MARATHA VIDYA PRASARAK SAMAJ’S

KARMAVEER ADV. BABURAO GANPATRAO THAKARE COLLEGE OF ENGINEERING

KBTCOE

DEPARTMENT OF MECHANICAL ENGINEERING

Presents

Technical Magazine

Mech-Spark

Volume: 8 Issue: 1

A.Y. 2025-26 Sem-I

Institute Vision

To be internationally accredited, Multidisciplinary, and Multi-collaborative institute working on technology enabled platform fostering innovations and patents through state-of-art academic system designed by highly qualified faculty for the development of common masses at large

Institute Mission

To educate and train common masses through undergraduate, post graduate, research programs by inculcating the values for discipline, quality, transparency and foster career and professional development for employment thereby contributing to the development of society

Department Vision

To be the centre for excellence and centre of learning for innovation, incubation and research in the domain of product design, thermal engineering and manufacturing technology thereby path finder for professionalism, entrepreneurship and new knowledge contributing to the common masses.

Department Mission

To educate and train undergraduate and post graduate students in Mechanical Engineering by inculcating the values for discipline, quality and transparency and profession development in the job and self-employment emphasis industry-based practices.

Program Education Objectives (PEO’s)

PEO1: To prepare technocrats that can satisfy the need of mechanical and allied industries.

PEO2: To develop critical thinking, problem solving skills, research aptitude and career and professionalism among the students.

PEO3: To improve and expand technical and professional skills of students through effective teaching-learning and industry interaction.

Program Specific Outcomes (PSOs)

PSO1: Ability to design, analysis and problem-solving skills using basic principle of mechanical engineering.

PSO2: Ability to impart technical and professional skills through industry institute interaction

PSO3: Develop practical skills for the benefits of society.

Objectives of Magazine

1. Primary objective of the magazine is to provide a wide platform to the aspiring engineers to showcase their technical knowledge and to explore innovative ideas.
2. This magazine is intended to bring out the hidden literary talents in the students and teachers to inculcate strong technical skills among them.
3. Share the latest developments, trends, and innovations in engineering, including new technologies, methodologies, and industry standards.
4. Encourage creativity and innovation within the engineering community by highlighting groundbreaking research, new inventions, and novel solutions to existing challenges.

Numerical Analysis and Experimental Validation of a Real-Time Thermal Management and Alert System for Lithium-Ion Batteries in Electric Vehicles

Abstract

This study presents a real-time thermal management system for lithium-ion batteries in electric vehicles. The system monitors battery temperature and activates cooling and alerts when it exceeds 60°C. It includes sensors, a microcontroller, cooling fans, and a GSM module. CFD analysis is used to optimize airflow. Experimental results show temperature reduction from 60°C to ~41–44°C within 10 minutes, improving safety and preventing thermal runaway.

1. Introduction

1.1 Background

Electric vehicles are widely adopted due to their environmental benefits and efficiency. However, lithium-ion batteries are prone to overheating, especially under high ambient temperatures or charging conditions. Optimal battery performance occurs within 15–35 °C, and exceeding this range can lead to degradation or thermal runaway, potentially causing fires.

1.2 Problem Statement

Existing battery management systems (BMS) primarily monitor parameters but often lack real-time cooling and alert mechanisms during idle or charging states. This creates a safety gap when vehicles are exposed to high temperatures.

1.3 Objective

The objective of this study is to design and validate a real-time thermal management system that:

- Detects overheating conditions
- Activates cooling mechanisms
- Alerts the user through alarms and remote communication

2. System Design and Methodology

2.1 System Architecture

The system includes:

- Contactless temperature sensors
- Arduino-based controller
- Four DC cooling fans
- Auxiliary battery
- GSM module and alarm system

When the temperature exceeds 60 °C:

- Cooling fans activate
- Audible alarm is triggered
- Notification is sent to the operator

The use of an independent auxiliary battery ensures system functionality even if the main battery fails.

2.2 Temperature Threshold

A threshold of 60 °C is selected to initiate preventive action before thermal runaway conditions (80–120 °C). This ensures early detection and mitigation.

2.3 CFD Analysis

CFD simulations were conducted to determine optimal airflow configuration.

- Initial battery temperature: 60 °C
- Ambient temperature: 40 °C
- Various fan arrangements tested

Findings:

- Perpendicular fan configuration (Case I) provided the best cooling
- Uniform airflow minimized hotspots, especially at the central cell

---

2.4 Mesh and Simulation Details

- Structured hexahedral mesh (~410,000 cells)
- k–ω SST turbulence model used
- Heat transfer through conduction and convection considered
- Mesh independence ensured accuracy (variation <0.5%)

---

3. Experimental Validation

A prototype was developed based on CFD results. Key setup:

- Battery heated to 60 °C
- Cooling system activated automatically
- Temperature monitored using infrared sensors

3.1 Auxiliary Battery Performance

- Runtime ≈ 45–52 minutes
- Sufficient for emergency response

---

4. Results and Discussion

4.1 Cooling Performance

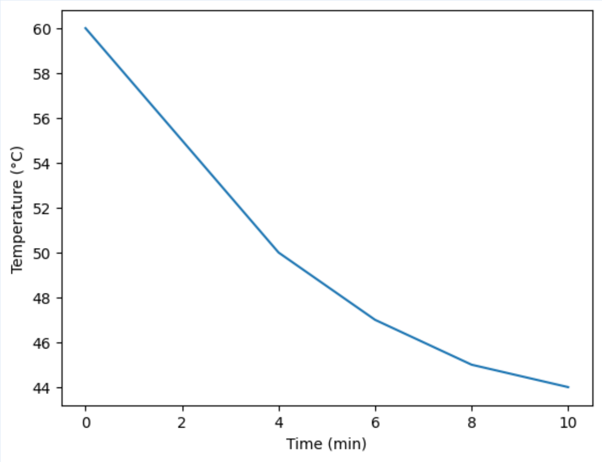
- Temperature reduced from 60 °C to:
    - ~41.1 °C (CFD)
    - ~44.2 °C (Experimental)
- Cooling achieved within 10 minutes

4.2 Accuracy

- CFD and experimental results showed ~93% agreement
- Minor deviations due to real-world factors like airflow variations and sensor limitations

4.3 Airflow Insights

- Maximum airflow velocity observed at battery center
- Effective cooling due to reduced stagnation zones



4.4 Safety Features

- Real-time alarm system
- Remote GSM alerts
- Fail-safe mechanisms for fan failure and low battery

---

5. Future Scope

- Integration with Battery Management System (BMS)
- Testing under extreme ambient conditions (>40 °C)
- Application in full-scale EV battery packs
- Advanced communication (Bluetooth, CAN systems)

---

6. Conclusion

This study presents an effective real-time thermal management system for EV lithium-ion batteries. By combining CFD-optimized airflow design with experimental validation, the system demonstrates reliable cooling performance and safety enhancement. The ability to reduce battery temperature rapidly and provide timely alerts significantly lowers the risk of thermal runaway and fire hazards. The proposed system is practical, cost-effective, and suitable for real-world EV applications, particularly in two-wheelers.

Prepared by:-

1. Dr. S. B. Sonawane

Faculty of Department of Mechanical Engg. M.V.P.S's K.B.T. College of Engineering, Nashik

Recent Trends in Jaggery Making Processes: A Review

Abstract

Jaggery, an unrefined sugar derived from sugarcane juice, is a key agro-based product in India, utilizing about 25–30% of total sugarcane production (~9.2 million tonnes in 2024). Traditional open-pan processing relies on bagasse as fuel but suffers from low thermal efficiency (15–60%), high fuel consumption, and environmental concerns. This review examines conventional and advanced jaggery-making processes, including multiple-effect evaporation (MEE), freeze pre-concentration, and vapour recompression systems (VRS). Freeze concentration removes water as ice prior to heating, reducing energy demand and preserving quality, while VRS improves efficiency by reusing vapour energy. These innovations offer significant potential for improving energy efficiency, product quality, and economic viability in the jaggery industry.

Keywords: Jaggery, Freeze concentration, Vapour recompression, Energy efficiency, Techno-economics

1. INTRODUCTION

Jaggery is produced by concentrating sugarcane juice without removing molasses, thereby retaining minerals (iron, calcium, phosphorus) and antioxidants. It is nutritionally superior to refined sugar and has growing domestic and export demand.

However, the industry faces three major challenges:

- Low thermal efficiency of furnaces
- Dependence on supplementary fuels
- Labour-intensive and unsafe working conditions

Conventional systems exhibit efficiencies of ~15% (single pan) to 50–60% (multi-pan). Improving energy utilization and process automation is essential for sustainability and profitability.

---

2. CONVENTIONAL JAGGERY MAKING PROCESS

The traditional process involves:

- Extraction: Juice extraction efficiency of 60–70%
- Pre-treatment: Filtration and settling
- Heating: Open-pan boiling using bagasse
- Clarification: Addition of chemical or vegetative clarificants
- Concentration: Continuous boiling and stirring
- Moulding: Cooling and solidification

Key Parameters:

- Initial concentration: 16–20°Bx
- Final temperature: ~118°C (solid jaggery)
- Scum removal: 1.5–4%
- Limitations:
- Poor heat utilization
- High fuel consumption
- Quality variability
- Worker exposure to heat and fumes

3. CLASSIFICATION OF PROCESSES

Jaggery production methods are classified as:

3.1 Conventional

- Open-pan boiling (single/multi-pan)
- Batch or semi-continuous operation

3.2 Modified

- Multiple Effect Evaporation (MEE)
- Freeze Concentration Systems (FCS)
- Vapour Recompression Systems (VRS)

These are based on the mechanism of water removal: evaporation or freezing.

---

4. MODIFIED JAGGERY MAKING PROCESSES

4.1 Multiple Effect Evaporation (MEE)

MEE uses vapour from one stage to heat the next, significantly improving energy efficiency.

Advantages:

- Reduced energy consumption
- Lower caramelization due to controlled temperature
- Suitable for large-scale plants

Disadvantages:

- Requires low-pressure steam
- High capital and maintenance costs
- Limited suitability for small units

4.2 Freeze Concentration System (FCS)

FCS removes water as ice at sub-zero temperatures before evaporation.

Freezing point depression: Tf<0∘C for sucrose solution\text{Freezing point depression: } T_f < 0^\circ C \text{ for sucrose solution}Freezing point depression: Tf <0∘C for sucrose solution

Performance:

- Concentration: 20°Bx → 40°Bx
- Water removal: ~63% before heating
- Bagasse saving: up to 77%

Advantages:

- Improved quality (minimal thermal degradation)
- Reduced fuel consumption
- Potential for solar-powered operation

Disadvantages:

- Sugar loss in ice phase
- High initial investment
- Technical complexity

4.3 Vapour Recompression System (VRS)

VRS compresses generated vapour and reuses it as a heating medium.

Advantages:

- Eliminates external fuel requirement
- High thermal efficiency
- Uniform heating improves product quality

Disadvantages:

- High capital cost
- Requires skilled operation
- Needs pressure-resistant equipment

5. TECHNO-ECONOMIC ASPECTS

Economic feasibility depends on:

- Scale of operation
- Energy savings
- Value addition

Key Observations:

- Medium and large units are more profitable
- Energy-efficient systems reduce operating costs
- By-products (bagasse) can be used for briquettes, paper, or compost

Value-added products such as organic jaggery and jaggery-based foods further enhance profitability.

6. FUTURE DIRECTIONS

Key focus areas for industry development:

- Improving thermal efficiency
- Adopting automation and safer equipment
- Promoting organic jaggery production
- Enhancing consumer awareness
- Providing financial and policy support
- Utilizing renewable energy and carbon credits

7. CONCLUSION

Conventional jaggery-making processes are energy-intensive and inefficient. Advanced techniques such as freeze concentration, MEE, and vapour recompression significantly improve efficiency and product quality.

Freeze pre-concentration reduces thermal load by removing up to 63% of water before heating, while VRS and MEE enhance evaporation efficiency under controlled conditions. Although these technologies require higher initial investment, they offer long-term benefits in sustainability, energy savings, and economic returns.

Prepared by:-

1. Dr. D. B. Uphade

Faculty of Department of Mechanical Engg. M.V.P.S's K.B.T. College of Engineering, Nashik

Ranking the solutions to mitigate sustainable innovation implementation barriers using a BWM-COPRAS approach

Introduction

Sustainable Innovation (SI) integrates environmental, social, and economic goals into products, processes, and supply chains. With increasing regulatory pressure and environmental concerns, organisations must adopt sustainable practices. However, implementing SI is complex due to multiple barriers such as high costs, lack of technology, and organisational resistance.

This study focuses on:

- Identifying **barriers to SI implementation**
- Determining **solutions to overcome them**
- Ranking solutions using a **hybrid BWM–COPRAS method**

Research Gap

Most existing studies focus either on identifying barriers or on proposing solutions, but very few address both aspects together in an integrated manner. Additionally, earlier research lacks proper prioritisation of solutions, making it difficult for organisations to decide which actions to implement first. There is also limited application of such studies in the Indian manufacturing context. This study addresses these gaps by identifying 36 barriers, proposing 16 solutions, and systematically ranking these solutions using a structured decision-making framework.

Methodology

The study uses a hybrid approach combining the Best-Worst Method (BWM) and the COPRAS method. The Best-Worst Method is applied to determine the importance or weights of different barriers. In this method, experts select the most important (best) and least important (worst) criteria and perform pairwise comparisons, which require fewer comparisons and provide more consistent results than traditional methods like AHP. The COPRAS method is then used to rank the solutions based on these weights. It involves constructing a decision matrix, normalising the data, applying weights, and calculating utility scores to determine the final ranking of solutions.

Identified Barriers

The study identifies a total of 36 barriers, which are grouped into seven categories. Technological barriers are the most critical and include inadequate infrastructure, lack of IT systems, and difficulties in integrating technologies. Strategic barriers include poor planning for innovation and lack of top management support. Economic barriers involve high implementation costs and uncertain returns on investment. Environmental and regulatory barriers arise due to weak government policies and poor enforcement. Organisational barriers include lack of skills, insufficient training, and resistance to change. Socio-cultural barriers are related to low customer awareness and a cost-conscious mindset. Operational barriers, which are the least critical, mainly involve weak collaboration within the supply chain.

Key Barrier Rankings

Among all barriers, inadequate technological infrastructure is identified as the most critical. This is followed by lack of strategic planning and high innovation costs. These findings clearly indicate that technology is the biggest obstacle to the implementation of sustainable innovation.

Identified Solutions

The study proposes 16 solutions to overcome the identified barriers. These include aligning organisational changes with technological advancements, improving supply chain collaboration, enhancing employee motivation and training, increasing investment in research and development, adopting Industry 4.0 technologies, implementing reverse logistics, and applying 6R principles such as reduce, reuse, and recycle.

Solution Ranking

Based on the COPRAS method, the most effective solution is organisational change aligned with technology. This is followed by investment in sustainable innovation and research and development, supply chain collaboration, implementation of 6R principles, and employee motivation and engagement. On the other hand, customer awareness programs and reverse logistics are ranked as less effective solutions.

Key Insights

The study reveals that the most effective solution involves a combination of technological upgrades and organisational transformation. It highlights that technology and strategy must work together for successful implementation. It also emphasises the importance of supply chain participation and the need to manage employee resistance. High costs continue to be a major constraint in adopting sustainable innovation.

Sensitivity Analysis

A sensitivity analysis was conducted using 15 different experiments by varying the weights of barriers. The results showed that the rankings of solutions remained stable, indicating that the model is robust and reliable.

Managerial Implications

The findings suggest that managers should invest in modern technologies and align their strategies with sustainability goals. They should focus on improving workforce training, promoting collaboration across the supply chain, and encouraging a cultural shift towards sustainability within the organisation.

Limitations

The study is based on expert opinions and focuses on a single Indian company, which may limit the generalisability of the results.

Therefore, the findings may not be directly applicable to all industries or regions.

Conclusion

In conclusion, sustainable innovation is essential but faces multiple and interconnected barriers. Technological limitations are identified as the most significant challenge. The hybrid BWM–COPRAS framework proves to be effective in prioritising solutions. The study concludes that synchronising organisational change with technological advancement is the most effective approach for achieving sustainable innovation.

Prepared by:-

1. Dr. P. C. Shete

Faculty of Department of Mechanical Engg. M.V.P.S's K.B.T. College of Engineering, Nashik

A comprehensive review on brake pad materials and geometries: Performance, environmental impact and emerging technologies

1. Introduction

Brake pads are critical components in automotive braking systems, converting kinetic energy into heat through friction. Their performance depends on **material composition and geometry**, which influence friction, wear, heat dissipation, noise, and durability .

Modern braking systems have evolved from drum brakes to **disc brakes**, focusing on safety, efficiency, and environmental sustainability. Current research emphasizes:

- Eco-friendly materials
- Improved thermal stability
- Reduced wear and noise
- Use of AI and nanotechnology

2. Material Composition of Brake Pads

Brake pads are composite materials made up of several constituents, each performing a specific function. Binders, such as phenolic or epoxy resins, hold the components together and provide structural integrity and thermal resistance. Fibers, including Kevlar, glass, and steel, enhance mechanical strength and durability. Fillers are used to control density, hardness, and cost, while friction modifiers like graphite help maintain a stable coefficient of friction. Lubricants reduce wear and temperature rise during braking, and abrasives assist in cleaning the rotor surface. The proper combination of these materials ensures reliable braking performance under varying operating conditions.

3. Types of Brake Pad Materials

3.1 Conventional Materials

Traditionally, asbestos was widely used in brake pads due to its excellent heat resistance and durability. However, its severe health risks led to its global ban. As a result, alternative materials such as non-asbestos organic (NAO), semi-metallic, and ceramic brake pads were developed. NAO pads are quieter but tend to wear faster, while semi-metallic pads provide better strength and heat dissipation but produce more noise. Ceramic pads offer balanced performance with low dust production and reduced noise, making them more environmentally friendly.

3.2 Advanced Composite Materials

Recent advancements have led to the use of advanced composite materials in brake pads. These include metallic, ceramic, polymer, and carbon-based composites. Metallic composites offer high thermal conductivity and durability, while ceramic composites provide excellent heat resistance and low wear rates. Polymer composites are lightweight and cost-effective, and carbon-based composites exhibit superior friction and durability. These materials significantly enhance braking performance, particularly in high-performance and heavy-duty applications.

4. Eco-Friendly and Sustainable Materials

Increasing environmental concerns have encouraged the development of eco-friendly brake pad materials. Natural fibers and agricultural waste materials such as coconut shell, banana peel, corn husk, sugarcane bagasse, sawdust, and snail shell are being explored as sustainable alternatives. These materials are biodegradable, cost-effective, and reduce environmental pollution.

Studies have shown that such materials can provide acceptable mechanical and tribological performance. For instance, sugarcane bagasse and sawdust exhibit moderate wear resistance, while maize husk and snail shell composites demonstrate stable friction characteristics. Despite these advantages, challenges such as variability in material properties and limited high-temperature performance remain, requiring further research for industrial application.

---

5. Brake Pad Geometry and Design

In addition to material composition, brake pad geometry plays a vital role in braking performance. Key geometric parameters include pad thickness, contact area, chamfers, slots, and grooves. Pad thickness affects durability and heat resistance, while the contact area determines braking force. Chamfers, slots, and grooves help reduce noise and improve heat dissipation.

Proper geometric design ensures uniform pressure distribution between the pad and rotor, preventing uneven wear, hot spots, and brake fade. Therefore, optimizing both material composition and geometry is essential for achieving efficient and reliable braking performance.

---

6. Performance Evaluation Parameters

6.1 Friction and Wear Characteristics

The performance of brake pads is largely determined by their friction and wear behavior. A stable coefficient of friction is essential for consistent braking, while low wear rates ensure longer service life. During braking, friction generates particles that may affect environmental and human health, making wear reduction an important consideration.

6.2 Thermal Stability

Brake pads operate under high temperatures, typically ranging from 210°C to 500°C. Excessive heat can lead to issues such as brake fade, thermal cracking, and reduced braking efficiency. Advanced materials and reinforcements improve heat dissipation and thermal stability, ensuring consistent performance under extreme conditions.

6.3 Noise, Vibration, and Harshness (NVH)

Noise and vibration, commonly referred to as NVH, are important factors affecting passenger comfort. Brake squeal, caused by friction-induced vibrations, typically occurs within a frequency range of 1–16 kHz. Proper material selection and geometric design help minimize these undesirable effects.

7. Environmental and Regulatory Considerations

Environmental regulations have significantly influenced brake pad development. The use of asbestos has been banned worldwide due to its health hazards, and copper content is being reduced because of its toxicity to aquatic life. New standards, such as Euro 7, also impose limits on brake particle emissions.

These regulations have accelerated the shift toward eco-friendly, copper-free brake pad formulations. Manufacturers are now focusing on sustainable materials that offer high performance while minimizing environmental impact.

8. Manufacturing Processes

Brake pads are manufactured through processes such as mixing, compression molding, curing, grinding, and finishing. Traditional techniques like powder metallurgy and sintering are widely used but can be energy-intensive and complex. Modern manufacturing approaches, including additive manufacturing (3D printing), offer improved design flexibility and efficiency, although their application in brake pad production is still developing.

9. Cost and Performance Trade-Offs

One of the key challenges in brake pad development is balancing performance, cost, and sustainability. Metallic materials are durable and cost-effective but may produce more noise and dust. Ceramic materials provide excellent performance but are expensive. Natural fiber-based materials are affordable and environmentally friendly but may lack consistency and high-temperature stability.

To overcome these limitations, researchers are exploring hybrid materials that combine the advantages of different components, achieving an optimal balance between performance and sustainability.

10. Emerging Technologies

Emerging technologies such as artificial intelligence (AI), machine learning (ML), and nanotechnology are transforming brake pad development. AI and ML enable prediction of material behavior, optimization of compositions, and improved design efficiency. Nanotechnology enhances material properties such as wear resistance, thermal conductivity, and friction stability.

Although additive manufacturing is still in its early stages for brake pad production, it holds significant potential for future applications, especially in customized and high-performance braking systems.

---

11. Conclusion

In conclusion, the performance of brake pads depends on the combined effects of material composition and geometric design. Advanced composite materials and natural fiber-based alternatives are playing a significant role in improving performance while addressing environmental concerns. The integration of modern technologies such as AI, nanotechnology, and advanced manufacturing methods is expected to drive future innovations.

Future research should focus on developing standardized testing methods, improving the performance of eco-friendly materials, and optimizing brake pad design to meet evolving regulatory and sustainability requirements.

Prepared by:-

1. Mr. N. K. Kharate

Faculty of Department of Mechanical Engg. M.V.P.S's K.B.T. College of Engineering, Nashik