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Design and Development of a Free Energy Generator Using a Flywheel with Energy Storage

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Abstract: This study presents the design, fabrication, and performance evaluation of a flywheel-based energy storage and electricity generation system intended for small-scale and decentralized applications. The system integrates a flywheel, an electric motor, a generator, a rechargeable battery, and a power inverter to store mechanical energy and convert it into usable electrical power. Unlike conventional fossil-fuel-based generators, the proposed system emphasizes energy efficiency, reusability of stored kinetic energy, and environmental sustainability. Experimental results demonstrate that the flywheel-assisted system can stabilize power output, charge a battery effectively, and supply alternating current suitable for domestic loads. The findings suggest that flywheel energy storage systems can complement existing renewable technologies by mitigating intermittency and enhancing energy reliability. This paper contributes to ongoing research on mechanical energy storage by presenting a low-cost prototype suitable for developing regions.

Keywords: *Flywheel Energy Storage, Mechanical Battery, Renewable Energy Systems, Kinetic Energy, Power Generation.*

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I. INTRODUCTION

The continuous growth in global population, industrialization, and urbanization has resulted in a rapid increase in energy demand worldwide. Electrical energy remains the backbone of modern economies, powering households, industries, communication systems, healthcare facilities, and transportation infrastructure. However, conventional electricity generation methods, which rely heavily on fossil fuels such as coal, oil, and natural gas, pose serious environmental and economic challenges. These challenges include greenhouse gas emissions, air pollution, climate change, and the depletion of finite natural resources.

In response to these challenges, renewable energy technologies such as solar, wind, hydroelectric, and biomass have been widely promoted as sustainable alternatives. Despite their advantages, renewable energy sources suffer from inherent intermittency and unpredictability due to their dependence on weather and environmental conditions. This intermittency creates instability in power supply, particularly in regions with weak or underdeveloped electrical grids.

Energy storage systems have therefore become a critical component of modern power systems. They enable excess energy generated during low-demand periods to be stored and released during peak demand or power outages. Among various energy storage technologies, mechanical energy storage systems particularly flywheel energy storage systems (FESS) have gained increasing attention due to their high efficiency, long operational lifespan, rapid response time, and minimal environmental impact.

A flywheel stores energy in the form of rotational kinetic energy by accelerating a rotating mass to high speeds. When energy is required, the stored kinetic energy is converted back into electrical energy through an electromechanical interface. Unlike electrochemical batteries, flywheels do not rely on chemical reactions, making them more durable and environmentally friendly.

This journal paper presents the expanded design, development, and performance evaluation of a flywheel-based energy storage and generation system intended for small-scale and decentralized applications. The study emphasizes system architecture, theoretical analysis, experimental testing, and practical applicability in developing regions.

A. Background and Related Studies

Flywheel technology has been used for centuries in mechanical systems such as potter's wheels, spinning wheels, and early engines to regulate speed and smooth rotational motion. In modern engineering, flywheels have evolved into sophisticated energy storage devices capable of operating at very high rotational speeds using advanced materials, magnetic bearings, and vacuum enclosures.

Early applications of flywheel energy storage were primarily mechanical. However, advancements in power electronics, control systems, and materials science have enabled flywheels to be integrated into electrical energy systems. Contemporary flywheel energy storage systems are widely applied in grid frequency regulation, regenerative braking in electric and hybrid vehicles, uninterrupted power supply (UPS) systems, and space applications.

Several studies have investigated the performance characteristics of flywheel energy storage systems. Mousavi et al. presented a comprehensive review of flywheel energy storage technology, highlighting its advantages such as high round-trip efficiency, high power density, and long cycle life compared to electrochemical batteries. Conteh and Nsofor analyzed composite flywheel materials for high-speed energy storage, demonstrating improved strength-to-weight ratios and energy density.

Other researchers have focused on reducing system losses through magnetic bearings and vacuum enclosures, thereby improving overall system efficiency. While these studies demonstrate the technical feasibility of advanced flywheel systems, their high cost and complex manufacturing processes limit their adoption in developing countries.

This study distinguishes itself by focusing on a simplified, low-cost flywheel-based energy storage system constructed using locally available materials. The objective is not to compete with high-speed industrial flywheel systems but to demonstrate a practical and scalable solution suitable for small-scale energy storage and backup power applications.

B. Problem Statement

Frequent power outages, rising electricity costs, and dependence on fossil fuels remain major challenges in many developing regions. Renewable energy systems alone are often insufficient due to variability in environmental conditions. There is therefore a need for complementary energy storage technologies that are affordable, reliable, and environmentally friendly. Existing storage solutions such as batteries suffer from limited lifespan, high replacement costs, and environmental disposal issues. A mechanically based energy storage system using a flywheel presents a viable alternative.

C. Objectives of the Study

➢ *Main Objective*

To design and develop a flywheel-based energy storage and power generation system for small-scale applications.

➢ *Specific Objectives*

- To design and fabricate a flywheel energy storage prototype using locally available materials.
- To analyze the electrical and mechanical performance of the system.
- To evaluate the system's efficiency and energy storage capability.
- To compare flywheel energy storage with other conventional energy storage technologies.

II. METHODOLOGY

A qualitative and experimental research design was adopted. Data were collected through literature review, system design, fabrication, and laboratory testing. Computer-aided design (CAD) tools were used to model system components and ensure dimensional accuracy.

➢ *System Design*

The system consists of an AC motor coupled to a flywheel through a shaft and belt mechanism. A generator converts mechanical energy into electrical energy, which is stored in a rechargeable battery. An inverter converts DC power to AC for end-use applications.

➢ *Materials and Components*

Key components include a cast iron flywheel, steel shaft, pillow block bearings, AC motor, generator coil, rechargeable battery, inverter, and control switches. Material selection was based on availability, durability, and cost-effectiveness.

Table 1: Materials

S/N	Material Description	Length (mm)	Width / Size	Thickness / Ø	Quantity	Material Type
1	Rectangular tubes	12,000	20 × 40 mm	5 mm	1	Iron
2	Shaft	480	–	Ø 25 mm	1	Steel
3	Bolt and nut	–	–	–	22	Iron
4	Electric cables (multistrand)	5,000	–	2.5 mm	1	Copper
5	Magnets	–	Ø 60 mm	10 mm	2	Ceramic
6	Flywheel	300	–	50 mm	1	Cast iron

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Table 2: Components

S/N	Component Description	Length (mm)	Width / Size	Thickness / Ø	Quantity	Material
1	V-Belt	–	Ø 400 mm	–	2	Rubber
2	Switch / Contactor	25	20 mm	28 mm	2	PVC
3	Pulley (Small)	–	Ø 75 mm	–	1	Steel
4	Pulley (Big)	–	Ø 150 mm	–	1	Steel
5	Pillow block bearing	90	60 mm	35 mm	2	Chromium
6	Ceiling fan coil	–	100 mm	Ø 70 mm	1	Copper & Iron
7	AC Motor	–	–	–	1	Copper & Iron
8	Mechanical timer switch	40	40 mm	25 mm	1	PVC

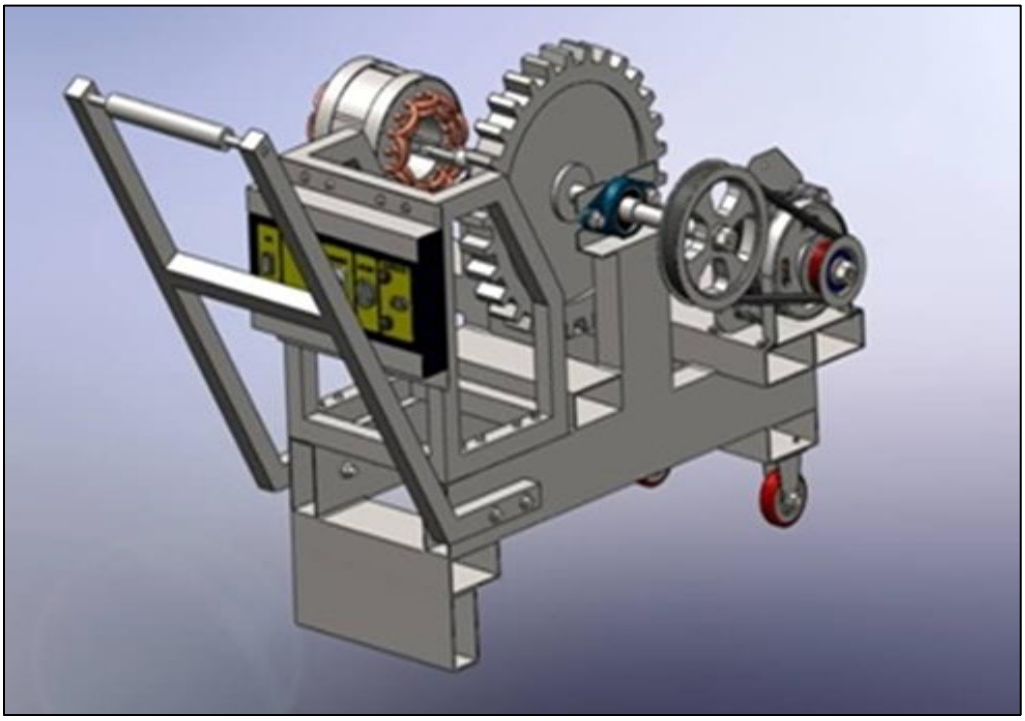

Fig 1 Isometric Drawing of the Machine

III. THEORETICAL ANALYSIS

- *Flywheel Energy Storage*

The kinetic energy stored in a flywheel is given by:

$$E = \frac{1}{2} I\omega^2$$

where E is the stored energy (J), I is the moment of inertia (kg·m²), and ω is the angular velocity (rad/s).

For a solid cylindrical flywheel:

$$I = \frac{1}{2} mr^2$$

where m is mass (kg) and r is radius (m).

IV. EXPERIMENTAL RESULTS

Experimental testing was conducted to evaluate the electrical and mechanical performance of the flywheel-based energy storage system. The system was operated under varying rotational speeds and load conditions to assess voltage output, charging capability, and system stability.

- *Voltage–Speed Characteristics*

The experimental results showed a direct relationship between rotational speed and generated voltage. As the speed of the flywheel increased, the output voltage from the generator increased proportionally. This behavior is consistent with electromagnetic induction principles and confirms the suitability of the generator for variable-speed operation.

- *Battery Charging Performance*

The DC output from the generator was successfully used to charge a rechargeable battery. The battery reached its nominal voltage within a reasonable charging time, indicating effective energy transfer from the flywheel system. The stored electrical energy was later supplied to an inverter to power AC loads.

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➢ *Load Testing*

The system was tested with light domestic loads such as lighting and small electronic devices. The inverter provided stable AC output voltage, and the flywheel contributed to smoothing power fluctuations during transient load changes.

➢ *System Efficiency*

Although mechanical and electrical losses were observed due to friction, belt transmission, and conversion inefficiencies, the system demonstrated acceptable performance for small-scale applications. The results confirm that flywheel energy storage can enhance system reliability by providing short-term energy buffering and backup power.

V. DISCUSSION

The experimental results confirm that flywheel energy storage can effectively support short-term energy needs and improve power stability. While the system does not generate energy from nothing, it efficiently stores and reuses input energy, making it suitable as a backup or supplementary power source.

VI. CONCLUSION

This study successfully designed and tested a flywheel-based energy storage and generation system. The prototype demonstrated reliable performance, environmental friendliness, and potential for application in areas with unstable power supply. Flywheel energy storage offers a promising alternative to conventional battery-based systems, particularly for small-scale and decentralized energy applications.

RECOMMENDATIONS

- Use of magnetic or vacuum enclosures to reduce friction losses.
- Integration of advanced control systems for improved efficiency.
- Scaling the system for higher power applications.

FUTURE WORK

Future research should focus on long-term performance evaluation, economic analysis, and hybrid integration with renewable energy sources such as solar and wind.

REFERENCES

[1]. Akhil et al (2013). *Electricity storage handbook in collaboration with NRECA*. Sandia, National Laboratories. (P56)

[2]. Akhil et al., (2019). *Contactless energy generation using flywheel,* IRJET Volume 06, Issue 06, June 2019. (Pp 34-36).

[3]. Akhilesh et al., (2016). *Electricity Generation using Flywheel,* International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 4 Issue IV, April 2016,ISSN: 2321-9653. (P12).

[4]. Asif M. and Muneer T. (2007). *Renewable and Sustainable Energy.* Reviews*, 2007*, vol. 11, issue 7, (pp. 1388-1413)

[5]. Berdichevsky et al., (2006). *Technologies of Energies of Energy Storage Systems*. Academic Press. (pp.50 -55).

[6]. Bitterly J., (1998). *Flywheel technology: past, present, and 21st century projections. IEEE Aerosp Electron Syst Mag*. 1998; 13(8): pp 13- 16.

[7]. Chung-Neng Huang and Yui-Sung Chen, (2016). *Design of a Flywheel Control for Fuel Cell Vehicles*, Sens. Mater., Vol. 28, No. 9, pp. (933-938).

[8]. Chung–Neng Huang, and Yui-Sung Chen (2016). *Design of Magnetic Flywheel Control for Performance Improvement of Fuel Cells used in Vehicles*, journal on strength – 2016 (pp. 1-13).

[9]. Conteh, Michael A.; Nsofor, Emmanuel C. (2016). *Composite flywheel material design for high-speed energy storage.* Journal of Applied Research and Technology, vol. 14, núm. 3, (pp. 184-190).

[10]. Dincer, I. (2000). *Renewable Energy and Sustainable Development: A Crucial Review.* Renewable and Sustainable Energy Reviews, 4, (pp,157-175).

[11]. Electric Motor. (2013). Retrieved June 6, 2023, from Wikipedia: The Free Encyclopedia:http://en.wikipedia.org/wiki/Electric_motor

[12]. Fiske O.J. and Ricci M.R (2006). Third Generation Flywheels for High Power Electricity Storage. LaunchPoint Technologies, Inc., Goleta USA. (Pp. 24-26).

[13]. Genta G. (2014). *Kinetic Energy Storage: Theory and Practice of Advanced Flywheel Systems*. United Kingdom: Butterworth-Heinemann; p67.

[14]. Hall CD (1997). *High speed flywheels for integrated energy storage and attitude control.* Proceedings of the 1997 American Control Conference (Cat. No. 97CH36041), IEEE; 1997 (3), (pp 1894– 1898).

[15]. Hebner et al, (2002). *Flywheel batteries come Around Again.* IEEE Spectrum, vol. 39, no. 4, April 2002 (pp. 46-51).

[16]. Lior, N. (2010). *Sustainable Energy Development*: *The Present Situation and Possible Paths to the Future*. Energy Journal N0. 35. Available at http://www.sciencedirect.com. [Accessed 0n 26th June 2023].

[17]. Maji et al., (2016), *Free Energy Using Flywheel*, IJSRD - International Journal for Scientific Research & Development, Volume 4, Issue 02, 2016 ISSN : 2321-0613.

[18]. Mayur et al., (2019). *Contactless Energy Generation Using Flywheel for EV*, IETIR Volume 06, Issue 04, April 2019 (pp. 377-384).

[19]. Michel A Conteh, Emmanuel C. Nsofor (2016). *Composite flywheel material :design of high-speed energy storage.* Journal of applied research and technology 14 (2016) (pp184-190).

[20]. Mirish. (2011). *Inverter Principles And Their Working*. Retrieved June 6, 2023, from Blogspot: http://inveters.blogspot.com/

[21]. Mohammed A, (2017), *Free Energy Generation Using Flywheel*, International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN: 2395-602X, Print ISSN : 2395-6011. (P26).
[22]. Moosavi-Rad, H., and Ullman, D.G., (1990). *Review of Battery Electric Vehicle Propulsion Systems Incorporating Flywheel Energy Storage*. International Journal of Automotive Technology No 16 (pp 487-500).
[23]. Mousavi et al (2017). *A comprehensive review of Flywheel Energy Storage System technology*, Renewable and Sustainable Energy Reviews, Elsevier, vol. 67(C), (pp 477-490).
[24]. Mousavi et al., (2017). *A complete assessment of flywheel strength storage device journal on renewable and sustainable energy.* Review No. 67. Of 2017 (pp. 477-490).
[25]. Nagorny et al (2005). *Design Aspects of a High Speed Permanent Magnet Synchronous Motor/Generator for Flywheel Applications.* (pp 205-206).
[26]. Narayan R., and Viswanathan B,. (1998). *Chemical and Electrochemical Energy Systems*. University Press. (P64).
[27]. Omer, A.M. (2008). *Energy, Environment and Sustainable Development*. Renewable and Sustainable Energy Reviews, 12, (pp. 2265-2300).
[28]. Ostergard R., (2011). *Flywheel Energy Storage: a Conceptual Study*. Uppsala University Press (p.45).
[29]. Rahul P. et. Al. (2019). *Design and Fabrication of contactless energy generation system with flywheel*. NCTEP-February 2019. (Pp 102-104)
[30]. Rushikesh et al., (2019). *Review of Free Energy Generation using Flywheel.* IRJET Volume 06, Issue 04, April 2019 (pp 869-876).
[31]. Siddharth S. (). *Free Energy Generation Advanced Research*, imperial Journal of Interdisciplinary Research (IJIR) Vol-3, Issue4, 2017 ISSN: 2454-1362.
[32]. Sunarlik W. (2017). *Working Principle of Synchronous Generators,* PrinsipKerjaGener. Sink. (Pp46).