Review and Improvement to the Design and Fabrication of a Simple and Affordable Vacuum Cleaner from Locally Available Materials

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CERTIFICATION

This is to certify that this research work on the "Review and Improvement to the Design and Fabrication of a Simple and Affordable Vacuum Cleaner from Locally Available Materials" was carried out by:

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DEDICATION

We dedicate this report to God and to our beloved family and friends, whose unwavering support has been our pillar of strength. Your love, encouragement, and sacrifices have shaped our journey, lifting us through every challenge and inspiring us to strive for excellence. This work stands as a testament to your faith in us, a reflection of the strength and motivation you have so generously given.

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With sincere gratitude and deep appreciation, we acknowledge the remarkable individuals whose dedication and expertise have been vital to the completion of this report. Their support, guidance, and encouragement have been invaluable in overcoming challenges along the way.

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ABSTRACT

The fabrication of a vacuum cleaner using locally available materials in Nigeria presents a cost-effective and accessible solution for household and small business cleaning needs. However, the initial design exhibited several performance challenges, including suboptimal air velocity, inadequate dustbag filtration, and inefficient dust deposition. These issues led to reduced suction efficiency and the release of fine dust particles back into the environment, limiting the vacuum cleaner's effectiveness.

This study focused on identifying and resolving these problems through targeted design modifications. By optimizing air velocity, improving dustbag filtration, and repositioning the dust collection system, the vacuum cleaner's overall efficiency was significantly enhanced. The redesigned model demonstrated better dust retention, improved suction, and a reduction in airborne particle emissions.

The findings of this research highlight the feasibility of developing functional vacuum cleaners using locally sourced materials. This project not only contributes to affordable cleaning solutions but also promotes local innovation and manufacturing. Despite infrastructural challenges such as inconsistent electricity supply, the study underscores the potential for continuous improvement in locally produced household appliances through research and development.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FREQUENTLY USED SYMBOLS, LABELS AND TERMS

No frequently used symbols, labels and terms found.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The development of affordable and efficient vacuum cleaners has become a significant concern for households and small-scale cleaning businesses, especially in developing regions where high-end vacuum cleaners are often too expensive. Vacuum cleaners are essential tools in maintaining clean indoor environments by removing dirt, dust, and other debris from floors and surfaces. However, the design and functionality of many low-cost vacuum cleaners are often compromised, especially in terms of air velocity, particle retention, and the efficiency of dust separation. These issues can lead to ineffective cleaning and the release of fine dust particles into the environment, undermining the overall effectiveness of the vacuum cleaner. Previous designs of vacuum cleaners fabricated from locally available materials often suffer from limitations such as inadequate air velocity through the wand, improper filtration of fine particles, and ineffective dust deposition mechanisms. These flaws not only reduce the cleaning efficiency but also compromise air quality in the environment. This study aims to review and improve upon the design and fabrication of such vacuum cleaners, addressing these critical issues to enhance performance and dust control.

1.2 Statement of the Problem

Many vacuum cleaners made from locally sourced materials suffer from limitations that negatively affect their functionality. These issues include:

1. Air Velocity: The velocity of air passing through the wand is not optimized, which may affect the exhaust and cause the fine particles to be released back into the environment.
2. Dustbag Particle Retention: The dustbag or filter holes are not properly sized to retain fine particles, allowing dust to pass through and be expelled into the air.

3. Dust Deposition: The point at which the air from the dustbag expands may not be well-positioned, which leads to improper deposition of dust and an increase in the number of fine particles present in the exhaust.

These problems can result in a vacuum cleaner that is ineffective at trapping dust and cleaning surfaces properly. The study intends to identify and resolve these issues through modifications to the design and functionality of the vacuum cleaner.

1.3 Aim and Objective of the Study

1.3.1 Aim

The aim of this study is to review and improve the design and fabrication of a simple and affordable vacuum cleaner made from locally available materials, with a focus on improving its air velocity, particle retention efficiency, and dust deposition process.

1.3.2 Objectives

1. To evaluate the velocity of air passing through the wand and assess its impact on the exhaust.
2. To determine the particle size of the dust to be cleaned and compare that to the old screen size.
3. To investigate the efficiency of the dustbag's particle size retention capability, ensuring it can trap fine dust particles effectively.
4. To design modifications to address the identified issues and improve the vacuum cleaner's overall efficiency.
5. To fabricate a functional prototype incorporating these improvements and assess its performance through testing.

1.4 Scope of Work

This study will focus on the design, modification, and fabrication of a vacuum cleaner prototype using locally available materials. The scope will involve:

1. Design Review: A critical assessment of existing vacuum cleaner designs to identify performance issues related to air velocity, dust particle retention, and dust deposition.
2. Fabrication: Constructing a new vacuum cleaner prototype with improved components based on identified weaknesses.
3. Testing and Evaluation: Conducting experiments to assess the air velocity, dust retention capability, and the efficiency of dust deposition in the modified vacuum cleaner design.
4. Performance Comparison: Comparing the performance of the improved vacuum cleaner with the original design to verify the effectiveness of the changes.

The study will primarily focus on vacuum cleaners intended for residential and small commercial use, without addressing larger, industrial-grade cleaning systems.

1.5 Significance of the Study

This study is significant in improving the design and functionality of vacuum cleaners, particularly in developing regions where cost-effective cleaning solutions are needed. The expected outcomes of this study include:

1. Increased Cleaning Efficiency: By addressing the identified issues, the improved vacuum cleaner design will provide better cleaning performance, ensuring more effective removal of dust and debris.
2. Health Benefits: Improved particle retention and reduced emission of fine particles into the air can enhance indoor air quality, leading to better health outcomes, particularly for individuals with respiratory conditions or allergies.
3. Cost-Effective Solutions: The use of locally available materials for fabrication allows for affordable vacuum cleaner alternatives, making these cleaning devices accessible to a larger population.

4. Sustainability: By focusing on locally sourced materials, the study contributes to sustainable design practices that reduce dependency on imported components and lower production costs.

1.6 Methodology

The methodology for this study will involve a combination of design analysis, experimental testing, and iterative fabrication. The following steps will be followed:

1. Literature Review: Conduct a review of existing literature on vacuum cleaner designs, focusing on airflow dynamics, dust retention, and filtration techniques.
2. Design Evaluation: Analyze the current design of the locally made vacuum cleaner, specifically assessing the airflow velocity, dustbag filtration efficiency, and the point of air expansion in the wand.
3. Modifications: Based on the findings, design modifications will be made to address the problems of air velocity, particle retention, and dust deposition. This will include altering the size of the dustbag holes, adjusting airflow paths, and improving the position of the air expansion point.
4. Fabrication: A prototype of the improved vacuum cleaner will be fabricated using locally available materials.
5. Testing and Data Collection: The modified vacuum cleaner will be tested to measure air velocity, dust retention efficiency, and the quality of exhaust. Comparisons will be made between the original and modified designs.
6. Analysis: Data will be analyzed to determine the effectiveness of the improvements, and recommendations will be made for further refinements.

This approach will ensure that the study provides practical solutions to the identified problems, resulting in a more efficient and affordable vacuum cleaner design.

CHAPTER TWO

LITERATURE REVIEW

We have conducted a detailed review of past literature related to vacuum cleaner technologies. By analyzing scientific journals, engineering reports, and patents, we gained valuable insights into the principles, innovations, and challenges that have shaped vacuum cleaner design over time. This comprehensive literature review provided a critical foundation for that project, allowing us to understand the state-of-the-art and apply these findings to our work. The knowledge gained from this earlier research is now serving as a reference point for further developments in our current project.

2.1 Vacuum Cleaners

A vacuum cleaner is a device that uses an air pump to create suction for removing dirt and debris from surfaces such as floors, carpets, and upholstery. The debris is typically collected in a dust bag or canister for later disposal. Over the years, vacuum cleaners have evolved to include various models and features, serving both domestic and industrial cleaning needs.

Figure 2.1 Vacuum Cleaner

The concept of vacuum cleaning dates back to the mid-19th century when people primarily used manual cleaning tools like brooms and carpet beaters. The first patent for a rudimentary cleaning device came from Daniel Hess in 1860, who invented a "carpet sweeper" (U.S.

Patent No. 29,077, 1860). This device used bellows to create suction, paired with a rotating brush to dislodge dirt. Although innovative, Hess's sweeper was hand-operated and did not resemble the motorized vacuum cleaners that followed.

Figure 2.2 Vacuum Cleaner Diagram

2.1.1 The Evolution of Vacuum Cleaners

In 1860, Daniel Hess from West Union, Iowa, created a revolutionary cleaning device that, while not called a vacuum cleaner at the time, laid the groundwork for future designs. Hess's invention, known as a "carpet sweeper," featured a rotating brush similar to traditional sweepers but with the added innovation of bellows that generated suction, allowing it to pick up dust and dirt. He secured a patent for this groundbreaking machine on July 10, 1860 (U.S. Patent No. 29,077), marking an early step toward modern vacuum technology.

Figure 2.3 Daniel Hess's Carpet Sweeper

- **The Emergence of Manually Powered Vacuums:** Eight years later, in 1868, Ives W. McGaffey of Chicago introduced a manually operated vacuum device called the "Whirlwind." Unlike Hess's device, the Whirlwind relied on a hand-crank mechanism that users had to turn while pushing the machine across the floor. Despite this cumbersome operation, McGaffey's invention represented a significant leap in cleaning technology. He partnered with The American Carpet Cleaning Co. of Boston to sell the Whirlwind for $25. However, its success was limited, with many units possibly destroyed in the Great Chicago Fire of 1871. Only two known Whirlwinds remain today, one of which resides in the Hoover Historical Center. McGaffey's patent for the Whirlwind was granted on June 8, 1869 (U.S. Patent No. 91,145).

- **Bissell's Contribution to Cleaning Technology:** In 1876, Melville R. Bissell from Grand Rapids, Michigan, developed a hand-powered carpet sweeper to help his wife, Anna Sutherland Bissell, clean sawdust from their carpets. This device led to the creation of Bissell Carpet Sweepers, and after Melville's death in 1889, Anna took over the business. Under her leadership, the company expanded its product line, including early portable vacuum cleaners. Bissell's name became synonymous with carpet sweepers and set the stage for future developments in household cleaning tools.

- **John S. Thurman and the Motorized Cleaner:** In 1898, John S. Thurman of St. Louis, Missouri, applied for a patent (U.S. Patent No. 634,042) for what he called a "pneumatic carpet renovator," granted on October 3, 1899. Unlike previous inventions, Thurman's cleaner was gasoline-powered and designed for commercial use. He marketed his motorized cleaning service to residents of St. Louis, charging $4 per visit. Thurman's machine didn't exactly vacuum in the modern sense—it blew dust into a container rather than sucking it up. Despite this, it is sometimes considered a precursor to modern vacuum cleaners. By 1906, Thurman had also introduced built-in central cleaning systems using compressed air, though these lacked the dust collection systems seen in later designs.

- **Hoover and the Commercial Success of Vacuum Cleaners:** It wasn't until the early 20th century that vacuum cleaners became commercially viable for home use. In the 1920s, the Hoover Company introduced the first widely successful upright vacuum cleaner. This model featured a motorized brush roll and a cloth filter bag, making household vacuuming more efficient and user-friendly. Hoover's design proved so effective that it became a staple in American homes, setting the standard for upright vacuums.

- **Canister Vacuums and Increased Maneuverability:** In the 1930s, manufacturers began offering canister-style vacuum cleaners, which separated the motor and dust collection unit from the cleaning head, connected by a hose. This design offered greater maneuverability and allowed for a variety of attachments, making these vacuums more versatile than their upright counterparts. Canister vacuums became popular for their ability to clean hard-to-reach areas and a wider range of surfaces.

- **The Bagless Revolution by Dyson:** In the 1980s, James Dyson introduced a major advancement in vacuum cleaner technology with the development of a bagless vacuum cleaner. Using cyclonic separation to trap dirt and dust, Dyson's design eliminated the need for disposable bags and offered more consistent suction performance. This innovation, patented in 1986 (U.S. Patent No. 4,573,236), not only reduced maintenance costs but also significantly improved the overall efficiency of vacuum cleaners, transforming the industry.

- **Robotic Vacuums and Automation:** The dawn of the 21st century saw another breakthrough with the introduction of robotic vacuum cleaners. The iRobot Roomba, launched in 2002, brought automated cleaning to the masses. Equipped with sensors and basic artificial intelligence, these devices could navigate and clean rooms without direct human intervention. Over time, robotic vacuums have become increasingly sophisticated, incorporating mapping technologies and mobile app connectivity, allowing users to schedule cleanings remotely.

- **The Airider and Floating Vacuums:** In 2004, a British company introduced the Airider, a vacuum cleaner that floated on a cushion of air, making it lighter and easier to maneuver. Though this concept was marketed as a new innovation, it had been explored decades earlier with the Hoover Constellation in the 1960s, which also used air propulsion to float the vacuum during use. While not widespread, the Airider exemplified the continuous quest for more user-friendly vacuum designs.

- **Smart Features in Modern Vacuum Cleaners:** Today's vacuum cleaners have embraced smart technology, offering features like mobile app control and scheduling, as well as sensors that intelligently map out rooms for more efficient cleaning. These advancements have turned vacuums into more than just cleaning tools—they have become an integral part of smart home ecosystems.

The evolution of vacuum cleaners from manual sweepers to robotic and smart devices highlights the intersection of mechanical engineering, innovation, and consumer needs. Early inventors like Hess, McGaffey, and Bissell laid the foundation, while figures like Dyson and modern tech companies have continued to push the boundaries of what vacuum cleaners can do. Through continuous innovation, vacuum cleaners have not only made cleaning more efficient but also more accessible and integrated into daily life

2.2 Types of Vacuum Cleaners

Over time, vacuum cleaners have evolved into various types, each with distinct advantages and disadvantages. These are the main types:

2.2.1 Upright Vacuum Cleaners

Upright vacuums combine the motor, dust collection system, and brush head in a single vertical unit. They typically have a beater bar that agitates the carpet, loosening dirt and dust, while the suction pulls debris into the collection bag or canister.

Figure 2.4 Upright Vacuum Cleaner

Merits:

- Excellent for cleaning large carpeted areas due to their powerful suction and wide cleaning path.
- Usually feature height adjustments, making them suitable for different carpet types.
- Some models include HEPA filters for better air filtration, beneficial for allergy sufferers.

Demerits:

- Bulky and heavy, making them difficult to maneuver in tight spaces or on stairs.
- Can be noisy compared to other vacuum types.
- Not ideal for hard floors without special settings or attachments.

2.2.2 Canister Vacuum Cleaners

Canister vacuums separate the motor and suction head into two distinct units. A flexible hose connects the main canister, which houses the motor and dust collection system, to a nozzle that can be easily moved around.

Figure 2.5 Canister Vacuum Cleaner

Merits:

- More versatile than upright vacuums, as they work well on both hard floors and carpets.
- Lighter and easier to maneuver in small spaces, on stairs, or under furniture.
- Quieter operation due to the separation of the motor and the nozzle.

Demerits:

- The two-piece design can be cumbersome, with the canister often getting caught on furniture or requiring frequent repositioning.
- Tend to be more expensive than upright vacuums.
- Not as effective as upright vacuums on large carpeted areas.

2.2.3 Bagless Vacuum Cleaners

Bagless vacuums use a dustbin or canister to collect dirt and debris instead of a disposable bag. They often employ cyclone technology, like the one patented by James Dyson (U.S. Patent No. 4,573,236, 1986), which creates centrifugal force to separate dust from the air.

Figure 2.6 Drum Vacuum Cleaner

Merits:

- No need to buy replacement bags, reducing the long-term cost of use.
- Transparent dust bins allow users to see when the vacuum needs emptying.
- Many models feature advanced filtration systems, such as HEPA filters, that capture small particles like pollen and pet dander.

Demerits:

- Emptying the dustbin can release dust back into the air, which is problematic for allergy sufferers.
- Regular maintenance is needed to clean filters and prevent clogging, which can reduce suction power.
- Some models may not be as durable as bagged vacuums.

2.2.4 Robotic Vacuum Cleaners

Robotic vacuums, like the iRobot Roomba (U.S. Patent No. 6,594,844, 2003), are autonomous cleaning devices equipped with sensors and algorithms to navigate and clean floors without human intervention. They often feature rotating brushes and suction mechanisms similar to traditional vacuums.

Figure 2.7 Drum Vacuum Cleaner

Merits:

- Highly convenient, as they can clean autonomously and be scheduled to operate even when the user is not home.
- Compact size allows them to clean under furniture and in hard-to-reach areas.
- Often integrated with smart home systems, allowing control via mobile apps.

Demerits:

- Less powerful suction compared to upright or canister vacuums, making them less effective for deep cleaning.
- They may get stuck on obstacles, and some models struggle to transition between different floor types.
- Limited battery life means they require frequent recharging.

2.2.5 Stick Vacuum Cleaners

Stick vacuums are lightweight, cordless vacuums powered by rechargeable batteries. They resemble upright vacuums but are more compact and are often used for quick clean-ups on hard floors and low-pile carpets.

Figure 2.8 Stick Vacuum Cleaner

Merits:

- Lightweight and easy to use, making them ideal for quick spot cleaning.
- Cordless models provide maximum mobility and convenience.
- Easy to store, often featuring wall mounts or compact designs for small spaces.

Demerits:

- Generally, have less powerful suction compared to upright or canister vacuums, making them unsuitable for deep cleaning.
- Limited battery life may require frequent recharging.
- Smaller dustbins mean they need to be emptied more frequently.

2.2.6 Wet/Dry Vacuum Cleaners

Wet/dry vacuums are designed to handle both liquid spills and dry debris. They have a more powerful motor and a large canister for collecting both types of messes, making them popular for industrial or garage use.

Figure 2.9 Wet/Dry Vacuum Cleaner

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Merits:

- Can handle a wide range of tasks, from vacuuming dry debris to cleaning up wet spills.
- Durable and ideal for heavy-duty or commercial use.
- Large capacity for collecting debris, reducing the need for frequent emptying.

Demerits:

- Often bulky and difficult to store.
- Noisy due to the powerful motor.
- Not ideal for everyday home use due to their industrial design and weight.

2.3 Parts and Major Components of Vacuum Cleaners

Vacuum cleaners are sophisticated machines that rely on a series of interconnected parts and components to perform their cleaning functions efficiently. Each component plays a crucial role in generating suction, capturing dirt and debris, and maintaining performance over time. Here's a detailed breakdown of the major parts and components of vacuum cleaners, their functions, and how they contribute to the overall operation of the machine.

2.3.1 Motor

The motor is the heart of the vacuum cleaner. It powers the fan or impeller that generates the suction necessary to draw in air and debris from surfaces. Most vacuum cleaner motors are electric and come in different power ratings, typically measured in watts or amps. The higher the motor power, the stronger the suction force it can produce.

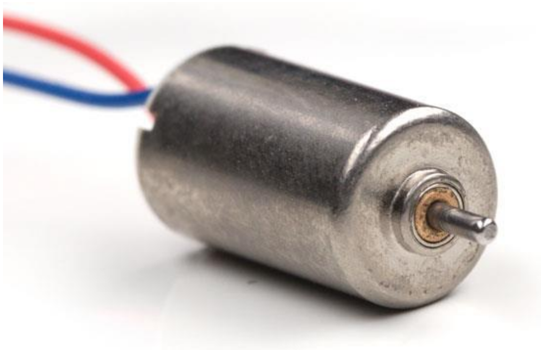


Figure 2.10 Vacuum Cleaner Motor

Types

1. Single-Stage Motor: Commonly used in household vacuums; generates suction with one impeller or fan.
2. Two-Stage Motor: Often found in industrial vacuums; contains two impellers that create stronger suction, allowing for better performance in heavy-duty cleaning tasks.

The motor directly influences suction power and airflow. More powerful motors generally mean better cleaning performance, especially on thick carpets or heavily soiled surfaces. However, higher power can also result in higher energy consumption and noise levels.

2.3.2 Fan/Impeller

The fan or impeller is connected to the motor and is responsible for moving air through the vacuum cleaner. As the fan spins, it creates a pressure drop that causes air to flow into the vacuum cleaner's intake, carrying dirt, dust, and debris with it.

Fans are typically made of lightweight, durable materials like plastic or metal to withstand high rotational speeds.

Impellers can have multiple blades arranged in a radial or axial configuration, depending on the type of vacuum and the desired suction power.

The shape, size, and speed of the fan directly affect the suction strength and airflow efficiency of the vacuum cleaner. A well-designed fan ensures optimal airflow while minimizing energy loss and noise.

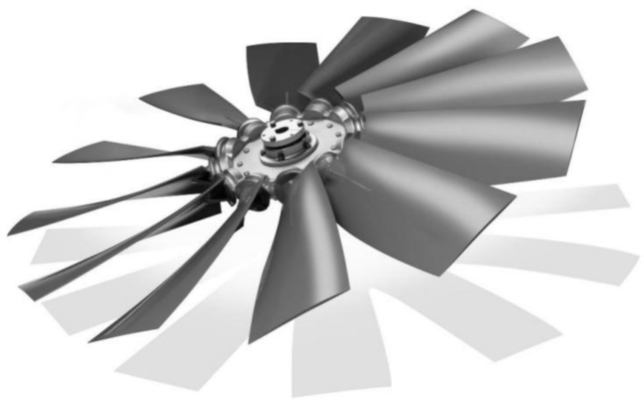


Figure 2.11 Vacuum Cleaner Fan

2.3.3 Filtration System

Filters in vacuum cleaners trap dirt, dust, and allergens to prevent them from being recirculated into the air. A good filtration system is essential for maintaining indoor air quality and preventing particles from damaging the vacuum cleaner's motor.

Types

- Pre-Motor Filters: Located before the motor, these filters prevent dirt from reaching the motor and causing damage.
- Post-Motor Filters: Positioned after the motor to trap fine dust particles that escape the main filter.

Figure 2.12 Vacuum Cleaner Filter

HEPA (High-Efficiency Particulate Air) Filters: These filters capture 99.97% of particles as small as 0.3 microns, making them ideal for households with allergies or asthma. HEPA filters are commonly found in higher-end vacuums.

Figure 2.13 HEPA Filters

Cyclonic Separation: Found in bagless vacuums, this system uses centrifugal force to separate dust and debris from the air, reducing the load on the filter.

Impact: A well-designed filtration system not only protects the motor but also ensures that the vacuum cleaner exhausts clean air back into the room. HEPA filters are particularly important for allergy sufferers, as they trap microscopic particles like pollen, pet dander, and dust mites.

2.3.4 Dust Collection System

The dust collection system stores the dirt and debris vacuumed from surfaces. Depending on the design of the vacuum, this system can be either a bag or a dustbin.

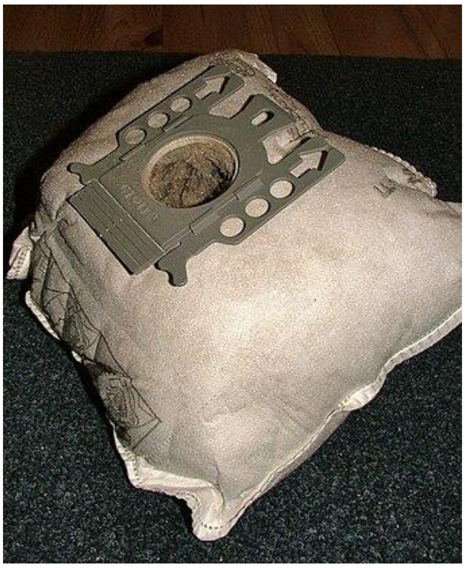


Figure 2.14 Vacuum Cleaner Dust Collection Bag

Bagged Vacuums

These vacuums use disposable or reusable bags to collect dirt. As the air passes through the bag, dirt particles are trapped inside, while clean air continues through the filtration system.

Merits

- Cleaner to empty, as the entire bag is disposed of. Better for allergy sufferers since dust isn't released during emptying.

Demerits

- Ongoing cost of replacement bags.

Bagless Vacuum

Instead of a bag, these vacuums use a removable dustbin or canister to store debris. Many bagless vacuums use cyclonic separation to remove particles from the air before they reach the dustbin.

Merits

- No need for replacement bags, reducing long-term cost. Easy to monitor when the bin is full.

Demerits

- Can be messier to empty, and dust may be released back into the air during disposal.

The dust collection system impacts convenience, ongoing costs, and cleanliness. Bagged systems are generally cleaner to maintain, while bagless systems provide the advantage of not needing frequent bag replacements.

2.3.5 Suction Inlet/Nozzle

The suction inlet, often referred to as the nozzle or cleaning head, is the entry point where dirt and debris are drawn into the vacuum. The nozzle is designed to make contact with the surface being cleaned, ensuring maximum suction and debris collection.

Figure 2.15 Vacuum Cleaner Wand

Types

- Standard Nozzle: Used on both hard floors and carpets.
- Motorized Brush Roll: Common in upright vacuums, this rotating brush agitates carpet fibers to loosen dirt for more effective cleaning.
- Hard Floor Tool: Designed for smooth surfaces like tile or wood, these nozzles typically lack rotating brushes and focus on strong suction.
- Turbo Nozzle: Uses air-driven brushes for enhanced cleaning on carpets and upholstery.

Impact: The nozzle design significantly affects the vacuum's ability to clean different surfaces. A vacuum cleaner with interchangeable nozzles is more versatile, able to tackle everything from thick carpets to delicate hard floors.

2.3.6 Hose and Attachments

The hose and attachments extend the vacuum cleaner's reach and versatility. The hose connects the vacuum body to various tools, allowing users to clean areas that are difficult to reach, such as crevices, upholstery, or stairs.

Figure 2.16 Vacuum Cleaner Hose

Types

- Crevice Tool: A narrow nozzle designed for tight spaces like between sofa cushions or along baseboards.

- Upholstery Tool: A flat, wide tool with a fabric-friendly surface, designed to clean furniture and curtains.
- Dusting Brush: A small, soft-bristled brush for cleaning delicate surfaces like blinds or shelves.
- Extension Wand: A long tube that increases the reach of the vacuum, making it easier to clean high or hard-to-reach areas.

Impact: The hose and attachments significantly increase the functionality of a vacuum cleaner, allowing it to be used for a wide variety of cleaning tasks. A high-quality, flexible hose combined with the right attachments can make a vacuum cleaner much more versatile and efficient.

2.3.7 Power Cord and Battery (for Cordless Models)

The power cord supplies electricity to the vacuum cleaner's motor, while in cordless models, a rechargeable battery provides the necessary power. The length of the power cord or battery life influences how long and how far you can use the vacuum before needing to recharge or switch outlets.

Types

- Corded Vacuums: Offer continuous power but are limited by the cord length, requiring the user to switch outlets when moving around large spaces.
- Cordless Vacuums: Provide more freedom of movement and are typically powered by lithium-ion batteries, which offer long-lasting charge cycles.

Impact: The power supply influences the convenience and mobility of a vacuum cleaner. Cordless vacuums are great for small, quick jobs and areas with limited access to power outlets, while corded vacuums are better for uninterrupted, extended cleaning sessions.

2.3.8 Exhaust Port

After air is drawn into the vacuum and passes through the filtration system, it exits through the exhaust port. The exhaust port is crucial in controlling the quality of air being released back into the room, especially in vacuums equipped with HEPA filters or other advanced filtration systems.

Impact: A well-designed exhaust port ensures that the vacuum releases clean air, free from dust and allergens, maintaining good indoor air quality.

2.3.9 Wheels and Casters

The wheels or casters help in moving the vacuum cleaner easily across various surfaces. Canister vacuums often have swiveled casters for better maneuverability, while upright vacuums typically feature fixed wheels that support pushing or pulling.

Impact: The quality and design of the wheels impact how easily the vacuum moves around, especially on carpets or uneven surfaces. Smooth, durable wheels can make the vacuum more user-friendly.

2.4 Major Issues with Vacuum Cleaners

2.4.1 General Challenges

Vacuum cleaners have become essential in homes across developed nations, transforming how cleanliness and hygiene are maintained. Nevertheless, these devices face several challenges that users should be aware of.

Lack of Standardization

A prominent issue with vacuum cleaners is the inconsistency in specifications and features among different brands and models. This lack of standardization can confuse consumers, complicating the process of selecting the right vacuum for their specific needs.

1. Durability Concerns

Many vacuum cleaners encounter durability problems, with key components like motors, filters, and brushes deteriorating over time. This wear and tear can lead to diminished performance and efficiency, often resulting in higher maintenance costs or, in some cases, the need to purchase a new vacuum altogether.

2. Noise Issues

Vacuum cleaners are often criticized for the noise they produce while in use. This noise can disrupt the tranquility of a home environment, which is one of the main drawbacks of using these devices (Wang, W., et al., 2012).

3. Environmental Impact

The ecological footprint of vacuum cleaners is an increasing concern. Many traditional models utilize non-biodegradable bags and filters, contributing to pollution. Furthermore, the energy consumption of various models raises issues regarding their overall environmental sustainability.

2.4.2 Vacuum Cleaner Challenges in Nigeria

While the aforementioned challenges are generally applicable, there are additional issues specific to vacuum cleaners in developing countries like Nigeria.

1. Unstable Power Supply

A major challenge in Nigeria is the inconsistency of the power supply. Frequent outages and voltage fluctuations can hinder vacuum performance, leading to potential damage or reduced efficiency. Users often find themselves needing to invest in reliable power solutions to address these problems.

2. Dust and Debris Conditions

Nigeria faces distinct environmental challenges, including an abundance of specific types of dust and debris. Some imported vacuum cleaners may struggle to effectively deal with these conditions, resulting in more frequent maintenance and filter replacements.

3. Limited Maintenance Services

Access to specialized repair services for vacuum cleaners in Nigeria is limited. This can be a significant hurdle for users who rely on these devices for everyday cleaning, making it difficult to find timely and cost-effective repairs.

4. Cost and Accessibility

The economic situation in Nigeria impacts the affordability and availability of high-quality vacuum cleaners. Many advanced models are financially out of reach for a substantial portion of the population, restricting their ability to enjoy the benefits of modern cleaning technology. Each component of a vacuum cleaner plays an essential role in its overall performance, efficiency, and usability. From powerful motors to advanced filtration systems, these parts work in harmony to make modern vacuum cleaners versatile and effective tools for cleaning various surfaces. Whether it's bagged or bagless, corded or cordless, the internal mechanics of a vacuum cleaner determine its functionality and reliability.

CHAPTER THREE

MATERIALS AND METHODS

The previous vacuum cleaner design considered various factors, such as type and application, to guide its fabrication. Based on this, certain guidelines were established for producing different vacuum cleaner types. These considerations will serve as the foundation for improving the new design.

3.1 Design Considerations

1. Determine the Area of Application of the proposed Vacuum Cleaner:

- Industrial, Commercial or Domestic Use.
- Indoors or Outdoors Use.
- Compact Spaces, Medium Size Enclosures or Open and Wide Spaces.
- Floors, Furniture Fabrics or Inside Equipment and Machineries.

2. Determine the Dust Particle Type and Size to be dealt with by the Vacuum Cleaner.

3. Determine the Size of the proposed Vacuum Cleaner:

- Volume of the unit based on its motor size and dust holding capacity required.
- Method of mobility – dragged on surfaces, on rollers, hand held or a hoisted backpack.
- Portability – How and when does it have to move?

4. Determine the Source of Power for the proposed Vacuum Cleaner

- DC (Battery) Power Drive/Motor
- AC Power Drive/Motor

5. Selection of Vacuum Cleaners options from the Literature Review that match the criteria determined from 1 – 3 above.

6. Design of the Components of the proposed Vacuum Cleaner.

7. Figure 2.10 and 2.11 shows the typical components of the two broad categories of Vacuum Cleaners – the Standard and the Handheld Vacuum Cleaner. The point to note is that the Standard Vacuum Cleaner has all the standard or what can be referred to as the basic components of a Vacuum Cleaner while the handheld type has some components made irrelevant and as such have fewer components.

8. Since the design process would only engage the design of the relevant components for the chosen type of Vacuum Cleaner sought it would be necessary to list all the basic components and through the process of type and category eliminate those components that are irrelevant.

- Air Jet Speed Design for Dust Particle Type and Size Pickup.
- Dust Particle Type and Size Agitation Mechanism Design.
- Air Stream Conveyor Rigid Pipe Section Design
- Flexible Hose,
- Filter/ Dust Sack,
- Motor/Fan/Impeller Unit
- Exhaust
- Power Control/Switch
- Housing Unit
- Unit Mobility.

3.1.1 Determine the Area of Application of the proposed Vacuum Cleaner.

The previous project specification focused on a vacuum cleaner for indoor domestic use, optimized for regular residential cleaning. This will serve as the basis for the new design.

3.1.2 Determine the Dust Particle Type and Size to be dealt with by the Vacuum Cleaner.

The previous design specification determined that a handheld vacuum cleaner must handle dust particles ranging from 0.5 to 100 micrometers in size. A physical survey identified that particles up to 1 centimeter should be managed, with a maximum dirt weight of 0.2 grams. These findings will inform the filtration system and suction power for the new design.

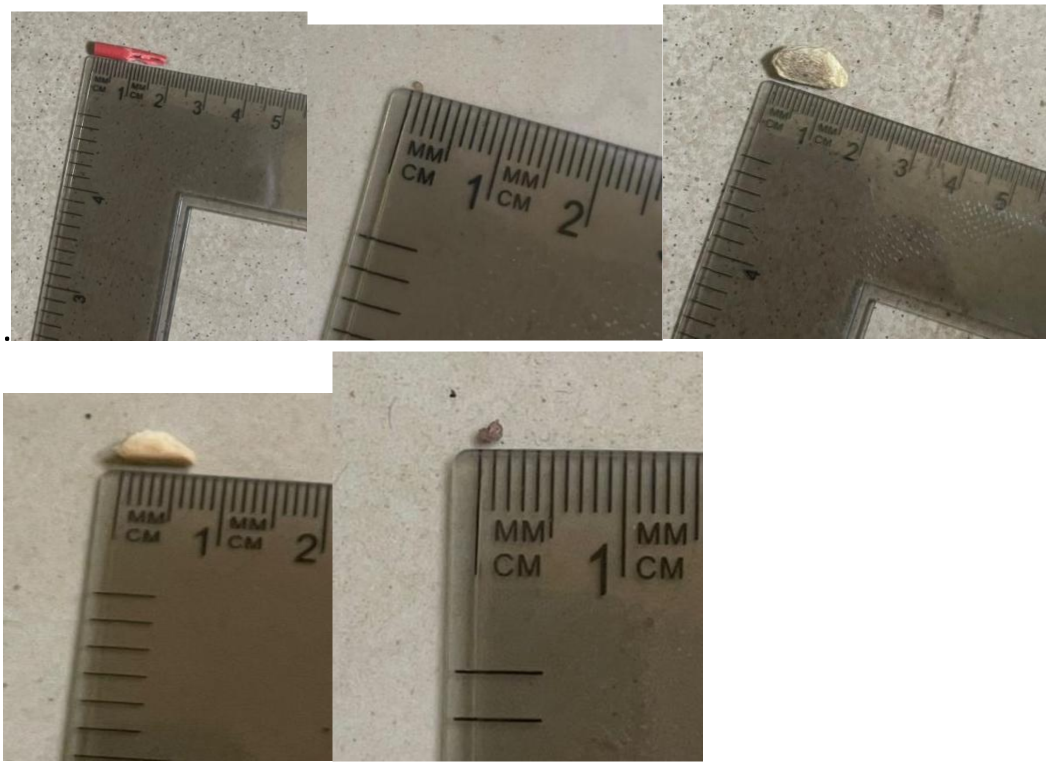


Figure 3.1 Size analysis of dirt particles commonly found indoors

3.1.3 Determine the Size of the proposed Vacuum Cleaner

The previous design of the portable backpack vacuums cleaner focused on ensuring the right size for optimal performance and user comfort. It was crucial to find a balance between size and weight—too large or heavy would make it cumbersome, while too small could reduce cleaning efficiency. The dust bag capacity was set at 1 liter, and the weight limit was kept under 10 kg to maintain portability. The design aimed to allow users to comfortably carry the vacuum cleaner with their hands, ensuring both practicality and ease of use. These considerations will be applied to the new design.

3.1.4 Determine the Source of Power for the proposed Vacuum Cleaner

The previous design opted for an AC Power Drive/Motor for the vacuum cleaner, prioritizing reliability and robustness over the efficiency of DC power. While DC motors are more efficient and suitable for portable devices, AC motors were chosen for their ability to handle voltage fluctuations and provide higher power outputs. This was essential for achieving the required suction power and ensuring consistent performance across various environments. These considerations will be applied to the new design.

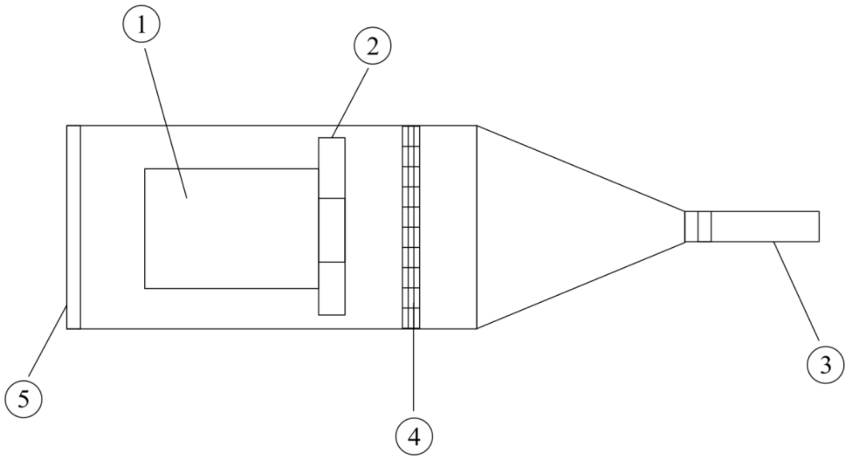
3.1.5 Selection of Vacuum Cleaners options from the Literature Review that match the criteria determined from 1 – 3 above

The previous design, based on a literature review, identified the backpack vacuum cleaner as the ideal option. Its portability, lightweight design, and efficient cleaning performance met the criteria set for the vacuum cleaner. These factors will be incorporated into the new design.

3.1.6 Design of the Components of the Previous Vacuum Cleaner

Old Conceptual Design

S/N	DESCRIPTION
1	MOTOR
2	BLADE



3	EXTENSION
4	FILTER
5	EXHAUST

Figure 3.2 Exploded view of old design concept

3.1.6 Design of the Components of the Improved Vacuum Cleaner

New Conceptual Design

S/N	DESCRIPTION
1	MOTOR
2	BLADE
3	EXTENSION
4	EXHAUST
5	DUST BAG
6	HANDLE

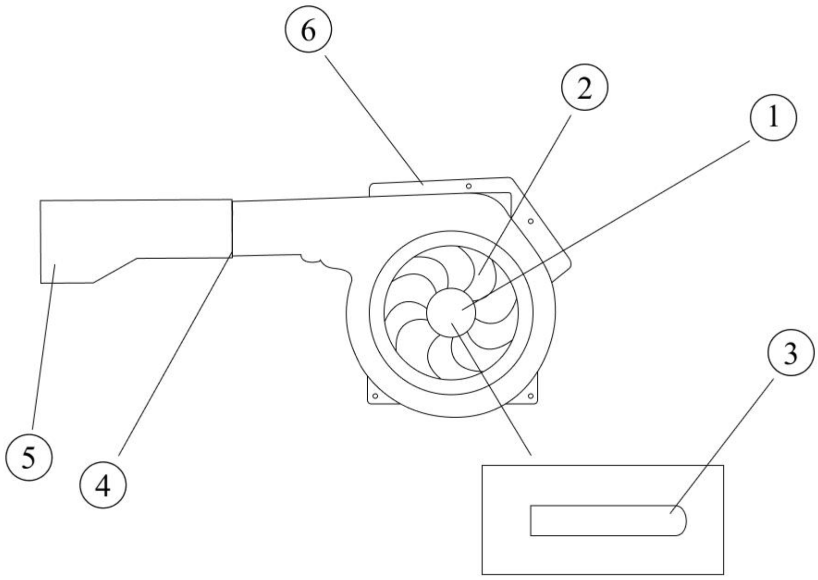


Figure 3.3 Exploded view of new design concept

a) Air Jet Speed Design for Dust Particle Type and Size Pickup

To design the air jet speed for the vacuum cleaner based on the weight of the heaviest particle (0.2 grams), we need to determine the necessary air velocity that will impart enough force to lift or move the particle using the given blower specifications, let's go step by step.

Given Data:

- Mass of particle: 0.2g = 0.0002 kg
- Force required: 2N (as given)
- Density of air (ρ): 1.225 kg/m³

- Pressure difference (ΔP): To be determined
- Blower airflow: 3.3 m^3/min = m^3/s = 0.055 m^3/s
- Blower power: 700W or 400W (two different values are mentioned, we'll assume 700W for max performance)
- Blow mouth diameter: 3 cm = 0.03 m
- Suck mouth diameter: 3.5 cm = 0.035 m

1. Calculate Required Air Speed

We use the Bernoulli equation and solve for V:

$$V = \sqrt{\frac{2\Delta P}{\rho}}$$

Since force is given as 2N, pressure can be estimated using:

$$F = P \times A$$

$$P = \frac{F}{A}$$

where is the area of the blow mouth:

$$A = \frac{\pi}{4}D^2 = \frac{\pi}{4}(0.03)^2 = 7.07 \times 10^{-4} m^2$$

$$P = \frac{2}{7.07 \times 10^{-4}} = 2828.4Pa$$

Now, using Bernoulli's equation:

$$V = \sqrt{\frac{2 \times 2828.4}{1.225}}$$

$$V = \sqrt{4619.1} = 68m/s$$

2. Verify Feasibility with Blower Specifications

The volumetric airflow rate is given as 0.055 m³/s. The expected velocity at the outlet can be calculated using:

$$Q = AV$$

$$V = \frac{Q}{A} = \frac{0.055}{7.07 \times 10^{-4}}$$

$$V = 77.8m/s$$

Since the required 68 m/s is within the range of the blower’s capacity (77.8 m/s), the design is feasible.

Conclusion

- The air jet speed needed to lift the 0.2g particle is 68 m/s.
- The blower can produce a maximum speed of ~77.8 m/s, meaning it should work effectively.
- The pressure difference required is ~2828 Pa.

So, we can conclude that this motor is sufficient.

b) Dust Particle Type and Size Agitation Mechanism Design

We have identified that households commonly contain various types and sizes of dust particles. To effectively remove tightly held dirt, especially in rugs, we have incorporated an agitation mechanism. This mechanism helps loosen and dislodge dirt particles, making them easier to vacuum. The mechanism essentially consists of a modified 1.5-inch pipe section, where a strip has been removed and attached to the wand.

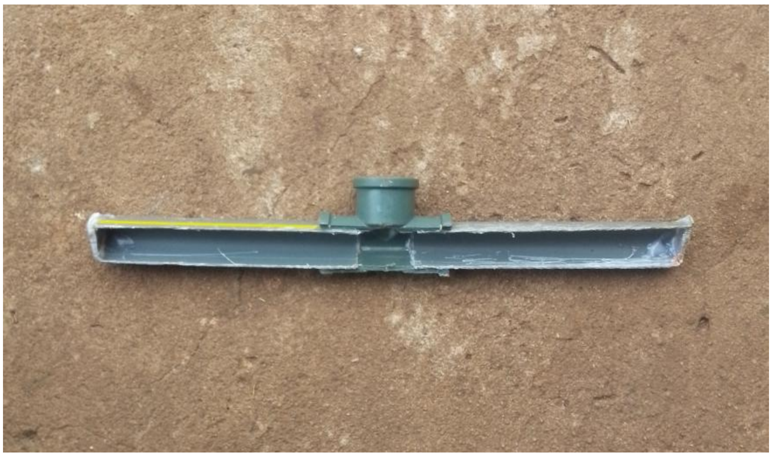


Figure 3.4 8 Inches Agitation Mechanism Design

c) Air Stream Conveyor Rigid Pipe Section Design

For the rigid pipe section of the vacuum cleaner (the wand), PVC pipes were utilized. To reduce the inlet diameter from the 6-inch diameter housing, two reducers were employed: a 6 to 4-inch reducer followed by a 4 to 2-inch reducer. To further enhance mobility, an adjustable pipe was added to the wand. This adjustment was followed by a reduction to the rigid pipe size of 0.5 inches. While this diameter choice may result in a lower pressure differential compared to typical designs, it was selected to increase suction efficiency. The use of a smaller area diameter in the slimmer area allows for higher airflow velocity, thereby improving the vacuum's overall performance.

Figure 3.5 Rigid 0.5-inch PVC pipe for wand

d) Flexible Hose

To provide flexibility and reach, we opted for a PVC adjustable pipe with a diameter of 1.5 inches for the flexible hose. This allows users to adjust the length of the hose according to their cleaning needs, enhancing the usability of the vacuum cleaner.

Figure 3.6 Flexible Hose

e) Filter/ Dust Sack

For the filtration system, we chose a fine cloth filter material over foam and paper filters. The fine cloth material offers superior filtration efficiency and durability, ensuring that even the smallest dust particles are captured and retained.

Figure 3.7 Dust Bag

f) Exhaust

To maximize space for the exhaust and ensure efficient airflow, we placed the motor at the base of the housing unit. This design allows for unrestricted airflow and minimizes noise levels, enhancing user comfort during operation.

Figure 3.8 Exhaust Side of the vacuum cleaner

g) Housing Unit

The housing unit is a blower. This choice provides a sturdy and durable housing for the vacuum cleaner components, ensuring long-lasting performance.

Figure 3.9 Housing

Table 3.1 Vacuum cleaner components and locally available material used

Component	**Material Used**	**Justification**
Body	Plastic PVC	Lightweight and durable.
Wand	PVC Pipe	Flexible, lightweight, and durable material suitable for directing airflow without kinking or leaking.
Nozzle	PVC Pipe	Easy to shape and customize for specific cleaning needs, while remaining durable and lightweight.
Motor	Manufactured Electric Motor	Cost-effective and readily available source of power for generating suction in the vacuum cleaner.
Filter	Cloth	Provides effective filtration of dust particles while allowing airflow, easy

		to replace or clean.
Power Supply	AC Adapter	Provides a stable power source, suitable for household use.

3.2 Morphological Chart

Table 3.2 Morphological Chart

Component/Feature	**Option 1**	**Option 2**	**Option 3**
Body Material	Plastic PVC	Sheet Metal	Flexible Composite Material
Suction Power Source	Old blower Motor (13,000rpm)	Old blender motor (10,000rpm)	AC Motor (15,000rpm)
Filter Type	Cloth Filter	Foam Filter	Paper Filter

3.3 Fabrication Process

Fabrication Process

1. **Connector Pipe Installation**

- Attach the connector pipe to the motor's inlet to direct airflow efficiently.

- Seal any gaps using adhesive to prevent air leaks.

2. **Hose and Nozzle Assembly**

- Connect a short piece of PVC pipe to the end of the connector path, serving as an extension before attaching the hose.
- Attach the flexible pipe, which functions as the hose.
- Secure a narrower metal pipe at the end of the hose to serve as the nozzle.

3. **Agitator Construction**

- Cut a PVC pipe T-connector symmetrically.
- Attach two PVC pipes to both ends of the T-connector to form the agitator.
- Secure the agitator to the metal pipe.

4. **Filter Installation**

- Place the filter cloth at the exhaust to ensure proper filtration.

5. **Power Supply Connection**

- Wire the motor to an appropriate power supply, such as a battery or AC adapter.
- Ensure all electrical connections are properly insulated and meet safety standards.

3.3.1 Tools Used for Fabrication

Table 1 Tool used for fabrication

Tool	**Purpose**

Ruler	Length and Diameter measurements
Saw	Cutting PVC pipe
Adhesive	Sealing

3.3.2 Challenges Encountered During Fabrication and Solutions

- Sealing Air Leaks: Use adhesive or tape to seal any gaps in the airflow path to ensure maximum suction power.
- Safety Concerns: Insulate all electrical connections properly to prevent electric shocks. Use the vacuum cleaner in a well-ventilated area to avoid inhaling dust and debris.

3.4 Optimization of the Vacuum Cleaner

We tried to make it as optimal as possible and also satisfy all the requirements of a good vacuum cleaner. Three of the most important requirements of a good vacuum cleaning machine are as follows:

1. It should produce an even suction at all times
2. The suction should be great enough to loosen the dirt from the fabric but not great enough to injure the fabric
3. The amount of air handled by the fan should be large enough to remove the loosened dirt and purify the fabric at the same time. (Whitnall, C.A., 1911)

Suction power is a very important parameter. Suction power in a vacuum cleaner is influenced by several key factors:

- Motor Power: The strength of suction is directly related to the speed of the motor. The more the speed of the motor, the more the suction. However, there is a trade-off to consider, as higher motor speeds can also lead to increased noise levels and energy consumption.

- Air Passageway Blockage: A clean vacuum bag and filter are essential for maintaining optimal airflow and suction power. If air flow is constricted because of blockages in the filter, the particles of air would move more slowly and thus decrease the suction power.

- Intake Port Size: A smaller intake port increases air speed, resulting in greater suction force due to Bernoulli's principle. Narrower attachments create stronger suction as they force air to move faster through them. Since the speed of the vacuum fan is constant, the amount of air passing through the vacuum cleaner per unit of time is also constant. No matter what size you make the intake port, the same number of air particles will have to pass into the vacuum cleaner every second. If you make the port smaller, the individual air particles will have to move much more quickly in order for them all to get through in that amount of time.
- The design of the fan blades: This also has a significant impact on suction power. The shape and orientation of the blades can affect the airflow pattern inside the vacuum cleaner, which in turn influences suction power. Almasi et al. (2022) observed that fan blades can be optimized to increase suction.
- Airflow Path: The design of the airflow path inside the vacuum cleaner can influence suction power. Smooth, unobstructed airflow paths are more efficient and can result in higher suction power. Design features such as bends, curves, and obstructions can reduce airflow and lower suction power.

- Seal and Gasket Quality: The quality of the seal and gaskets in the vacuum cleaner can affect suction power. A tight seal ensures that air is drawn through the vacuum cleaner and not leaked out, maximizing suction power.

In the optimization phase of our project to fabricate a vacuum cleaner from locally available materials, several key challenges were encountered and addressed to enhance the performance and efficiency of the device.

The speed of the motor is constant and cannot be increased and so we concentrated on other aspects. We focused on optimizing the blade and enhancing the filter system. We experimented with different blade shapes and types that we found to maximize airflow and suction power. Additionally, we explored various filter materials and configurations to improve dust and debris capture efficiency without compromising airflow.

Another critical aspect of optimization was ensuring air tightness to prevent air leaks and maximize suction power. We carefully sealed all seams and joints in the vacuum cleaner body to eliminate any potential leakage points. This meticulous sealing process significantly enhanced the overall performance of the device.

Furthermore, we optimized the intake port size to balance airflow and suction power. By reducing the intake port size to 0.5 inches, we were able to increase the air velocity entering the vacuum cleaner, thereby enhancing suction power while maintaining optimal airflow.

Overall, through systematic optimization efforts focused on blade design, filter system, airtightness, and intake port size, we were able to significantly improve the performance and efficiency of our locally fabricated vacuum cleaner.

3.5 VACUUM CLEANER DRAWING

Figure 3.10 Wand Diagram

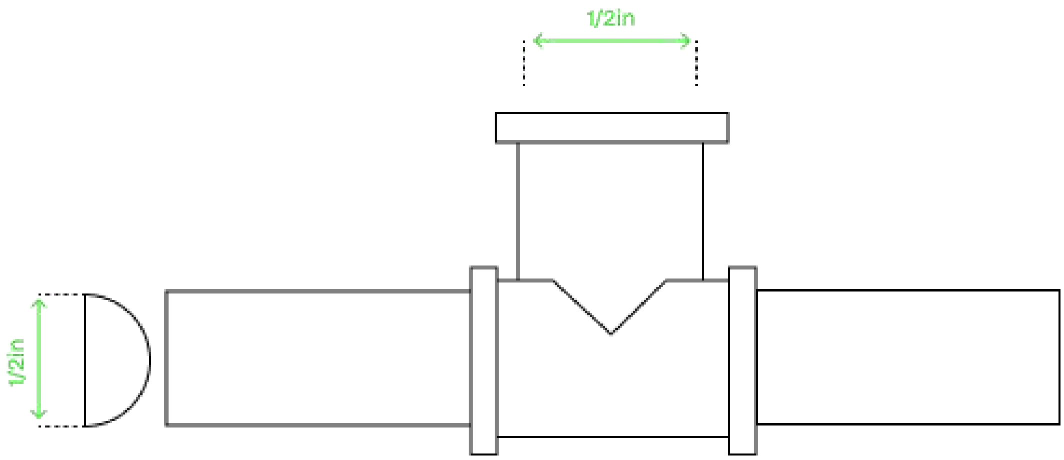


Figure 3.11 Agitator Mechanism Diagram

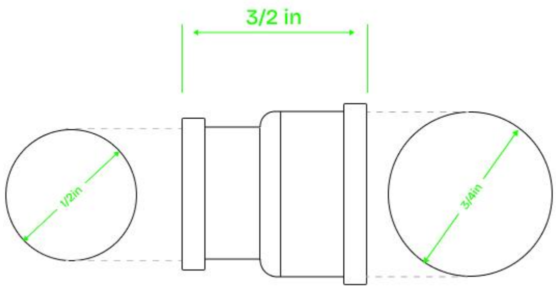


Figure 3.12 3/4 Inch to 1/2 Inch Pipe Reducer

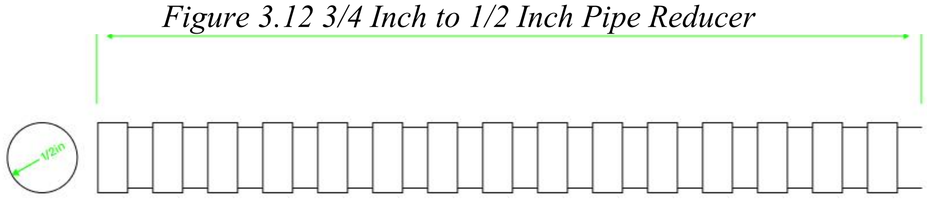


Figure 3.13 – Flexible Pipe Diagram

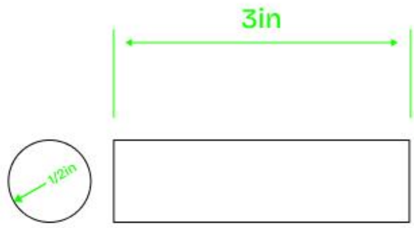


Figure 3.14 Connector Diagram

3.6 Specification

To determine the performance of this vacuum cleaner, we rely on its motor specifications. The motor operates with a rated power of 700 watts and runs at a no-load speed of 14,000 rpm. It functions within a voltage range of 220V to 240V at a frequency of 50-60Hz.

The vacuum's efficiency is influenced by its maximum airflow, which reaches 3.3 m^3/min, and its dual-function capability, allowing both blowing and suction. The suction mouth has a diameter of 3.5 cm (1.4 inches), while the blow mouth measures 3 cm (1.2 inches).

Constructed from high-quality PVC, this vacuum cleaner incorporates a multi-layer filtration system with fine mesh filters to enhance dust collection. Its lightweight design ensures easy handling, while additional features such as variable speed control, an ergonomic handle, and a lock-on button for continuous operation improve user convenience.

Figure 3.15 Picture of the Vacuum Cleaner in Design Stage

CHAPTER FOUR

RESULT

The new and Improved components for the vacuum cleaner underwent rigorous tests and analysis, focusing on wand velocity, dust bag retention efficiency and wand expansion dynamics to evaluate its performance, usability and ergonomic design. these targeted enhancements address critical flaws identified in the previous iteration of the project. by benchmarking these metrics against leasing commercial vacuum cleaners, the analysis aimed to validate improvements in core functional areas.

To assess whether the redesigned vacuum cleaner can deliver an optimal performance, insights from MINTEL (2010) were applied, which highlight key product priorities:

1. Suction Power.
2. Maneuverability.
3. Versatility.

These refinements aim to directly align the vacuum's performance with the factors most valued by users, as highlighted in product performance studies (Smith, J., et al., 2019).

4.1 Testing and Performance Evaluation

4.1.1 Performance Evaluation Criteria

The following criteria were developed to assess the newly designed wand and dustbag retention system, which integrate with the existing motor:

1. Airflow Efficiency in the Wand: The re-designed vacuum cleaner should ensure optimal velocity and laminar airflow through the wand to maximize suction delivery from the motor.
2. Maneuverability: Evaluate ease of movement during use, including ergonomic handle design and smooth telescoping/expansion mechanisms.

3. Wand Weight: Maintain lightweight construction to minimize user fatigue while ensuring structural rigidity.
4. Dustbag Retention and Sealing: Test the dustbag's ability to retain debris without leakage, even during abrupt movements or when full.
5. Surface Versatility: Validate performance across hard floors and carpets by optimizing wand tip adaptability (e.g., brush roll compatibility).
6. Durability of Modular Components: Assess wear resistance of the wand joints, expansion mechanisms, and dustbag sealing interfaces under repeated use.

4.1.2 Testing Methods

1. Airflow Velocity and Consistency Test: The airflow velocity and consistency were tested by measuring airflow at the wand's tip under various suction settings and conditions, both statically and during dynamic movement, while recording data over time to assess fluctuations and compare results against industry benchmarks.

2. Maneuverability and Ergonomics Test: The maneuverability and ergonomics were tested by evaluating the ease of movement, comfort, and control during typical household cleaning tasks, while assessing the handle design, weight distribution, and the effectiveness of the telescoping wand mechanism across different surfaces and obstacles.

3. Weight Test: The weight was tested by measuring the vacuum cleaner's total weight and assessing user feedback on comfort and fatigue during extended use, ensuring the design remains lightweight without compromising strength or durability.

4. Noise Level Test: The noise level was tested by measuring the sound produced during operation at various power settings using a sound level meter, and comparing the results to industry standards to ensure acceptable noise levels for household use.

5. Durability and Usage Test: The durability and usage were tested by running the vacuum cleaner continuously for a specified period of 1 hour to simulate normal operating conditions, assessing its performance, wear resistance, and filtering efficiency under prolonged use.

4.1.3 Results and Discussion

The velocity of the suction power was tested by measuring the vacuum cleaner's ability to lift a standard weight of 0.2 grams from a distance of 0.5 centimeters, indicating sufficient suction.

During operation, the vacuum cleaner produced a noise level of 110 decibels, which is within the acceptable limits for household use.

Table 4.l Performance Evaluation Criteria

Criteria	**Description**
Airflow Velocity	Sufficient enough to lift up & deposit debris
Weight	Light weight
Noise Level	Within acceptable limits for indoor use
Durability	Withstands frequent use without any wear or damage
Dustbag Retainability	Traps dust particles without releasing them back

4.2 Bill of Engineering Measurement and Evaluation (BEME)

Table 4.2 Bill of Materials

S/	**Component**	**Material**	**Dimensio**	**Quantit**	**Price**	**Total**

N			n	y	(Naira)	Price (Naira)
1	Electric Motor	N/A	700 watts	1	20,000	20,000
2	Pipe	PVC	½ inch diameter	1	1,000	1,000
3	Pipe	Steel	½ inch diameter	1	3000	3000
4	T-Connector Joint	PVC	½ inch diameter	1	400	400
5	Diameter reduction joint	PVC	¾ to ½ inch diameter	1	400	400
7	Flexible Pipe	PVC	½ Inch Diameter	1	5000	5000
6	Glue	Epoxy Resin	-	1	1.200	1200
	Total					**31,000**

The total material cost for manufacturing this vacuum cleaner is 31,000 Naira. A market survey of home vacuum cleaners shows that they are priced at 70,000 Naira and above. While commercial models may include extra features and attachments, this locally made vacuum cleaner offers an affordable solution for household cleaning.

4.3 Comparative Analysis of The New Vacuum Cleaner Design Versus the Previous Design.

1. Materials

Table 4.3 Materials Comparative Analysis

Component	**New Vacuum Cleaner Design**	**Previous Vacuum Cleaner Design**
Body	Shaped PVC pipes	Shaped PVC pipes
Hose	PVC pipes and wands	PVC pipes and wands
Motor	Repurposed electric motors	PVC pipes and wands
Filter	Cloth filter	Cloth filter

2. Performance

Table 4.4 Performance Comparative Analysis

Performance Metric	**New Vacuum Cleaner Design**	**Previous Vacuum Cleaner Design**
Dustbag Retention	Improved	Poor
Wand Expansion	Optimized	Excessive
Suction Power	Moderate	Moderate
Noise Level	Moderate	Moderate
Overall Durability	Durable	Durable

3. Cost

Table 4.5 Cost Comparative Analysis

Cost	**New Vacuum Cleaner Design**	**Previous Vacuum Cleaner Design**
Purchase Cost	Low	Low

4.4 SWOT Analysis of the Vacuum Cleaner Fabricated from Locally Available Materials

4.4.1 Strengths

- **Cost-Effective:** The vacuum cleaner is significantly cheaper than purchasing a standard vacuum cleaner.
- **Sustainable:** Using locally available materials reduces the environmental impact linked to manufacturing and transportation.

- **Customization:** Locally sourced materials allow for customizing the vacuum cleaner's design to meet specific needs and preferences.
- **Skill Development:** Fabricating the vacuum cleaner provides an opportunity for individuals to develop skills in engineering, design, and fabrication.
- **Performance:** The performance is sufficient for basic cleaning tasks.

4.4.2 Weaknesses

- **Dustbag Retention:** The dustbag kept falling off when in use.
- **Aesthetics:** The design may not be aesthetically pleasing.
- **Features and Accessories:** The features and accessories are limited.

4.4.3 Opportunities

- **Local Production:** Fabricating vacuum cleaners from locally available materials can promote local production and entrepreneurship.
- **Innovation:** Ongoing innovations in design and materials may improve the performance and durability of locally fabricated vacuum cleaners.

4.4.4 Threats

- **Competition:** Standard vacuum cleaner manufacturers may offer products with superior performance and more features.
- **Technological Advancements:** Rapid advancements in technology could make standard vacuum cleaners more affordable and efficient, reducing the appeal of locally fabricated alternatives.

The fabrication of vacuum cleaners using locally available materials provides several benefits, including cost-effectiveness and sustainability. However, challenges such as lower performance compared to standard vacuum cleaners and the issue of the dustbag falling off need to be addressed. Continued innovation and the growing demand for affordable, sustainable solutions offer opportunities for growth in this sector.

4.5 Design Analysis and Recommendations

Based on extensive testing and analysis throughout the design process, we have developed the following recommendations:

- Opt for a high-speed motor with a high RPM (revolutions per minute) for improved performance.
- Ensure the vacuum cleaner is airtight to maintain optimal airflow.
- Use a concentric shape reducer for better airflow efficiency over an eccentric shape.
- Consider using encased centrifugal fans for the best suction performance.
- Choose a fan with substantial thickness or a metal fan, such as aluminum, for enhanced durability and performance.
- Include ergonomic features in the design, such as comfortable handles and lightweight construction, to enhance usability and user comfort.

These recommendations aim to improve the overall design and performance of the vacuum cleaner, ensuring optimal functionality and efficiency.

4.6 Results of detailed design

Table 4.6 Results of detailed design

S/N	Parameters	Unit	Calculated Data
1	Rated Power	Watt (W)	700
2	Suction Power	Pascal (Pa)	360
3	Weight	Kilogram (kg)	3.3
4	Noise	Decibels (db)	110
5	Dust bag volume	Liters (l)	0.6

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Key Findings

Constructing a vacuum cleaner in Nigeria using readily accessible materials is both practical and affordable. With fundamental design concepts and basic tools, it is possible to create a working vacuum cleaner for home use. Common materials like plastic buckets, PVC pipes, and electric motors can be adapted to serve as key components in the assembly process.

5.2 Recommendations for Future Studies or Improvements

Future studies could aim to refine the design of the homemade vacuum cleaner to enhance its efficiency and overall performance. Investigating alternative, locally abundant materials and components may contribute to a more sustainable manufacturing process. Additionally, assessing the vacuum cleaner's functionality through user feedback in real-life conditions could offer important guidance for further improvements.

5.3 Conclusion

Through careful design modifications, this study successfully addressed the key issues affecting the performance of the previously fabricated vacuum cleaner. Optimizing air velocity improved suction efficiency, ensuring that fine dust particles were not released back into the environment. Enhancing the dustbag filtration system by resizing the filter holes significantly increased particle retention, preventing dust from escaping. Additionally, repositioning the dust deposition area allowed for more effective dust collection, reducing the number of fine particles in the exhaust.

These improvements demonstrate that a functional and efficient vacuum cleaner can be fabricated using locally available materials in Nigeria. This project not only provides an affordable alternative for individuals and small businesses but also showcases the potential for innovation in local manufacturing. Despite challenges such as unstable electricity supply, our success in refining this design highlights the importance of continuous research and development in creating cost-effective, practical cleaning solutions tailored to local needs.

CHAPTER SIX

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