MAGLEV-Based Vertical Axis Wind Turbine for Efficient Energy Generation

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INTRODUCTION

Bangladesh's growing demand for clean and sustainable electricity necessitates compact renewable energy solutions capable of operating efficiently under low and variable wind conditions. Conventional small-scale vertical-axis wind turbines (VAWT) suffer from significant mechanical losses due to bearing friction, higher start-up torque requirements, and frequent maintenance, which reduce overall efficiency and reliability in urban and low-wind environments [1].

To address these limitations, this project focuses on the design and fabrication of a MAGLEV-assisted Airfoil-type VAWT [2]. By incorporating permanent NdFeB magnets to partially levitate and support the rotor, mechanical contact is minimized, thereby reducing frictional losses and improving start-up performance. Additionally, a multi-coil[4] electromagnetic generator is integrated at the base to convert rotational motion into electrical energy. The proposed system aims to demonstrate improved efficiency, smoother operation, and enhanced feasibility for small-scale renewable energy applications in Bangladesh [3].

Key focus areas:

• Magnetic levitation to minimize friction and start-up torque

• Lightweight, low-cost prototype for small-scale renewable applications

• Fabrication, assembly, and controlled airflow performance evaluation

OBJECTIVES

• To Design a functional MAGLEV-based VAWT prototype using NdFeB magnets.

• To Reduce friction by eliminating conventional bearing contact.

• To Fabricate a lightweight, cost-effective rotor and support structure.

COMPLEX ENGG. PROBLEM

Complex Engineering Problem Characteristics (WK/WP/EA)

•WP1: Requires in-depth fundamentals (aerodynamics, magnetics, energy conversion) to model drag-torque and magnetic forces.

• WP2: Conflicting requirements—strong levitation vs. stability; low cost vs. high-grade magnets; lightweight vs. rigidity.

• WK3: No obvious off-the-shelf solution; iterative modelling and prototyping to address novel stability issues.

• WK6: Multidisciplinary, system-level integration (rotor + maglev + generator coils + structure).

•EA3–EA4: Innovative low-friction design supporting SDG 7 (Affordable & Clean Energy).

METHODOLOGY

Design and workflow

Airfoil rotor design for reliable low speed startup. Maglev setup uses repulsive NdFeB magnets with alignment features to keep a stable levitation gap and eliminate bearing friction. Four copper coils are fixed around the base , capturing induced voltage from rotation . Testing focuses on airflow driven RPM, generated voltage and overall levitation stability.

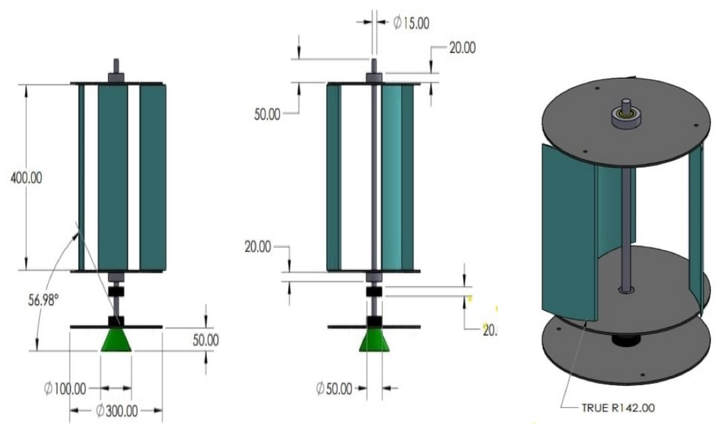
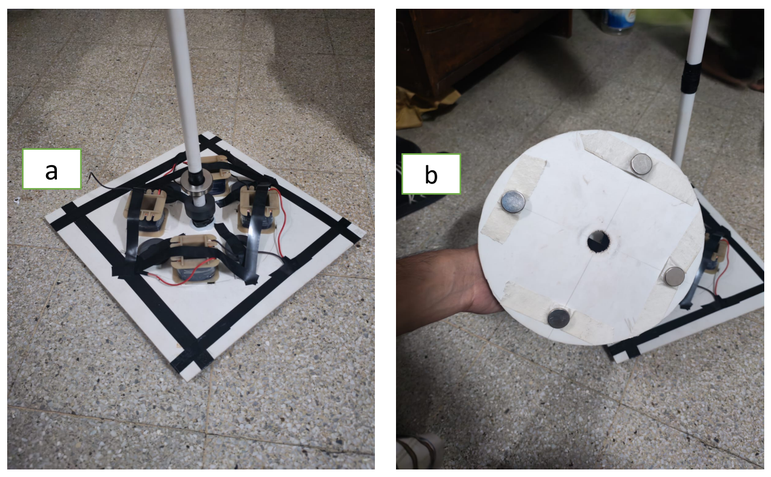


Fig. 1. Prototype design with dimensions

Prototype Fabrication Process



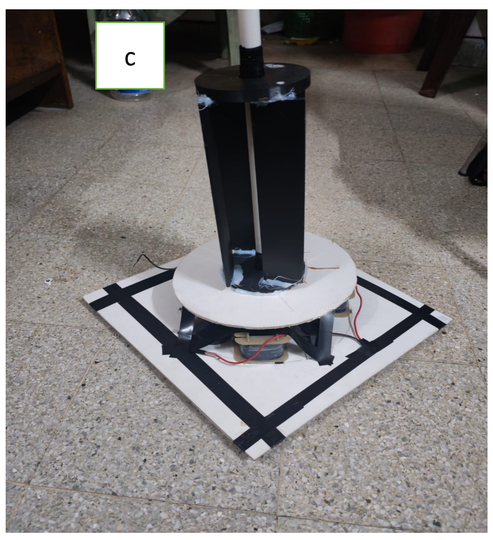


Fig. 2. (a)Fabricated base with generator coil.(b)Rotor Disc. (c) Final assembled MAGLEV VAWT prototype

Blades: Airfoil blades were 3D printed for lightweight structure and dimensional accuracy.

Base Plate: PVC plate fabricated to support coils and magnetic levitation system.

Coil Assembly: Six copper wind coils (31 AWG, ~1500 turns) were fixed onto the base using industrial adhesive with uniform spacing.

Maglev Setup: NdFeB magnets aligned concentrically to maintain stable levitation gap.

Shaft Integration: Central PVC shaft positioned through all plates to ensure vertical alignment and smooth rotation.

This system aims to improve efficiency, smoother operation for small scale renewable energy application

RESULTS & DISCUSSION

Performance Summary

A comparative evaluation was conducted between the fabricated MAGLEV-assisted VAWT and a similar-scale bearing-supported VAWT under identical airflow conditions. The primary performance indicator was induced open-circuit voltage across the coil assembly.

The MAGLEV prototype consistently demonstrated improved start-up behavior and higher voltage generation at low wind velocities due to reduced mechanical friction and lower starting torque.

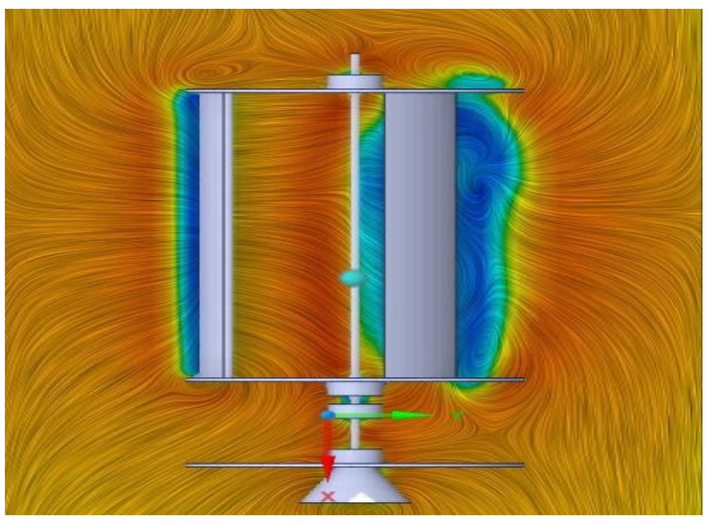


Fig. 3 : CFD flow around Savonius VAWT showing wake and drag effects.

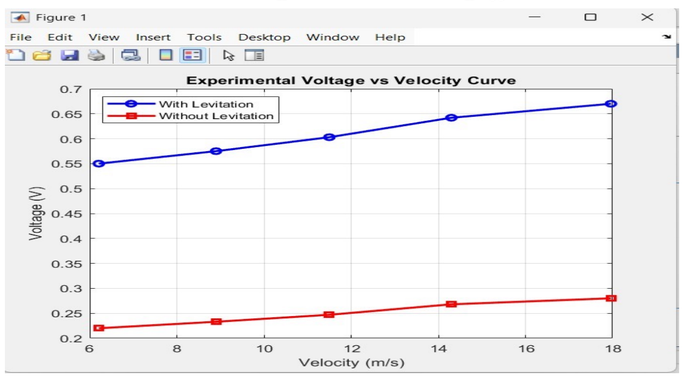


Fig. 4 :Voltage vs air velocity (MAGLEV vs conventional VAWT).

Key Findings & Limitations

60–90% higher voltage at 2–3 m/s due to reduced friction.Nearly linear trend ($E \propto \omega$); advantage narrows at higher speeds as drag dominates.Minor instability at high RPM.

Limitations:

• Low output (0.2–0.5 V), partly due to reduced coil design — 1500 turns, 31 AWG used instead of planned 2000 turns, 42 AWG, limited by local material availability.

• Sensitive magnetic alignment affecting stability.

• Open-circuit testing only; loaded and scaled performance unverified.

MAGLEV improves low-speed response, but electrical optimization and structural refinement are required for practical deployment.

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