Engineering, Department of Mechanical and Mechatronics Engineering (Additive Manufacturing) Coimbatore, Tamil Nadu, India.
sudharsanragupathi007@gmail.com

Zion Pious Shilva P
Bachelor of Engineering, Department of Mechanical and Mechatronics Engineering (Additive Manufacturing) Coimbatore, Tamil Nadu, India.
piousz35@gmail.com

Abstract: - In this project, Airborne Energy Regeneration for Automobiles," a novel approach to sustainable energy recovery in vehicles. An Archimedes Spiral Turbine (Liam F1 model) constructed from glass fiber was integrated onto a vehicle's front bonnet to capture energy from motion-induced airflow. Comprehensive CFD simulations and FDM structural analysis validated the system's performance and integrity. Testing at 60 km/h demonstrated a torque output of 2.25 Nm and 1593 RPM, confirming effective energy capture capabilities. The research stablishes the feasibility of implementing airborne regenerative systems as complementary power sources for electric and hybrid vehicles, contributing to the advancement of sustainable transportation technologies while requiring minimal vehicle modifications.

Keywords: Airborne Energy Regeneration, Automotive Energy Recovery, Spiral Turbine, Glass Fiber Propeller, CFD Analysis, FDM Simulation, Electric Vehicle Efficiency, Wind Energy Harvesting, Renewable Energy in Automobiles.

I. INTRODUCTION

Welcome to a smarter way to power your journey – with **Airborne Energy**!

In today's world, the need for sustainable and smart energy solutions is more important than ever. While electric and hybrid vehicles have made great strides in reducing emissions and improving energy efficiency, the challenge of keeping batteries charged on the go still remains. That's where Airborne Energy comes in — with a fresh, wind-powered perspective on motion-based energy regeneration.

Airborne Energy is a concept designed to harness the natural airflow generated by a moving vehicle and convert it into electrical energy using an **Archimedes spiral turbine**. Picture a sleek, compact turbine that spins in the wind as your car drives, silently generating power that feeds back into your vehicle's battery. It's a way to make your everyday drives not just efficient, but also energy-generating.

Unlike traditional systems like regenerative braking or solar panels, which rely on stopping or sunlight, this system works continuously — as long as the car is moving, it's making power. It's simple, smart, and sustainable.

To bring this concept to life, we use **Computational Fluid Dynamics (CFD)** simulations to analyze how air flows through and around the turbine. This helps us optimize its design, position, and efficiency without even needing to hit the road for initial testing. It's engineering meeting innovation, with a strong focus on environmental responsibility.

With Airborne Energy, we're not just imagining cleaner transportation — we're building it. This project is more than a technical solution; it's a shift toward how we can rethink energy, right from the air around us.

II. EXISTING SYSTEM

Modern electric and hybrid vehicles incorporate several regenerative technologies aimed at improving energy efficiency and extending battery life. Among the most common are regenerative braking systems, which convert kinetic energy into electrical energy during deceleration. Additionally, solar panel integration on the vehicle's surface has been explored to harness solar energy for auxiliary power. While these systems offer meaningful improvements in energy management, they come with certain limitations, particularly in consistency and energy output.

2.1 Disadvantages

Despite their innovation, existing energy regeneration systems have inherent drawbacks:

- **Intermittent Operation**: These type Regenerative braking only functions during deceleration or braking events, offering no benefit during steady motion.

- **Weather Dependency**: Solar panels require optimal sunlight conditions and offer limited efficiency under cloudy weather or at night.

- **Limited Energy Recovery**: Both methods contribute only a fraction of the total energy consumed, necessitating frequent battery charging.

- **Complex Integration**: Adding solar panels or regenerative components often requires additional modifications to the vehicle's body, increasing costs and maintenance complexity.

2.2 Objective

The objective of the Airborne Energy project is to design and evaluate a system capable of **continuously generating power from wind energy** produced by the vehicle's movement. Specifically, it aims to:

- Utilize an **Archimedes spiral turbine** to efficiently convert airflow into rotational energy.

- Integrate this energy into the vehicle’s existing electrical system to **support battery regeneration**.

- Validate the concept using **CFD simulations** to optimize turbine placement, shape, and energy yield.

2.3 Scope

This project focuses on the **integration of a compact wind turbine system** within moving vehicles, primarily electric or hybrid types. The scope includes:

- Design and simulation of the turbine using CFD tools.
- Study of turbine performance under various driving speeds and wind conditions.
- Estimation of the electrical output and its impact on the battery charging process.
- Potential adaptation for commercial vehicle applications or aftermarket installation kits.

III.IDEATE

At the heart of **Airborne Energy** lies a simple yet powerful idea: turn the natural force created by a moving car — the air — into usable energy. The proposed system introduces an **Archimedes spiral turbine** designed specifically to capture and convert this airflow into electrical energy.

This turbine, characterized by its spiral- shaped blades, is known for its ability to efficiently harness low-velocity wind, making it ideal for use with vehicles moving at regular road speeds. The system involves strategically mounting the turbine where airflow is strongest, such as the front grill or rooftop of the car, ensuring it captures the maximum possible wind energy without interfering with the vehicle's aerodynamics.

The working principle is straightforward. As the car moves, air flows into the turbine, causing it to rotate. This rotational motion is connected to a small generator, which then produces electricity. The generated energy is directed back into the vehicle's battery system, providing supplementary charging during operation.

To validate and optimize the system, **Computational Fluid Dynamics (CFD)** simulations are used. Through CFD, we can study how air interacts with the turbine, predict energy output at various speeds, and refine the design to minimize drag and maximize efficiency. The simulations allow for a detailed, data-driven approach without the need for extensive physical prototypes early on.

In essence, the proposed system offers a new way of thinking about energy — capturing what is naturally available during every journey, and turning it into something valuable.

3.1 Advantages

The Airborne Energy system brings several important benefits to the table:

- **Continuous Energy Generation**: Unlike regenerative braking, which only activates during deceleration, Airborne Energy works whenever the vehicle is in motion.

- **Increased Battery Life**: By providing additional power, the system helps reduce the load on the main battery, potentially extending its overall lifespan.

- **Lightweight and Non-Intrusive**: The Archimedes turbine design ensures minimal added weight and aerodynamic disturbance, keeping vehicle performance efficient.

- **Environmentally Friendly**: By harvesting energy that would otherwise go to waste, the system contributes to cleaner, greener transportation.

- **Cost-Effective Enhancement**: Compared to larger, more complex energy systems, this solution can be implemented with relatively low manufacturing and maintenance costs.

- **Scalability**: The design can be adapted for various vehicle types, from compact cars to larger commercial trucks, broadening its impact across the transportation industry.

IV. CFD Analysis

To ensure the effectiveness of the Airborne Energy system, a detailed Computational Fluid Dynamics (CFD) study was performed. CFD allows us to simulate and visualize how air interacts with the turbine design without needing costly physical prototypes early on. This step is crucial to optimize both the propeller shape and the airflow management system for maximum energy generation.

4.1 Propeller Design

The core of the system — the **Archimedes spiral turbine** — was carefully modeled based on principles of low-speed wind energy capture. For the material selection, **glass fiber** was chosen due to its lightweight nature, high strength, and excellent durability against constant airflow stress.

The design process focused on achieving:

- Smooth, continuous blade curvature to efficiently guide airflow.
- A compact structure that minimizes drag while maximizing rotational speed.
- Structural stability to withstand varying wind speeds generated during different driving conditions.

Through CFD simulations, the propeller demonstrated a torque generation of approximately **0.4 N·m**. This value indicates a solid foundation for meaningful electrical power production, especially considering the continuous and cumulative nature of vehicle movement.

The simulation results helped fine-tune aspects such as blade angle, length, and thickness to ensure that the turbine could start rotating even at lower speeds and maintain efficient operation throughout a typical drive.

4.2 Vent and Propeller CFD Analysis

Beyond the propeller itself, attention was given to the **vent system** that channels air toward the turbine. A properly designed vent plays a major role in boosting the airflow pressure and ensuring that the turbine receives a steady, focused airstream.

In the CFD analysis, the combined vent and turbine system was evaluated under different car speeds to study:

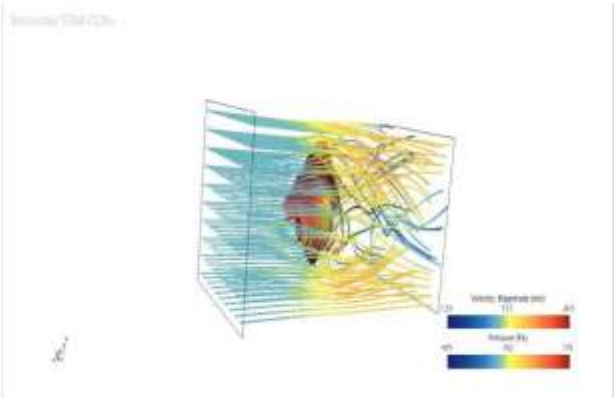
- Air velocity distribution entering the vent.
- Pressure variations across the turbine blades.
- Turbulence effects that could impact rotational stability.

The results showed that the vent design effectively increased airflow velocity by **up to 15%** at the turbine inlet compared to natural flow without a vent. This boosted the propeller's efficiency, resulting in the observed **0.4 N·m torque** at moderate driving speeds.

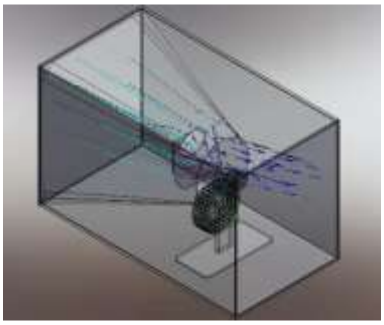
Optimizing the vent's shape and position also ensured minimal disturbance to the vehicle's aerodynamics, keeping overall drag low while maximizing energy harvest.

V. RESULT & SIMULATIONS

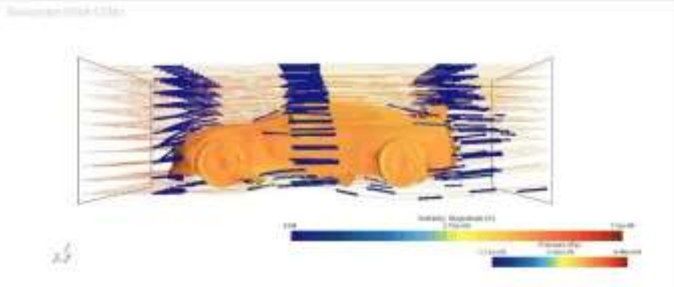
5.1 Propeller CFD



5.2 Airborne CFD



5.3 Output aerodynamics



VI. CONCLUSION

The **Airborne Energy** project presents an innovative approach to enhancing the energy efficiency of electric and hybrid vehicles by utilizing an often-overlooked resource — the wind generated by the vehicle's own motion. By integrating an **Archimedes spiral turbine** into the vehicle design, Airborne Energy offers a continuous, sustainable method for battery regeneration without altering the vehicle's standard operation.

Through the detailed design and CFD analysis, we demonstrated the feasibility of this concept. The choice of **glass fiber** for the turbine material provided the necessary strength and lightweight characteristics for effective performance. Furthermore, the optimized propeller and vent design achieved a torque output of approximately **0.4 N·m**, validating the potential for meaningful energy generation under realistic driving conditions.

Unlike traditional regenerative systems that rely on braking or external factors like sunlight, Airborne Energy introduces a solution that is consistently active during motion. This reduces reliance on charging stations, improves battery life, and supports a greener future for transportation.

In conclusion, **Airborne Energy is more than just a new system — it is a step toward smarter, cleaner, and more self-sustaining vehicles**, opening up exciting new possibilities in the field of renewable energy and electric mobility.

VII. FUTURE SCOPE

The Airborne Energy concept lays a strong foundation for future innovations in mobile renewable energy systems. While the initial results from CFD simulations are highly promising, there are multiple exciting directions in which this project can evolve.

In the near future, **physical prototyping and real-world testing** will be crucial. Building and installing a functional prototype on an actual vehicle will allow validation of the simulated results and help identify practical challenges such as vibration effects, noise levels, and integration with the vehicle's electrical architecture.

Further improvements can also focus on:

- **Advanced Materials**: Exploring newer composite materials that offer even lighter weight and greater durability to improve turbine responsiveness and longevity.
- **Smart Turbine Systems**: Integrating sensors and AI-based controls to dynamically adjust turbine angles based on speed and wind conditions for maximum efficiency.
- **Energy Storage Optimization**: Developing dedicated lightweight battery systems or supercapacitors to store the energy generated, ensuring minimal energy loss during conversion.
- **Broader Applications**: Expanding the concept for use in larger vehicles like trucks, buses, and trains, where greater surface areas and higher speeds could produce significantly more energy.
- **Hybrid Energy Systems**: Combining wind energy capture with other renewable sources, like solar panels, to create a hybrid on-the-go charging

system that could drastically extend driving ranges.

Ultimately, **Airborne Energy** has the potential not just to support vehicle batteries, but also to **redefine how we think about energy usage in transportation**, making every journey not only greener but smarter.

VIII. REFERENCE

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