A Study on The Manufacturing Process and Market Performance of Power Point Batteries

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***Abstract*—This study focuses on the manufacturing process, technological infrastructure, marketing strategies, and sales performance of lead acid batteries at Power Point Batteries. The qualitative methodology of the study develops through direct interviews with marketing department and secondary data was collected from websites. The study explains the complete manufacturing process of lead acid batteries, starting from raw material procurement, grid casting, lead oxide production, paste mixing, plate pasting, curing, formation, assembly, electrolyte filling, sealing, testing, and final dispatch. It highlights the importance of quality control, safety measures, and technological improvements in ensuring battery efficiency and durability. The study also examines the company's marketing strategies, including regional marketing, social media promotion, customer referrals, trade shows, and advertising campaigns. Sales strategies such as direct sales, distributor partnerships, and retail collaborations are analysed to understand market reach and customer engagement. In addition, the research discusses customer satisfaction measurement through warranty management, field visits, and after-sales service support.**

***Index Terms*—Manufacturing process, market performance**

I. INTRODUCTION

The early automobile industry initially relied on manual hand cranking to start engines. This method was physically demanding and dangerous, often causing injuries due to engine kickback. As vehicles became more complex and widespread in the early 20th century, the need for a safer and more reliable starting method became evident. In 1912, the invention of the electric starter motor by Charles Kettering revolutionized the automotive industry. The electric starter required a reliable source of electrical energy, and the lead-acid battery emerged as the ideal solution due to its ability to deliver high currents over short periods.

From this point onward, lead-acid batteries became a standard component in automobiles. Their role expanded beyond engine starting to include powering vehicle lighting, ignition systems, and accessories.

II. REVIEW OF LITERATURE

Jianping Yu, Jintang Yang, Hua Zhang (2020) Energy based sustainability evaluation of spent lead acid batteries recycling

The sustainability of lead-acid battery (LAB) recycling systems has gained increasing attention due to the growing demand for secondary lead and the associated environmental risks of improper recycling practices. Traditional sustainability evaluation approaches, including Life Cycle Assessment (LCA), material flow analysis, and energy analysis, have been widely used to assess environmental and economic impacts of LAB recycling. While these methods provide valuable insights into resource consumption and emissions, they often fail to fully integrate ecological impacts and resource quality into a single comprehensive framework. Emergy analysis, developed as a systems-based evaluation tool, has been increasingly applied to assess the sustainability of industrial and recycling systems. Emergy converts all resource inputs—natural, economic, and human—into a common unit of solar emergy joules (sej), enabling a holistic comparison of different process inputs and outputs. Several studies have applied emergy analysis to metal recycling systems, including lead recovery processes, to quantify resource efficiency, economic contribution, and environmental loading.

Maryam Johari & Seyyed-Mahdi Hosseini-Motlagh (2025) Coordination of social welfare, collecting, recycling and pricing decisions in a competitive sustainable closed-loop supply chain: a case for lead-acid battery

The growing emphasis on sustainability has compelled firms to integrate environmental and social considerations alongside economic objectives in their operational and strategic decisions. In response to increasing regulatory pressure, environmental awareness, and competitive dynamics, organizations are increasingly adopting sustainable closed-loop supply chain (SCLSC) models that incorporate both forward and reverse logistics. Closed-loop supply chains (CLSCs) aim to recover value from end-of-life products through activities such as collection, recycling, remanufacturing, and disposal, thereby reducing hazardous waste and conserving natural resources. A substantial body of literature has focused on the environmental benefits of CLSCs, particularly in reducing pollution and improving resource efficiency. Studies indicate that effective reverse logistics systems significantly lower environmental impacts by minimizing landfill disposal and promoting material recovery. In industries dealing with hazardous materials, such as batteries, electronics, and chemicals, CLSCs are recognized as essential for mitigating environmental and health risks. However, early CLSC research primarily emphasized economic and environmental objectives, often neglecting the social dimension of sustainability.

Objectives:

- To study the manufacturing process and technological infrastructure.
- To study the cost for marketing strategies and sales performance.

III. RESEARCH METHODOLOGY

The qualitative methodology of the study develops through direct interviews with marketing head and Accounts head at Power Point Batteries to obtain insight on production practices, and marketing strategies, environmental challenges. Information obtained from the company's website and other relevant industry articles shall serve as secondary sources of this broader information for the study.

IV. DATA ANALYSIS AND INTERPRETATION

Construction

The manufacturing process of lead acid batteries is a complex and systematic industrial operation that involves multiple stages, beginning with raw material preparation and ending with final inspection and dispatch. Lead acid batteries are widely used in automotive, industrial, and backup power applications due to their reliability, cost-effectiveness, and recyclability. However, their production requires strict control over quality, safety, and environmental aspects because of the hazardous nature of lead and sulfuric acid. Each stage of the manufacturing process plays a critical role in determining the performance, durability, and environmental impact of the final product.

1. Raw Material

The primary raw materials will be imported from Bangalore. It is used in the manufacturing of lead acid batteries include lead, lead alloys, sulfuric acid, distilled water, separators, and battery containers. Lead is the most significant material and is obtained either from primary mining sources or through recycling of used batteries. In modern battery manufacturing, recycled lead constitutes a major portion of raw material usage, as it reduces production costs and minimizes environmental damage.

Sulfuric acid is prepared at a controlled concentration to serve as the electrolyte, while distilled water is used to avoid impurities that could affect battery performance. Separators made of PVC, rubber, or absorbent glass mat (AGM) materials are used to electrically isolate the positive and negative plates. Battery containers are typically manufactured from polypropylene due to its strength, acid resistance, and durability.

2. Grid Casting

Grid casting is the first major production stage in the manufacturing process. In this stage, lead or lead alloy is melted in furnaces at controlled temperatures and poured into molds to form grids. These grids act as current collectors and provide mechanical support to the active material of the battery plates. Lead used for battery plates melts at a temperature of approximately 327.5°C (621.5°F). Because battery plates are rarely made of 100% pure lead and are

instead composed of lead alloys—typically lead-calcium-tin or lead-antimony—the melting range can vary slightly, but it generally remains in the same, relatively low-temperature range.

Different lead alloys are used for positive and negative grids to enhance corrosion resistance, strength, and electrical conductivity. The quality of grid casting significantly influences battery life and efficiency. Defects such as cracks, improper thickness, or poor alloy composition can lead to premature battery failure. Therefore, automated grid casting machines and quality inspection systems are commonly employed to ensure uniformity and precision.

3. Lead Oxide Production

Lead oxide is a critical component in the preparation of battery plates. It is produced by oxidizing molten lead in specialized equipment such as ball mills or Barton reactors. The physical and chemical characteristics of lead oxide, including particle size, surface area, and chemical composition, directly affect the electrochemical behaviour of the battery.

Proper control of lead oxide production is essential to ensure high battery capacity, good charge acceptance, and long cycle life. Manufacturers carefully monitor temperature, airflow, and oxidation conditions during this process to maintain consistency.

4. Paste Mixing

In the paste mixing stage, lead oxide is mixed with distilled water, sulfuric acid, and various additives to form a lead paste. Additives are used to improve paste adhesion, porosity, and electrochemical performance. The composition of the paste differs for positive and negative plates to achieve desired chemical properties. This stage requires precise control of temperature, moisture content, and mixing time. Improper paste formulation can result in weak plate structure, reduced capacity, and poor battery life. Automated paste mixers are widely used to maintain uniformity and repeatability.

5. Plate Pasting

Plate pasting involves applying the prepared lead paste onto the cast grids. Positive and negative grids are pasted separately using automated pasting machines to ensure uniform thickness and weight. Excess paste is removed to maintain consistency and avoid imbalance between plates.

The pasted plates are then stacked on racks and transferred for curing. The quality of plate pasting directly affects battery performance, as uneven paste distribution can lead to reduced capacity and internal short circuits.

6. Plate Curing and Drying

Curing is a controlled chemical and physical process in which the pasted plates are exposed to specific temperature and humidity conditions for a predetermined period. During curing, the lead compounds in the paste undergo chemical changes that strengthen the plate structure and improve adhesion between the paste and grid.

Proper curing enhances the mechanical strength of the plates, improves charge acceptance, and increases battery life. After curing, the plates are dried to remove excess moisture, which is essential to prevent defects during formation.

7. Plate Formation

Plate formation is one of the most critical and energy-intensive stages in lead acid battery manufacturing. In this process, the cured plates are submerged in sulfuric acid and subjected to controlled electrical charging. This electrochemical reaction converts the lead compounds in the paste into their active forms.

The positive plates are converted into lead dioxide, while the negative plates are transformed into sponge lead. Proper formation ensures that the battery can store and release electrical energy efficiently. Formation parameters such as current density, temperature, and charging time are carefully controlled to optimize battery performance and durability.

8. Battery Assembly

After formation, the positive and negative plates are assembled into plate groups. Separators are placed between plates to prevent direct contact and short circuits. The assembled plate groups are then inserted into battery containers.

This stage requires precision to ensure correct alignment, spacing, and electrical connectivity. Improper assembly can lead to internal resistance, reduced capacity, and premature battery failure. Automated assembly lines are commonly used to enhance accuracy and productivity.

9. Electrolyte Filling

Once the battery is assembled, diluted sulfuric acid is added to the cells as the electrolyte. The electrolyte facilitates the movement of ions between the positive and negative plates during charging and discharging cycles.

The concentration and purity of the electrolyte play a crucial role in determining battery performance, capacity, and life span. Manufacturers carefully control electrolyte density to match the specific application of the battery.

10. Sealing and Cover Welding

After electrolyte filling, battery covers are sealed or welded onto the containers using heat sealing or ultrasonic welding techniques. Terminals are securely sealed to prevent acid leakage and contamination. Battery covers will import from Bangalore.

Modern lead acid batteries are often designed as maintenance-free or valve-regulated lead acid (VRLA) batteries. These designs include pressure-regulated valves that release excess gas while preventing electrolyte loss, thereby enhancing safety and reducing maintenance requirements.

11. Initial Charging and Final Formation

The sealed batteries undergo an initial charging process, sometimes referred to as final formation. This step stabilizes the electrochemical reactions within the battery and ensures uniform charge distribution across cells.

During this stage, batteries are tested for voltage stability, capacity, and charging efficiency. Any battery failing to meet specified standards is rejected or reprocessed.

12. Inspection and Quality Testing

Quality control is an essential aspect of lead acid battery manufacturing. Final inspection includes visual examination, voltage testing, capacity testing, leak testing, and short-circuit testing. Advanced manufacturers also employ automated testing systems and statistical quality control techniques.

Only batteries that meet predefined quality and safety standards are approved for packaging and sale. This ensures reliability and customer satisfaction.

13. Packaging and Dispatch

Approved batteries are cleaned, labeled, and packaged according to transportation and safety regulations. Proper packaging is essential to prevent damage and leakage during storage and transportation. The batteries are then dispatched to distributors, retailers, or industrial customers. Packing materials will import from Bangalore.

V. REGRESSION ANALYSIS

Hypothesis:

Null Hypothesis (H_0): There is no significant relationship between Raw material cost and final cost of production.

Alternative Hypothesis (H_1): There is a significant relationship between Raw material cost and final cost of production.

Statistical Values:

Intercept = −0.724

The intercept represents the estimated final product cost when raw material cost is zero. Since the p-value is 0.453 (greater than 0.05), the intercept is not statistically significant. The coefficient of 0.220 means that for every one-unit increase in raw materials cost, the final product cost increases by 0.220 units on average. The positive coefficient shows a direct relationship between the two variables.

VI. TO STUDY THE COST FOR MARKETING STRATEGIES AND SALES PERFORMANCE

Market Research and Demand Analysis:

By keeping a close watch on trends in the demand for products and the prevailing conditions in the market, the company is able to identify new product opportunities. This method ensures that the product development is done in keeping with the existing demands of the customers and any possible market. Here is a run-through of the process:

A. New Product Identification

a) Description: The company performs extensive market research in order to comprehend the changes in dynamics of the customers and the battery industry. This involves analysing customer preferences and market shifts and spotting gaps in offerings. Data from trade, industry reports, and competing products are all

having their hands on-the-ground in scouring the new opportunity areas.
b) Process: It is always evaluating sales data, customer input, and competitor analysis for discovering the trends that will be emerging in product demand

B. Customer Feedback and Customization Requests:
a) Description: The company ensures that listening to customer feedback and customization requests will lead to developments in products, adapted to meet particular demands
b) Process: Direct client feedback gathering from the Sales team, Customer Service, and Project Management comes as a result originating during project discussions or post-installation surveys.

C. Market Trends and External Factors:
a) Description: The trends that the company is monitoring on a continuous basis include those like that of sustainability and energy efficiency. The market conditions are also relevant with those changes in these products as affected by respective government regulations impacting environmental standards.
b) Process: This active surveillance programme of emerging technologies, consumer habits, and government regulations would thus enable the company to adjust its product portfolio available in the market and maintain a competitive edge. For example, increasing demand for smart home systems has forced accelerated development of intelligent battery solutions.

Product Development Process
All goods and services manufactured by the company are produced under highly controlled conditions, so as to satisfy customer demands and requirements, adhere to current product trends on the market, and stay afloat in terms of quality. The framework of product development entails several critical phases from idea generation to the launching of new products:
A. Idea Generation and Market Research:
a) Description: This first stage consists of the generation of new ideas based on findings from market research and from customer feedback and input derived from upcoming lighting trends. The company gives great attention to the study of the industry's reports concerning consumer demands, competitive behaviour, and the exploration of market gaps.

b) Key Activities:
- Analysing consumer-wants complaints or dissatisfaction.
- Evaluating the general prevailing regulatory and environmental conditions.
- Gathering insights from the sales and marketing teams about what the customers want.

B. Concept Development and Feasibility Study:
a) Description: The details of concept development begin once an idea is recognized; the process involves fleshing out the ideas followed by the feasibility testing. In this stage, the product is assessed with respect to technical, financial, and operational viability vis-a-vis the proposed design.

b) Key Activities:
- Technical feasibility: Engaging R&D in order to establish whether such a product is presently feasible for development with current technologies.
- Financial feasibility: Undertake a cost analysis to ensure that the product is indeed profitable.
- Operational feasibility: To establish that the actual scaling-up of production is being done utilizing available resources and facilities.

C. Final Product Development and Scaling Up Production:
a) Description: The company firm will finalize the overall design and setup for mass production shortly after the product has passed testing. The company fine-tunes the manufacturing approach to achieve the best possible cost and quality of the product.

b) Key Activities:
- Sourcing of materials and components, establishing supply chains, and finalization of production timeframes.
- Setting up production lines, calibrating equipment, and training production Establishing production lines, calibration of machines, and training of workers.
- Final quality checks during small batch runs.

D. Marketing and Launch:
a) Description: The product is now ready for market entry, and the company is making preparations for the

new product launch. This involves marketing strategy development, training of sales personnel, and setting up of distribution channels.

b) Key Activities:

- Marketing and publicity campaigns to promote the product.
- Briefing of sales personnel so that they are well aware of the product's features.
- Distribution channel breakdown including online sales, retail collaboration, and direct-to-consumer methods.

E. Post-Launch Review and Continuous Improvement:

a) Description: The company continues to monitor the performance of the product on the market after the launch. Customer feedback and feedback from the sales team and distributors are collected, allowing pointing out possible improvement areas or updates for the product.

b) Key Activities:

- Analysing customer feedback and product performance indicators.
- Addressing any issues raised after launch, such as recalls or faults.
- With further market acceptance and technological changes, the process of improvement of the product will continue.

R&D Investment

The company invests in R&D as a percentage of its annual turnover; this investment mostly pertains to product innovation, improvements in efficiency. Being an Indian company, R&D typically attracts an investment of 5-10% of the annual turnover.

A. Key Areas of R&D Investment:

a) Sustainability and Environment-Friendly Solutions: Products that reduce emissions, reuse and are made from green substances. Other products within the current project concern are being developed to address environmentally sustainable products under other company commitments.

b) Manufacturing Process Improvements:Being a good part of the amount from the R&D Budget, this is also spent by the company to do improvement to the manufacturing facility with the aim of making all processes efficient and consistent throughout production.

Marketing Channels

The marketing of the products at Power Point battery will mainly be by the regional managers, word of mouth referrals and also social media handling. Here below is a detailed basis for each marketing channel:

A. Regional Managers:

a) Role in Marketing:

Regional managers typically have the application of any marketing activity on a localized perspective. They fully understand the local market behaviour and customer needs. This position involves prospecting new customers, promoting new offerings, and building relationships with existing customers.

b) Targeted Outreach:

Regional managers directly forward products from the manufacture to local businesses, and project consultants. They provide personal recommendations and tailor solutions according to the specific needs of the local markets.

c) Network Expansion:

They also network within their region's trade shows, conferences, and networking happenings to contribute towards an expanded reach of the company.

C. Word-of-Mouth Referrals:

a) Customer Referrals:

For reaching out especially for performing, word of mouth marketing plays a critical role in the success of company. Personal recommendations are most appreciated and valued, especially when it comes to India. Often a happy customer will talk about the company's products to others, resulting in new business.

b) Building Trust:

This kind of marketing will build trust and credibility because potential clients will rather rely on the words of their peers or co-workers than old-fashioned advertising. Positive word-of-mouth referrals will create repeat businesses and keep customer loyalty.

D. Social Media Handling:

a) Online Presence:

Power Point battery uses its social media pillars such as Facebook, Instagram and youtube to boost its online presence and reach out to a wider public. The company also shares product updates and industry news, customer testimonials, and promotional offers for the benefit of potential customers.

b) Targeted Campaigns:

Social media is another platform to conduct targeted advertising campaigns that can reach definite customer segments against demographics, interests, and behaviours. These campaigns raise brand awareness and generate traffic to the corporate website.

c) Engagement and Customer Interaction:

Social media also allows the company to communicate directly with customers, respond to inquiries, and resolve complaints in a timely manner ensuring a higher level of interaction that imparts satisfaction among their customers and builds up a community around the brand.

Product Promotion

With these enumerated actions, there could be much credence laid upon the consideration of Poer Point batteries advertising strategy mix in targeting its products and services. Advertising strategy generating for example something like this could be applied in the lighting world.

A. Advertising Campaigns:

a) Print Media:

Ads in industry-specific magazines, newspapers, and catalogues. These can showcase new products or highlight special features of their lighting solutions.

b) Billboards & Outdoor Advertising:

Billboard advertisements rely on settings in local areas; this could have a double impact of enhancing recognition of the brand in high-traffic areas like highways or business districts.

B. Collaborations and Sponsorships:

a) Sponsorship of Industry Events:

Trade shows, exhibitions, design festivals, or industry conferences can allow the sponsors to market their products to the target audience, such as architects, contractors, and engineers.

C. Trade Shows and Exhibitions:

a) Showcasing Products:

Trade shows hold crucial marketing for the battery industry to launch new products, grow potential contract relationships, and allow the company to take on a leadership role. To achieve those exposures of products and engagement with potential customers, it may participate in or sponsor some trade fairs.

Sales Strategies

Poer Point battery would likely implement a combination of direct and indirect sales strategies, tailored to their target market and the nature of their products. Here are some common strategies they might employ:

A. Direct Sales:

a) In-House Sales Team:

Specialized personnel interfacing directly with potential clients in person, telephonically, or via email. This team will be tasked with both commercial clientele (e.g., business and government projects) and residential markets (e.g., homeowners and architects).

B. Channel Sales and Partnerships:

a) Distributor Partnerships:

Partnership with distributors/wholesalers to sell products through a greater network with access to local markets and customer bases for easier expansion and sales.

b) Retail Partnerships:

Collaborate with retail chains or specialty lighting stores. Retail partnerships increase visibility and bring the product into attention with those customers with a preference towards buying in a physical store instead of the internet.

Customer Satisfaction Measurement

For customer satisfaction measurement, the following methods could apply to on-time service support, frequent visits to the field, and warranty management:

B. Warranty Management:

a) Warranty Claims Tracking:

Keep track of the number and kind of warranty claims with the time taken to resolve those claims. A high claim ratio could be a sign of product quality problems

or may suggest that the service support level is not what it should be.

b) Resolution Time for Warranty Issues:
Monitor how long it actually takes to resolve warranty claims. The fewer complaints generated over this time, the happier the customer will be.

c) Warranty Coverage:
Warranty should be clear to the customer in what includes in the warranty and customer satisfaction on submitting a claim and its resolution.

d) Customer Feedback Post-Warranty Service:
This Would be after project completion remitting the feedback received from the customer on repair and replacement in warranty. This would help in understanding how the customer views the whole experience under warranty services.
Incorporating all these aspects in one comprehensive customer satisfaction survey or tracking systems would help the organization maintain major areas concerning customer loyalty under close monitoring, especially reliability in service, field visit scheduling, and warranty support.

VII. CORRELATION ANALYSIS

Hypothesis:
Null Hypothesis (H_0): There is no significant relationship between cost for marketing strategy and sales.
Alternative Hypothesis (H_1): There is a significant relationship between cost for marketing strategy and sales.
The Pearson correlation coefficient r = 0.860 indicates a strong positive correlation between marketing cost and sales. This suggests that when marketing cost increases, sales tend to increase. When marketing cost decreases, sales tend to decrease. The value 0.860 is very close to +1, which shows a strong linear relationship. The obtained p-value is 0.061 At 5% level 0.061 is greater than 0.05 indicating that the relationship between marketing cost and sales is not statistically significant. With 10 degrees of freedom, the null hypothesis is rejected and the alternative hypothesis is accepted.

VIII. FINDINGS

- The company believes in manufacturing superior quality of goods as per the industrial standards. All the batteries manufactured will go through stage of quality check in order to ensure superior quality.
- Cost Drivers like raw material, labour, manufacturing and processing, R & D and marketing represent the main cost categories.
- The employees are very regular on duty that is mainly on because of the various incentives provided by the company. The more stress is giving on the health factor that causes very low employee absenteeism.
- Strategic decisions taken by the Director, managers have the authority regarding operations, which is quick responsiveness.
- Ash water is converted into clean water which is used for other purposes.
- Old batteries will be export to Bangalore for recycling process

IX. SUGGESTIONS

- Upgradation of half-automated to completely automatic battery assembly process to reduce human error.
- Continue to implement social media sites and utilize other e-commerce platform for brand promotion and sales through use of the company website.
- Expand the market other than coastal region by high growth market targeting.
- Establish clear working capital policies and performance benchmarks to guide financial decisions and monitor progress. This will support strategic alignment and ensure accountability in managing short-term assets and liabilities.

X. CONCLUSION

The Lead Acid Battery Industry plays a significant role in supporting automotive, industrial, renewable energy, and backup power applications. Despite the emergence of newer battery technologies, lead acid batteries continue to remain widely used because of

their reliability, affordability, easy recyclability, and established manufacturing infrastructure.

The battery industry is experiencing unprecedented growth, acting as a crucial driver for global decarbonization, renewable energy storage, and the electric vehicle revolution. Driven by policy support, expanding EV adoption, and energy storage needs, the sector is shifting toward massive localized manufacturing, advanced cell chemistry, and stringent, high-efficiency production. The battery sector is moving toward a future defined by high-efficiency manufacturing, prioritizing safety and quality to meet the global demand for sustainable mobility and energy.

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