DESIGN OF A COBWEB REMOVER MACHINE USING LOCALLY SOURCED MATERIAL

BY

OSEMWENGIE OSADEBAMWEN KELVIN

ENG1704508

SUPERVISED BY: Engr. Dr. (Mrs.) T.I FRANCIS - AKILAKI

DEPARTMENT OF PRODUCTION ENGINEERING

FACULTY OF ENGINEERING

UNIVERSITY OF BENIN

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ABSTRACT

Cobwebs are a common nuisance in both residential and commercial spaces, often requiring manual removal that can be time-consuming and tedious especially hard to reach corners. This project focuses on the development of an efficient and cost-effective cobweb remover using locally available materials like electric motor (rotational motion), brush (removal of the cobweb), Rechargeable Battery (as the power source) and telescopic pole (for high buildings). The primary objective is to design a device that simplifies the process of cobweb removal while minimizing the need for expensive or specialized equipment providing 75% efficiency.

The outcome of this project is an innovative cobweb remover that is not only effective but also accessible to a wide range of users, including homeowners, cleaning services, and facility managers. By utilizing locally sourced materials and promoting sustainable design, this project contributes to eco-friendly cleaning practices while improving the quality of life for individuals in various environments.

It was successfully fabricated and our results were compared with the traditional methods. And it was observed that the cobweb remover has an efficiency of 78% while the traditional method of removing cobweb was 60.7% which shows that the design is more efficient and reliable.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Cleaning industrial ceilings is a laborious undertaking, posing a widespread challenge across various industries. Traditionally, this task has relied on manual labor, with the number of workers deployed contingent upon the size of the industrial facility. However, the current workforce engaged in this role is often insufficient due to associated health risks and potential life-threatening situations. Some industrial cleaning procedures necessitate execution during factory shutdowns, impacting overall working hours and causing delays in project completion. In residential settings, floor cleaning is typically facilitated by vacuum cleaners, yet there is a noticeable absence of automated devices for ceiling cleaning. The prevailing method involves using manual processes, such as vacuum cleaners equipped with extension rods. Unfortunately, these approaches are time-consuming and demand a significant workforce, especially for larger areas. To address these challenges, an innovative solution in the form of an automatic cobweb cleaner has been developed. Furthermore, both interior and exterior wall cleaning share common challenges in research activities. Dust particles generated during cleaning procedures can pose serious health hazards, leading to eye, skin, and respiratory diseases. The nature of the cleaning techniques is not only tedious but also time-consuming. This project seeks to mitigate these issues by introducing a wall cleaning vehicle controlled remotely. The robot incorporates a vacuum module, an electric motor, a Remotely Piloted Vehicle (RPV), and a regulator unit to manage the entire dust cleaning operation. Thanks to sophisticated and precise control systems, the robot can operate with minimal vibration, ensuring quiet and efficient performance. The noise generated during its operation is tolerable and does not pose a threat to human ears. In terms of durability, efficiency, and time reduction in execution, this robotic system surpasses existing modules.

We are considering a tall building, the cost of maintenance (removing cobwebs), designing a machine that can conveniently clean off cobwebs, reduce labour, providing more efficient way than the traditional method of using brooms and hiring labour. Most cleaning methods for cobwebs removal in a building are manually implemented. It would require the use of platforms such as ladders for tall buildings to reach the top ceilings and edges to clean the cobwebs. Extension rods are sometimes attached to broom sticks to reach the areas where cleaning is needed. These methods pose health and safety challenges.

Traditional cleaning tools like brooms and vacuum cleaners face challenges in effectively removing cobwebs due to their sticky nature. In contrast, this innovative device leverages the stickiness of cobwebs by utilizing a rapidly spinning rod. When the rod comes into contact with a cobweb strand, it initiates a rapid winding process, causing the interconnected strands to be tightly wound around it. This process is so swift that the cobwebs seem to collapse towards the rod, resembling the effect of a powerful magnet. The collected cobwebs, now adopting the slim tubular shape of the rod, are kept away from the cleaned surface, preventing their redeposition. The slim rod design offers the advantage of easy maneuverability in narrow gaps and corners where cobwebs tend to accumulate. Unlike conventional devices, this invention eliminates the need for secondary cleaning tasks caused by cobwebs falling to the floor. The removal of collected cobwebs from the rod is a quick and simple process, involving a mere push by the thumb and forefinger along the soiled portion of the rod. In comparison to traditional tools, this invention is cordless, lightweight, and quickly deployable without extensive setup. With the majority of its weight concentrated in the handle, it minimizes stress on the user's wrist compared to brooms or vacuum cleaners. It surpasses traditional tools in terms of weight, making it less tiring for use on walls and elevated surfaces. Additionally, this cobweb cleaning device boasts a simpler design and operates silently, in contrast to the noise generated by vacuum cleaners (Blackledge and Coddington, (January 2003). "Are three-dimensional spider webs defensive adaptations?").

1.2 Statement of the research problem

The cleaning process of cobweb removal can me tedious considering our case study being a high building, the normal traditional method of removing cobwebs are manual base and energy demanding as it is only convenient and efficient for low cliff buildings. We are considering the problems that can be encountered when asked to clean off cobwebs from production 500 level class faculty of Engineering University of Benin.

Some questions that come to mind can include;

1. Is there automated way of getting cobwebs removed from high building walls?
2. Can this system to be designed provide efficient and thorough cleaning of cobwebs?
3. Is the design health safe and labour reduced?
4. Is the method of operation convenient and easy to learn?
5. Is the design pocket friendly and accessible to all?

1.3 Aim

The aim of this research is to design and fabricate a mechanized cobweb machine using locally sourced materials for effective cobweb removal.

1.4 Objectives

In order to achieve the aim of this research, the following objectives would be pursued.

1) To provide a cobweb cleaning device that is fast and efficient;

2) To provide a cobweb cleaning device designed for quick and easy removal of the collected cobwebs from the cleaning device itself;

3) To provide a cobweb cleaning device that requires the least disturbance of items on or near the surfaces being cleaned;

4) To provide a cleaning device that is less stressful on the Wrist than conventional devices such as a vacuum cleaner or a broom;

5) To provide a cobweb cleaning device that can easily access narrow gaps between ordinary items such as tools, boxes, jars, etc.;

6) To provide a cobweb cleaning device that is light and portable and to provide a cobweb cleaning device that does not require the use of a ladder when used on high ceilings

7) To provide a cobweb cleaning device that consumes less energy than an ordinary vacuum cleaner;

8) To design a method that is efficient and reduces the man power, consumes less time reduces the accident during cleaning process.

9) To design a compartment circuit that works electronically to remove cobwebs from tall buildings.

1.5 Scope of the Research

The use of electronic system is taken into consideration, principal of motor driving system, this research tends to consider Vacuum Pump, Vacuum nozzle, Dust collector, and how it can be effectively utilized in this project work is also evaluated. An air compressor mechanism is reviewed. A simple wind blower mechanism driven by a motor is also considered in this project work.

1.6 Significance of the Study

This project aims to present an in-depth examination of a mechanical device designed to thoroughly remove cobwebs, particularly in the context of high-rise buildings. The focus is on an autonomous cobweb cleaner showcased in this project. The intention is to address the limitations of traditional cleaning methods for walls and ceilings, offering an efficient alternative that minimizes the need for manual labor, reduces cleaning time, and lowers the risk of accidents during the cleaning process. Machine-based cleaning is demonstrated to be more effective than manual approaches. The proposed cleaner simplifies the dust collection process, leading to the conclusion that the proposed system is highly efficient for cleaning purposes.

The need for having a clean environment can’t be over emphasized. As the saying goes cleanliness is nearest to Godliness. This project provides a more efficient and affordable way of removing cobweb from our very high elevated buildings. Holistically speaking a more mechanically convenient way of cobweb remover can draw the attention of all as against the common traditional method employed.

This research work overcomes the frequent challenges and limitations encountered when cleaning off cobwebs from tall building walls

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORY OF COBWEB REMOVER

The challenge of eliminating cobwebs using typical household tools has been a persistent issue throughout human history, as noted by Craig, C. L. (1997) in the "Annual Review of Entomology." Using a broom proves unsatisfactory, as cobwebs often adhere to the broom strands and require subsequent removal. Additionally, when swept, cobwebs accumulate on the broom and may drop onto floors and other surfaces, necessitating further cleaning. Cleaning elevated surfaces with a broom can result in catching cobwebs on one's head. Furthermore, the act of sweeping with a broom may redistribute accumulated cobwebs more firmly onto the surfaces being cleaned. Brooms are cumbersome for cleaning nooks and crannies where cobwebs gather, requiring the movement of objects like boxes and jars. Between walls and appliances, the use of a broom is challenging without first relocating appliances. The weight distribution of a broom also strains the user's wrist when sweeping elevated surfaces. High ceilings or elevated surfaces may require a ladder, introducing an element of danger. Dusters, mops, and similar tools face similar challenges as brooms in cobweb removal.

Vacuum cleaners, though noisy and heavy, struggle to efficiently suction cobwebs, which tend to stick to the suction tube's opening and inner surfaces. In tight spaces next to soft materials, such as curtains, vacuum cleaners may inadvertently suction these materials, disrupting the cleaning process. Setting up a vacuum cleaner is cumbersome due to unraveling the electrical cord and connecting various attachments. Users often need to navigate the canister around furniture and corners during use, making it impractical. The weight and bulk of the vacuum cleaner wand make cobweb cleaning tiring, especially on high ceilings or rafters, where a ladder is usually necessary, posing safety risks.

The inventor is aware of several patents in the cleaning devices category. However, most are unsuitable for cobweb removal. One patent specifically designed for chimney cleaning is irrelevant, while others address leaves and debris in gutters, grass trimmers, and dental hygiene appliances. The only relevant patent focuses on cobweb removal but resembles a typical vacuum cleaner, inheriting associated bulk, weight, and cleaning process challenges (Keefer, 2007, "The systematics and biology of the spider genus Nephila (Araneae:Nephilidae) in the Australasian region").

2.2 Methods of cobweb remover

Some Methods have been used over the years to remove cobwebs from the buildings, these methods include;

2.2.1 Vanquish Them with a Vacuum

A vacuum cleaner will make short work of any cobweb. A handheld vacuum is ideal because it’s easy to maneuver. But you can also use your regular floor vacuum. Attach the extension nozzle to make it easier to reach the cobwebs. Spiders love to create webs in dark spaces, like the underside of furniture. Using a vacuum means you won’t have to get down on your knees to reach these places.

The vacuum’s suction will suck those webs in fast. You might have to go over some areas a few times for webs stuck to the wall. Check every furniture and curtain. The folds in curtains and creases in sofas are favorite hiding places of spiders. Run your vacuum over them. You can also use a lint roller to remove any leftover webs. Don’t forget to empty your vacuum’s dust bag after use. Anotaux, et al (2012). "Ageing alters spider orb-web construction".

One effective method for eliminating spider webs is utilizing a vacuum cleaner. Opting for a handheld vacuum offers greater maneuverability, but if one is unavailable, a vacuum equipped with an extension nozzle can serve the purpose. Simply use the handheld vacuum or nozzle to suction any visible webs. In case the webs are stubborn, multiple passes over the area may be necessary. For cobwebs on furniture or curtains, vacuuming is followed by the use of a lint roller to clear any remaining web remnants.

Ensure to inspect beneath furniture regularly, as certain spider species may construct webs in dimly lit spaces. A weekly practice of overturning couches, chairs, tables, and other furniture items helps in identifying and removing any detected webs. This particular method of cobweb removal is of particular interest due to its distinct advantages over alternative approaches. The components of the vacuum module include a Vacuum Pump, Vacuum Nozzle, and Dust Collector.

In the transmitter unit, data transmission occurs through the antenna, with the signal received by the receiver. The sensor identifies the surface, sending a signal to the controller. The relay, when activated by the received signal, positions itself as Normally Closed (NC), prompting the vacuum pump to create a vacuum by moving air from high pressure to low pressure. The electric motor then activates the fan, generating suction to extract dust particles.

The cleaning component encompasses the vacuum pump and the controller unit responsible for triggering the vacuum pump nozzle. According to Judith (1987), this method is exemplified by the "Digiovanni Cobweb Vacuum Cleaner."

Figure .2.1 An Automated vacuum cleaner

2.2.2 Sweep Webs Away

A broom is also a handy tool for getting rid of cobwebs. Run the bristles along the ceiling or across the walls. Use a long-handled broom to reach the corners. Some webs will float down so make sure you sweep the floor afterward. There will be no traces of spider webs. (Kaston, 1964). "The evolution of spider webs". American Zoologist.

Figure 2.2 A domestic Broom

Figure 2.3 A domestic broom

2.2.3 Swipe with Soft Dusters

Some professional cleaning services do not bother with vacuums. They use soft dusters instead. These handy and fluffy cleaners can get rid of dust and cobwebs in one swipe. The soft bristle or cloth also means less chance of damaging wallpaper or paint job.

It's also easy to make your own soft duster. You can tie an old sock or shirt at the end of a long stick, Swipe it around the surface in a gentle manner.

Figure 2.4 The modern broom in use

Figure 2.5 A modern Brush

2.2.4 Deal with Textures Using a Roller Brush

It's annoying how fast cobwebs can become stuck to walls and ceilings. It's even more irritating if these surfaces are textures. A broom or feather duster will only smear the webs on a larger area. A paint roller is more effective in this situation. Stick several patches of double-sided tape on the sponge side of the roller. Roll it over the ceiling or wall. The cobwebs will stick to it fast.

Remove the tape once its surface is already covered. It's useless at this point and can't collect any more webs. Change the adhesive tape and repeat the process. You might have to do this a few times Sweep the floor afterward.

2.2.5 Spray Your Screens

Spiders also love to spin their webs in the corners of window screens. Getting the web out can be difficult. Some could become wedged tight in the corners. Others will shrink and stick to the screen. A water hose or spray bottle will save the day.

Spray down the window screen with water. Aim the nozzle at the spider webs and let loose. Remove the screen. Use a spray bottle to get rid of the webs lodged in the screen's small openings. Focus on the windows next. Clean them to remove any residue from the webs. A liquid soap and water solution will work well.

Figure 2.6 Repellent Spray

6. Bleach Them Away

Every household should have a bottle of bleach or two. It's one of the best cleaning materials around. It's also an effective cobweb deterrent. Mix a cup of bleach in a large pan of water. Fill a spray bottle with the solution. Shake it well and spray over every spider web you see. Wipe the area with a clean, dry cloth. Repeat as needed. This bleach solution will also remove any spider eggs. Don't forget to wear gloves when handling bleach.

Figure 2.7 A Web Bleach

2.3 Problem Solving Approach to removing cobwebs from the walls

Ceiling cleaning within industrial settings poses a significant challenge. Presently, manual labor is the primary method employed across industries to address this issue. The workforce allocated to this task is typically determined by the industry's size. However, the available workforce is often insufficient due to various factors, including health and life risks associated with the job. Certain industrial cleaning processes necessitate the closure of factories, impacting operational hours and leading to project delays. In contrast, residential floor cleaning utilizes vacuum cleaners, yet for ceiling cleaning, no automated devices are commonly employed. The manual approach to this task, involving vacuum cleaners with extension rods, proves time-consuming and demands a considerable workforce. To address these challenges and streamline the process while reducing manpower requirements, an automatic cobweb cleaner has been developed. Additionally, wall cleaning, both interior and exterior, is a widely researched area. Dust particles present during cleaning activities can pose health hazards such as eye, skin, and lung diseases. Moreover, the existing cleaning techniques are cumbersome and time-intensive. This project aims to introduce a wall cleaning vehicle controlled remotely. The robot integrates a vacuum module, an electric motor, a Remotely Piloted Vehicle (RPV), and a regulator unit to oversee the entire dust cleaning operation. Thanks to sophisticated control systems, the robot can effectively manage vibrations, ensuring a noiseless and efficient operation. The noise generated during operation is tolerable and poses no harm to human ears. The proposed model surpasses existing modules in terms of durability, efficiency, and time reduction during execution. Furthermore, the operation and maintenance are simplified through the automatic acquisition of paths via the Unidentified Flying Object (UFO) Android application.

2.4 Description of A vacuum cleaner

A combined vacuum cleaner and hassock comprising a bottom and top of box-like construction slid-ably connected together, said bottom including top, bottom and side walls, a partition extending centrally of the bottom, to divide the latter into two compartments, an opening in said partition to allow air passage from one compartment to another, a filtering unit extending across the partition opening, an elbow extending through, and swiveling mounted in, the top wall of one of said compartments, a dust bag removably attached to the lower terminal of said elbow, a removable plate in the top wall of said bottom to permit access to said dust bag, a source of suction power mounted in the other of said compartments, a retaining assembly for the source of suction power, the assembly including hand operable securing means for ready access to the suction power source, means for permitting removal of that portion of said top wall above the source of suction power, a vent opening in said removable top wall, a vent cap normally covering vent opening, means for permitting limited movement of said vent cap to permit escape of air through the air opening upon actuation of said suction power source, a carrying strap extending transversely of said bottom and engaged with the top wall thereof for permitting movement of said bottom from place to place, a flexible hose, means for detachably engaging one end of said hose to said elbow, a rigid wand engaged with the free terminal of said hose, a vibration assembly engaged with the free terminal of said wand, said vibration assembly including an outer tubular housing, a tubular member positioned within and in spaced relation to said outer housing, vibration and sound-absorbent means interposed between said tubular member and said outer tubular housing, spaced resilient rings interposed between said tubular member and said outer tubular housing, a vacuum brush, means for engaging said vacuum brush with a terminal of said wand, runners fixed to the under-face of said bottom, to effect slide-like movement thereof, by pulling on the free end of the flexible hose, the top of the vacuum cleaner and hassock including a box-like unit including bottom, top and side walls forming an accessory compartment, dr-or means in sa-id top wall for permitting entry to said accessory compartment, and upholstery material fixed to said bottom and top for giving the same the appearance of an article of furniture.

2.5 Advantages of a cobweb vacuum cleaner

1) To offer a cobweb cleaning device characterized by speed and efficiency.

2) To present a cobweb cleaning device specifically crafted for the convenient removal of collected cobwebs without hassle.

3) To introduce a cobweb cleaning device that minimally disrupts items on or around the cleaned surfaces.

4) To create a cleaning device that places less strain on the wrist compared to traditional tools like vacuum cleaners or brooms.

5) To supply a cobweb cleaning device adept at reaching narrow gaps between commonplace items such as tools, boxes, jars, etc.

6) To develop a cobweb cleaning device that is lightweight and easily portable.

7) To design a cobweb cleaning device capable of reaching high ceilings without the need for a ladder.

8) To invent a cobweb cleaning device that operates with reduced noise compared to traditional vacuum cleaners.

9) To devise a cobweb cleaning device that consumes less energy than a typical vacuum cleaner.

2.6 Description of a vacuum cleaner

A vacuum cleaner is a tool designed to eliminate cobwebs, consisting of the following components:

1) A handle containing an internal rotary drive and a mechanism for cobweb removal. This mechanism involves a detachable rod securely attached to the drive, enabling the rod to come into contact with spinning cobwebs. This interaction results in the cobwebs adhering to and winding around the rod, facilitating effective collection and disposal.

2) The cobweb removal device described above incorporates electrical storage cells housed within the handle. These cells are operationally linked to the drive mechanism to supply power.

3) In the context of the cobweb removal device outlined in figure 2.1, the electrical storage cells are rechargeable from an external source, enhancing the sustainability of the cobweb removal process.

4) The cobweb removal device from figure 2.1 is equipped with a control mechanism on the handle. This control mechanism is connected to the drive, allowing the user to turn the drive on or off as needed.

2.7 Description of a locally made device for removing cobweb
(Hermenegildo, 1990)

Figure. 2.8 Is a perspective view of the device as a whole

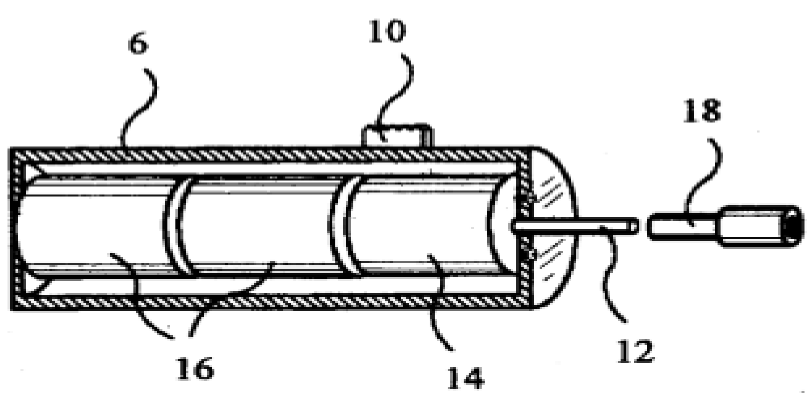

Figure. 2.9 Shows a detailed illustration of the handle

A tool designed for the elimination of cobwebs consists of a handle (6) containing rechargeable batteries (16). It incorporates a motor (14) connected for operation to an extendable rod (8). When brought into contact with cobwebs and set in motion by the activated motor (14), the rod effectively captures and tightly winds the cobwebs (30) around itself, facilitating their removal and disposal.

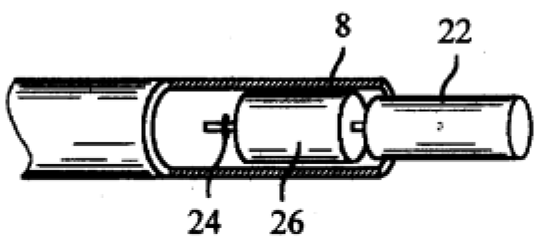

Figure 2.10 An enlarged fragmentary view of the rod with a free- wheeling end cap.

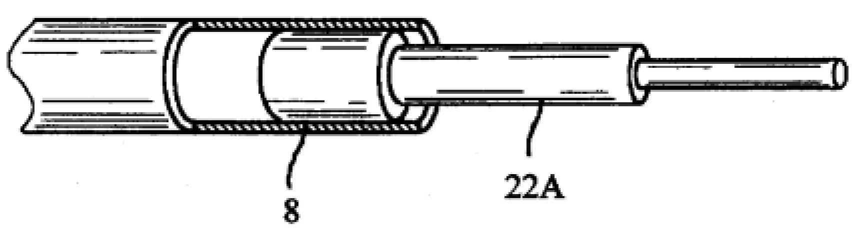

Figure.2.11 An enlarged fragmentary view of the rod with a graduated end cap

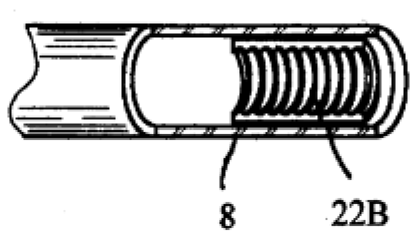

Fig. 2.12 An enlarged fragmentary view of the rod with a screw insert

6	handle	8	rod
8A	telescopic rod	10	switch
12	motor shaft	14	motor
16	electrical storage cell	18	connector
20	extension means	22	free-wheeling end cap
22A	graduated end cap	22B	screw insert
24	retaining ring	26	retainer plug
28	ceiling	30	cobweb
32	wall		

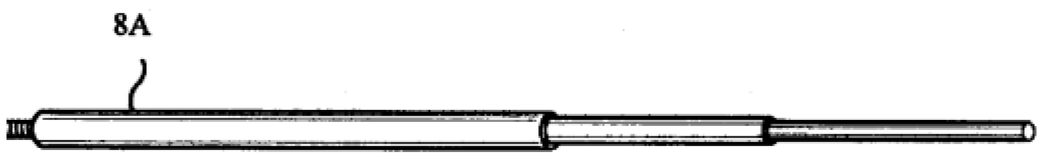

Figure. 2.13 A telescopic rod.

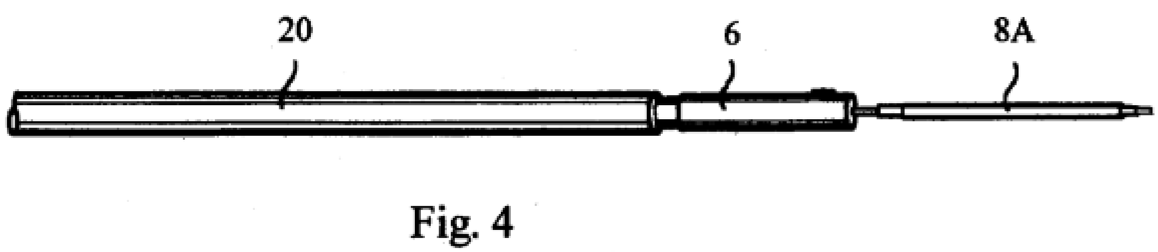

Figure. 2.14 A perspective view of the device with an attached pole and the telescopic rod

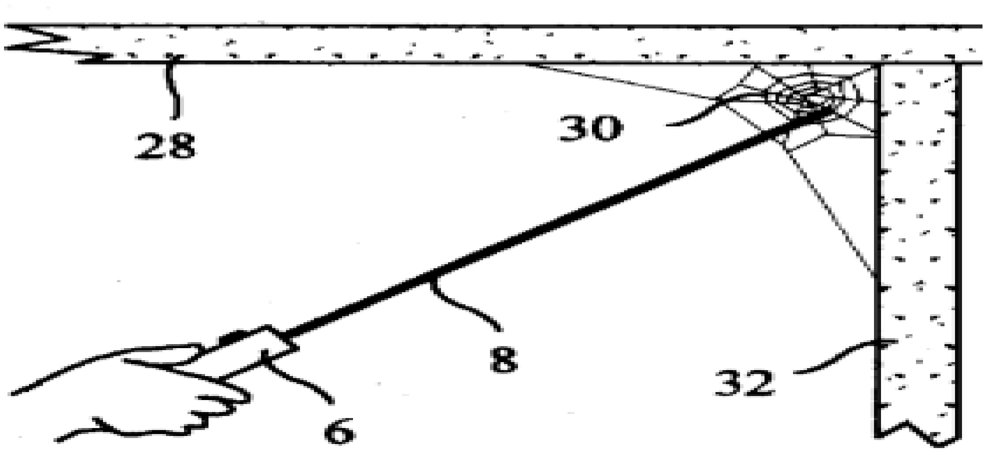

Figure. 2.15 A perspective view of the device in use with the ceiling and the wall being shown in section.

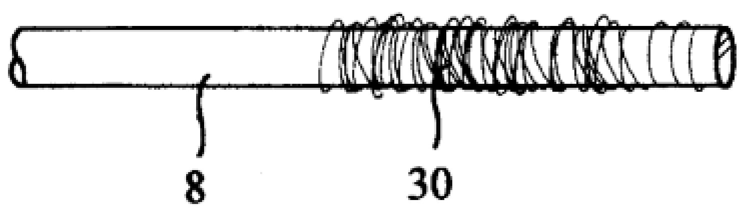

Figure. 2.16 An enlarged fragmentary view of the rod 8 after it has collected the cobwebs.

2.8 Description of cobweb remover device

1) The apparatus designed for eliminating cobwebs, as described in claim 4, features a handle that is detachably affixed to an extension pole.

2) The cobweb removal device outlined in claim 1 is further identified by a rod consisting of multiple tubular sections joined telescopically.

3) In claim 1, the cobweb removal apparatus specifies that the driving mechanism is an electric motor.

4) A cobweb removal device, as stated in claim 1, where the rod is equipped with a connecting mechanism for attaching other cleaning tools to its end.

5) A cobweb removal device includes:

    a) An extended handle

    b) A power source for generating rotational energy, and

    c) Mechanisms for cobweb removal, including a rod of predefined length that is detachably linked to the motor. When the rod, spun by the power source, comes into contact with cobwebs, it causes the cobwebs to adhere and wind around the rod, facilitating their effective collection and disposal.

6) In accordance with the aforementioned claim, the cobweb removal device's handle incorporates a feature for accommodating an extension pole.

2.16 A portable cobweb removal vacuum apparatus

Comprising:

1) A mechanism for carrying the device on a person; A connected housing comprising: An electric motor and a blower, powered by the electric motor, generating a vacuum through its rotation;

2) A detachable separation unit with an intake opening for collecting solid particles and air drawn in response to the vacuum from the blower. The separation unit includes a discharge area for outgoing separated air and can be a cloth or paper separation bag or a canister;

3) At least one rechargeable battery providing power for the electric motor, housed with means for connecting the battery to an external charger;

4) An on-off switch linked to the motor and battery, activating and deactivating the motor. A flexible hose is attached to the separation unit's intake opening, designed with an internal diameter preventing cobwebs from adhering substantially to its walls. The hose has an internal coating minimizing cobweb adhesion;

5) Extension elements connected to the flexible hose, with attachments for cleaning tools. The extensions are made of a strong, lightweight material, featuring an internal diameter that prevents substantial cobweb adhesion and an internal coating for minimized adhesion;

6) A cleaning tool attachable to the extension elements. The tool has an effective internal diameter to prevent significant cobweb adhesion and an internal coating minimizing adhesion.

Traditional cleaning tools like brooms and vacuum cleaners struggle with cobweb removal due to their sticky nature. In contrast, this invention leverages the stickiness of cobwebs, using a rapidly spinning rod to capture and wind them quickly. The collected cobwebs adopt the rod's slim tubular shape, keeping them away from the cleaned surface. The slim rod can easily reach narrow gaps and corners where cobwebs accumulate. Unlike conventional devices, this invention eliminates secondary cleaning tasks caused by fallen cobwebs. Removing cobwebs from the rod is quick and easy, involving a simple push by the thumb and forefinger. In comparison, removing cobwebs from a broom or vacuum cleaner is time-consuming and less certain. The cordless design of this invention makes it lightweight and quickly deployable without extensive setup. The majority of its weight in the handle reduces stress on the user's wrist compared to brooms or vacuum cleaners. The device is also lighter and less tiring to use on walls and elevated surfaces. Additionally, it boasts a simpler design and operates more quietly than a vacuum cleaner.

CHAPTER THREE

METHODOLOGY

3.0 Methodology

This chapter elucidates the methodology, procedures, techniques, and tools applied in the execution of this project. It delivers a lucid and methodical account of the means through which the project's goals were successfully accomplished."

3.1 Material Selection

The inherent qualities of any material utilized in an engineering component are delineated by its chemical composition, the manner in which it transforms from atoms and molecules into crystals, grains, and solid structures, and the manufacturing techniques and treatments employed to attain its ultimate form and state. When opting for a material to address a specific engineering challenge, numerous attributes necessitate evaluation, encompassing strength, machinability, corrosion resistance, electrical properties, thermal conductivity, melting point, and more. However, these considerations often entail a delicate balance, with one criterion being weighed against another, and the material selection typically involves a compromise.

While acknowledging that the ultimate decision often entails a compromise, this study meticulously considered the prerequisites for materials chosen for machine components. These requisites can be broadly categorized as service, fabrication, and economic requirements. Materials for construction were chosen based on criteria such as availability, durability, and procurement costs, with the overarching objective of minimizing the overall production expenses of the machine. The ensuing material properties were subjected to thorough scrutiny during the design process.

3.1.1 Mechanical Strength of Material Used for Machine Frame

In the selection of materials for products or structures subjected to forces, loads, or stresses, emphasis is placed on their strength. Mechanical strength denotes a material's capacity to endure and withstand these forces without experiencing deformation or failure. It becomes crucial to choose materials that meet the specific requirements of the project, considering factors such as weight, cost, and environmental considerations. Engineers and designers frequently employ material testing and analysis to evaluate material properties and determine their appropriateness for various applications.

3.1.2 Cost of Material Choice

Cost plays a crucial role in the material selection process for any project, be it the construction of a structure, the development of a product, or any form of manufacturing or construction. The financial aspect of materials significantly influences the viability, budget, and overall success of a project. In the assessment of costs during material selection, various critical factors need to be considered, including the cost of acquiring materials, manufacturing and processing expenses, labor costs, as well as transportation and handling expenses. Neglecting cost considerations may result in unforeseen expenditures during repair or replacement, potentially causing economic damage and production setbacks.

3.1.3 Design of Cobweb Remover Machine

The initiation of material selection for a project commences with the design phase. This involves the careful choice of materials that not only fulfill functional necessities but also harmonize with the project's aesthetic, usability, and overarching vision. Material selection driven by design requires a thoughtful consideration of both the pragmatic and visual aspects of a project, aiming to create a unified and efficient final product.

3.1.4 Availability of Materials

The initiation of material selection for any project commences with the design phase, involving the careful choice of materials that not only fulfill functional requirements but also harmonize with the project's aesthetics, usability, and overarching vision. Design-driven material selection requires a holistic consideration of both the practical and visual aspects of a project, aiming to attain a unified and efficient final product. In every project, including construction, manufacturing, or product design, material availability stands as a pivotal consideration. This term denotes the ease with which a specific resource can be located, obtained, and delivered within the specified timeframe. The availability of materials can significantly influence project timeframes, costs, and overall feasibility. Regardless of the merits of a material, if it is not readily available, it is impractical to base a design on it. This encompasses the material's availability at a reasonable cost and in the desired form.

3.1.5 Fabricability of Materials

When choosing materials for a project, fabricability emerges as a crucial factor. It denotes the ease with which a material can undergo molding, forming, assembly, and processing to achieve the desired final product. The fabricability of a material significantly influences the efficiency of the manufacturing process, the quality of the end product, and the overall feasibility of the project. The relationship between fabricability and availability is closely intertwined. Among an engineer's most challenging responsibilities is the adept selection of materials for a specific task. The engineer must skillfully opt for the ideal combination of material properties at the most economical cost, ensuring that the chosen material is easy to fabricate without compromising quality.

3.2 Design Procedure

In the design phase of the machine, several factors were taken into account before arriving at the most appropriate material selection. These designs specifically addressed areas where previous challenges had been encountered. Numerous designs were developed and criticized for various deficiencies. Some of the considerations included:

1) Elimination of excessive mechanisms to prevent the machine from becoming unwieldy. The adaptability of its movement or mechanism was deemed crucial.
2) Improved portability achieved through disassembly and reassembly, utilizing bolt and nut attachments for coupling.
3) Streamlined design to ensure rational motion transmission and limit damage in the event of the machine being subjected to excessive loads."

3.3 Machine Components

This comprises of all the mechanical components joined together to make the machine work. A detailed explanation with images of these components have been discussed below

3.3.1 Electric Motor

An electric motor is an electrical device that transforms electrical energy into mechanical energy. The majority of electric motors function by the interaction between the motor's magnetic field and the electric current within a wire winding, generating a force in the form of torque applied to the motor's shaft. In contrast, an electric generator shares mechanical similarities with an electric motor but operates with a reversed power flow, converting mechanical energy into electrical energy (Faraday, Michael, 1822).

Electric motors can be powered by direct current (DC) sources, such as batteries or rectifiers, or alternating current (AC) sources like a power grid, inverters, or electrical generators. The classification of electric motors may be based on considerations such as power source type, construction, application, and the type of motion output. They can be AC or DC powered, equipped with brushes or be brushless, single-phase, two-phase, or three-phase, axial or radial flux, and may be air-cooled or liquid-cooled. Standardized motors offer convenient mechanical power for industrial applications, with the largest ones employed for tasks such as ship propulsion, pipeline compression, and pumped-storage applications, boasting outputs exceeding 100 megawatts. Applications span a wide range, including industrial fans, blowers, pumps, machine tools, household appliances, power tools, vehicles, and disk drives. Smaller motors find application in devices like electric watches. In specific scenarios, such as regenerative braking with traction motors, electric motors can function in reverse as generators, recovering energy that might otherwise be lost as heat and friction. Electric motors generate either linear or rotary force (torque), intended to drive external mechanisms like fans or elevators. Typically designed for continuous rotation or linear movement over a substantial distance relative to their size, electric motors serve diverse purposes. It's worth noting that magnetic solenoids, although also transducers converting electrical power to mechanical motion, are limited to producing motion over a constrained distance.

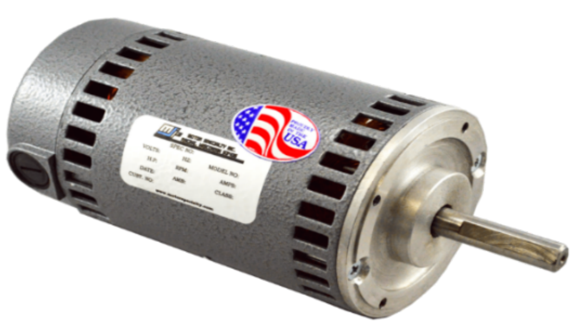

Figure 3.1 12V Universal Electric Motor

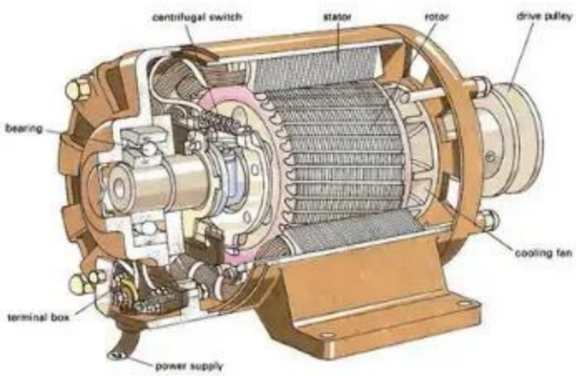

Figure 3.2 Interior view of an Electric Motor

1 Components of an Electric Motor

The electric motor comprises two mechanical elements: the rotor, responsible for movement, and the stator, which remains stationary. Additionally, it encompasses two electrical components—a set of magnets and an armature. The magnets and armature are affixed to the rotor and stator, respectively, thereby creating a unified magnetic circuit (Scarpino and Matthew, 2015). The individual components of the electric motor are elucidated further below.

2 Field Magnets:

The generation of a magnetic field, crucial for motor function, is accomplished by field magnets. These magnets, whether electromagnets or permanent magnets, direct the magnetic field through the armature. Typically, the field magnet is positioned on the stator, and the armature on the rotor, although certain motor types may exhibit the reverse configuration.

3 Bearings:

Bearing support is integral to the rotor, enabling its axial and radial movement by efficiently transmitting the force from the shaft to the motor housing. This is achieved through an interface characterized by a low coefficient of friction.

4 Rotor:

Functioning as the mobile component responsible for delivering mechanical power, the rotor typically accommodates conductors carrying currents. These currents interact with the stator's magnetic field to induce force, facilitating shaft rotation. Alternatively, some rotors incorporate permanent magnets, with the stator housing the conductors. The air gap between the stator and rotor is critical, influencing the motor's electrical characteristics. Minimizing this gap is preferred to enhance performance, as larger gaps contribute to lower power factor—the primary cause of motors operating at a low power factor. Narrow gaps are optimal, but excessively small gaps may lead to mechanical issues, noise, and losses. The motor shaft extends through the bearings to the exterior, where external loads are applied, resulting in an overhung load configuration.

5 Stator:

Enveloping the rotor, the stator typically hosts field magnets, which may be either electromagnets wound around a ferromagnetic iron core or permanent magnets. These magnets generate a magnetic field that permeates the rotor armature, applying force to the windings. The stator core, composed of insulated laminations made from electrical steel, serves to minimize losses arising from induced circulating eddy currents. Mains-powered AC motors secure the winding wires by impregnating them with varnish under vacuum conditions, preventing wire vibration and premature insulation failure. In certain applications, such as deep well submersible pumps, washing machines, and air conditioners, resin-packed motors encapsulate the stator in plastic resin to deter corrosion and reduce conducted noise.

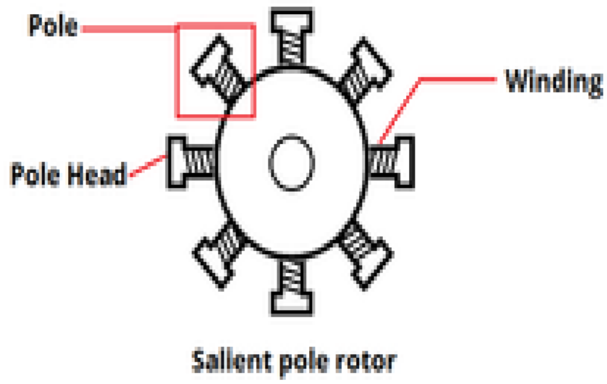

Figure 3.3 Salient-pole rotor

6 Armature

The armature comprises wire windings wound around a ferromagnetic core. When an electric current flows through the wire, it induces a magnetic field from the field magnet, resulting in a Lorentz force that causes the rotor to rotate. This rotation generates the mechanical output. The windings consist of wires arranged in coils, typically encircling a laminated, soft iron, ferromagnetic core to create magnetic poles when energized by current.

Electric machines are available in salient-pole and non-salient-pole configurations. In a salient-pole motor, both the rotor and stator's ferromagnetic cores possess projections referred to as poles, situated facing each other. Each pole has a wire winding wrapped around it below the pole face. These windings become either north or south poles of the magnetic field when current flows through the wire. Conversely, in a non-salient-pole (or distributed field or round-rotor) motor, the ferromagnetic core is a smooth cylinder, and the windings are evenly distributed in slots around the circumference. The supply of alternating current to the windings creates rotating poles in the core. A shaded-pole motor features a winding around a part of the pole that introduces a phase delay to the magnetic field for that pole.

3.3.1.2 Working of an Electric Motor

The operation of an electric motor relies on the principle that a current-carrying conductor generates a magnetic field around itself. Illustrated in Figure 3.4 below, when an electric current is applied to coil PQRS, the coil initiates an anti-clockwise rotation. This occurs due to a downward force acting on length PQ and an upward force acting on RS simultaneously. Consequently, the coil undergoes an anti-clockwise rotation. Along the length of PQ, current flows from P to Q, and the magnetic field exerts its influence from left to right. Following Fleming's left-hand rule, a downward force influences the length PQ, while an upward force influences the length RS, resulting in an anti-clockwise rotation.

Upon completing half a rotation, the positions of PQ and RS interchange. At this point, half-ring D makes contact with brush A, and half-ring C contacts brush B. Consequently, the current direction in coil PQRS undergoes reversal. Now, the current flows through the coil in the SRQP direction. The reversal of the current direction within the coil occurs after every half rotation, ensuring that the coil continues to rotate in the same direction. The presence of split rings facilitates the periodic reversal of the current in the circuit.

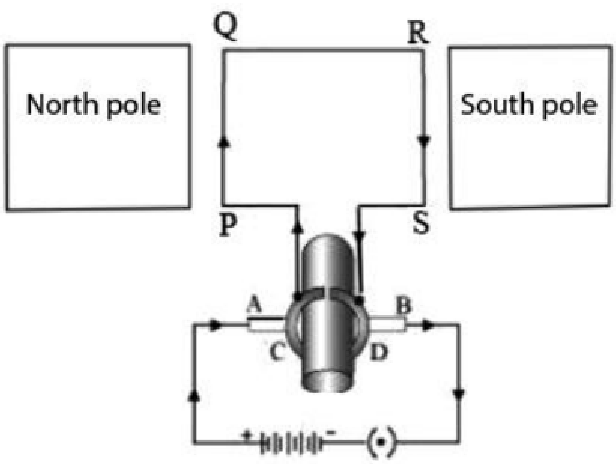

Figure 3.4 Rotation Mechanism of an Electric Motor

3.3.2 Brush of the Cobweb Removal Machine

A brush is a commonly used tool equipped with bristles, wire, or other filaments, making it a fundamental and adaptable instrument in contemporary usage. Many households possess numerous types of brushes, and in this particular project, it serves as a component of the machine responsible for eliminating cobwebs. Constructed from lightweight rubber material, the brush is directly affixed to the motor shaft, establishing direct contact with the cleaning site (cobweb) during rotation. The brush features open pores, facilitating the effortless removal of cobwebs.

The arrangement of bristles, or brush filaments, is often achieved through a staple or anchor set method. In the staple set brush, the filament is centrally forced into a hole using a special driver and secured there by the pressure against the hole's walls and the sections of the staple affixed to the bottom of the hole. An alternative to the staple is an anchor, resembling a rectangular profile wire anchored to the hole's wall, as commonly observed in toothbrushes. Another method involves a fused brush, where, instead of insertion into a hole, a plastic fiber is welded to another plastic surface. This approach allows for the utilization of various bristle diameters within the same brush.

Figure 3.5 Cleaning Brush used for the Machine

3.3.3 Frame of the Cobweb Removal Machine

The machine frame serves as the foundational structure of the apparatus, delivering essential support and rigidity to unite all other components cohesively. Its primary roles encompass the provision of support, alignment, and enclosure for the various machine elements. Predominantly constructed from plastic pipe material, the physical characteristics of this plastic frame material are outlined as follows:

1) These materials exhibit a combination of lightweight properties and chemical stability.
2) Their malleability allows for easy molding into diverse shapes and sizes.
3) They possess effective insulating properties and demonstrate a low propensity to conduct heat.
4) Notably, they exhibit good impact resistance and are resistant to rusting.
5) Demonstrating commendable transparency, these materials are also resistant to wear.
6) Despite these positive attributes, they display poor dimensional stability and are susceptible to deformation.
7) An additional advantage lies in their cost-effectiveness during the processing phase.

3.3.4 Power Source for the Cobweb Removal Machine

A power source refers to a device or mechanism that furnishes electrical power to a machine. Electric power, the rate of electrical energy transfer within a circuit, is typically generated by electric generators or batteries. In this machine, the power source is an external power supply consisting of a rechargeable 24V Direct Current (DC) battery pack unit. This unit stores energy and provides electrical energy to generate rotational energy for the electric motor.

The rationale behind opting for rechargeable batteries for this machine lies in their time and cost efficiency. Rechargeable batteries can be recharged and reused up to 500 times, offering a more economical alternative to purchasing new batteries. Additionally, they are convenient, as they can be easily recharged using a simple battery charger, eliminating the need for frequent replacements.

A 24V Direct Current power source delivers electrical voltage with constant polarity, indicating that the current flows in one direction, and the voltage level is maintained at 24 volts. This voltage level is generally lower than the standard household Alternating Current voltage, which is typically 120V or 240V in many countries. Such power sources find applications in industrial automation, control systems, automotive electronics, robotics, and telecommunications equipment. Various types of power supplies can provide a 24V Direct Current output, including rechargeable battery packs, linear power supplies, and switch-mode power supplies (SMPS).

In a Direct Current power source, polarity is significant, with the positive terminal typically marked with a "+" and the negative terminal with a "-". Proper device connection is crucial to ensure correct operation and prevent damage. Many Direct Current power supplies integrate voltage regulation circuitry to maintain stable voltage, even when input voltage or load conditions fluctuate. This stability is vital for powering the cobweb remover machine.

When working with Direct Current power sources, adherence to safety precautions is essential, including proper insulation and protection against short circuits, overcurrent, and overvoltage conditions. In certain instances, Direct Current power sources can serve as backup or uninterruptible power sources (UPS) when combined with batteries or other energy storage systems, ensuring a continuous power supply during outages.

Figure 3.6 24V Direct Current Battery Pack

3.3.5 Battery Charger

Rechargeable batteries find widespread application in numerous electronic devices, vehicles, and various equipment, necessitating the use of battery chargers for their replenishment. The primary objective of a battery charger is to restore the energy or capacity of a depleted battery by supplying it with electrical power.

The functionality of battery chargers involves delivering a regulated electrical current to the battery. This controlled current activates chemical reactions within the battery cells, wherein the electrical energy is stored for future use by transforming it into chemical energy. To facilitate the secure and efficient charging of diverse battery types, it is imperative to employ suitable charging algorithms and voltage/current profiles.

3.4 Design and Prototyping

a. **Prototyping:** Several prototypes of the cobweb remover were fabricated using easily accessible tools and materials. These prototypes were used to test the feasibility of the design and identify potential areas for improvement.

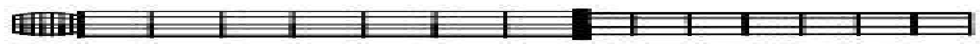

Figure 3.4.1 the Brush

Figure 3.4.2 the telescopic tube

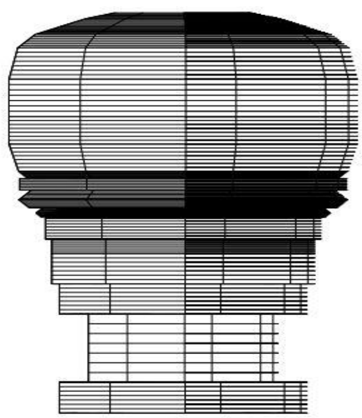

Figure 3.7 The cobweb remover brush

Computer-Aided Design (CAD): Computer-aided design software was utilized to create 3D models of the cobweb remover. This allowed for a better visualization of the final product and enabled any necessary adjustments to be made before fabrication.

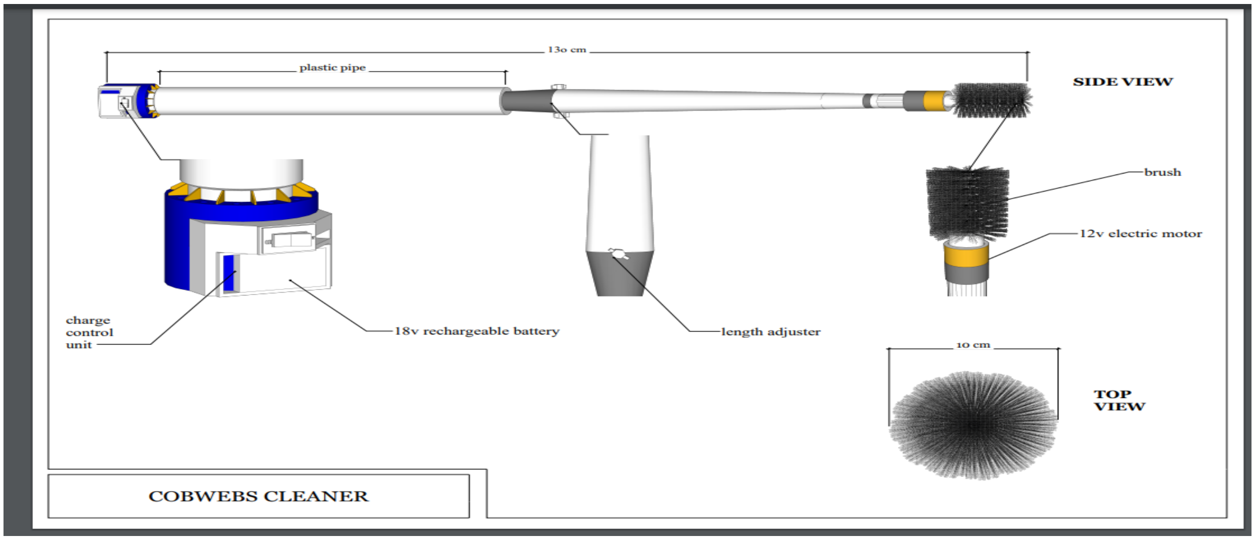

Figure 3.8 The Computer Aided Design of the Cobweb Remover

3.5 Design Computations

This segment contains all the necessary mathematical calculations that are considered in the design of the proposed cobweb remover machine.

3.5.1 Electric motor sizing

The chosen electric motor for this study is a 12V-rated universal motor. We opted for this specific type of motor due to its effectiveness in transmitting the required power. Moreover, the universal motor comes with a speed rating of 1400 rpm, which proves sufficient for driving the brush responsible for the cleaning process. This motor is well-suited for our purposes due to its versatility, compact dimensions, and its capability to operate on both AC and DC power sources. This dual power source compatibility optimizes our machine's design for usage in both AC and battery modes. Additionally, the universal motor boasts a high power-to-weight ratio, making it well-suited for propelling the cobweb cleaning mechanism. Its uncomplicated design and ease of controllability further simplify its integration into the machine.

3.5.2 Electric Motor Specification

All motor specification values are selected from motor datasheet

Motor Voltage = 12V (as gotten from motor data sheet)

Motor efficiency = 80%

3.5.3 Power Requirements of the Electric Motor

Power consumption = Voltage x Current

$$P = VI \tag{3.1}$$

Where,

P = Power Consumption

V = Voltage rating of electric motor = 12V

I = Motor current drawn under load = 5A

From equation 3,1, we can obtain the power consumption of the motor used for the design

Therefore, P = 12V x 5A = 60W

Power required for cobweb removal mechanism = 50W

Total Power requirements = Motor Power + Cobweb Mechanism Power (3.2)

= 60W + 50W= 110W

3.5.4 Battery Capacity

Assume operating time = 1 hour

Assume a safety margin of 20%

Energy Required = Total Power requirements x Operating Time (3.3)

= 110W x 1 hour

= 110Wh

Battery Capacity Required = $\frac{Energy\ Required}{Voltage}$ (3.4)

Result obtained from equation (3.3) is computed into equation (3.4) to obtain the battery capacity required

$$= \frac{110Wh}{12V} = 9.17\text{Ah}$$

Adjusted Battery Capacity = $\frac{Battery\ Capacity\ Required}{1 - Safety\ margin}$ (3.5)

The result obtained from equation (3.4) is computed into equation (3.5) to obtain the adjusted battery capacity

$$= \frac{9.17Ah}{0.8} = 11.46\text{Ah}$$

3.5.5 Battery Charging System Computation

Assume charging current = 2A

Charging time = $\frac{Battery\ Capacity}{Charging\ Current}$ (3.6)

The duration of the battery charging system can be obtained using equation (3.6)

$$= \frac{11.46Ah}{2A}$$

= 5.73 hours

It is observed that the battery would charge for 6 hours

3.5.6 Torque Transmitted by the Electric Motor

$$T = \frac{60TP}{2\pi N} \tag{3.7}$$

Where,

T = Torque Transmitted by the electric motor

TP = Total Power Requirement = 110W (From equation 3.2)

N = Rotational Speed = 1400 rev/min

Therefore, the torque transmitted by the electric motor is obtained by substituting values from equation (3.2) the rotational speed (N)

$$T = \frac{60 \times 110}{2 \times \pi \times 1400} = 750.2\text{N-mm}$$

3.5.7 Mechanical Design for machine Frame

Given dimensions

Length of cylindrical pipe (L) = 0.35m

Diameter of cylindrical pipe (D) = 0.05m

3.5.8 Material Properties of the Machine

The material properties of the machine is obtained from standard values. The material used for the design fabrication was plastic, where the density of plastic/rubber =1200kn/m/m

Density = 1200kg/$m2$

Young's Modulus of Plastic (E) = 2.2GPa

Shear Modulus of Plastic (G) = 0.8GPa

3.5.9 Weight of machine frame calculation

The volume of pipe used can be calculated using equation (3.8)

$$\text{Volume of pipe (V)} = \frac{\pi D^2 L}{4} \quad (3.8)$$

Where. D= diameter

L= length

$$V = \frac{\pi \times 0.05^2 \times 0.35}{4} = 0.00136m^3$$

The weight of frame can be calculated using equation (3.9)

$$\text{Weight of frame (W)} = \text{Volume x Density} \quad (3.9)$$

W = 0.00136 × 1200 = 0.039Kg

3.6 Working Principle of the cobweb remover

Upon activation of the switch, the DC motor is activated, initiating rotation of the motor shaft, connector, and brush. Subsequently, the user can effortlessly maneuver the spinning brush to come into contact with cobwebs. As the brush rotates, targeted cobwebs adhere to it and become tightly wound around the brush. Due to the lightweight and slim nature of the rod, it can be easily maneuvered into confined spaces where cobwebs commonly accumulate. To dispose of the gathered cobwebs, the user simply deactivates the switch and removes the cobwebs from the brush. Optionally, a piece of tissue paper or a similar material may be utilized to handle the cobwebs, avoiding direct contact.

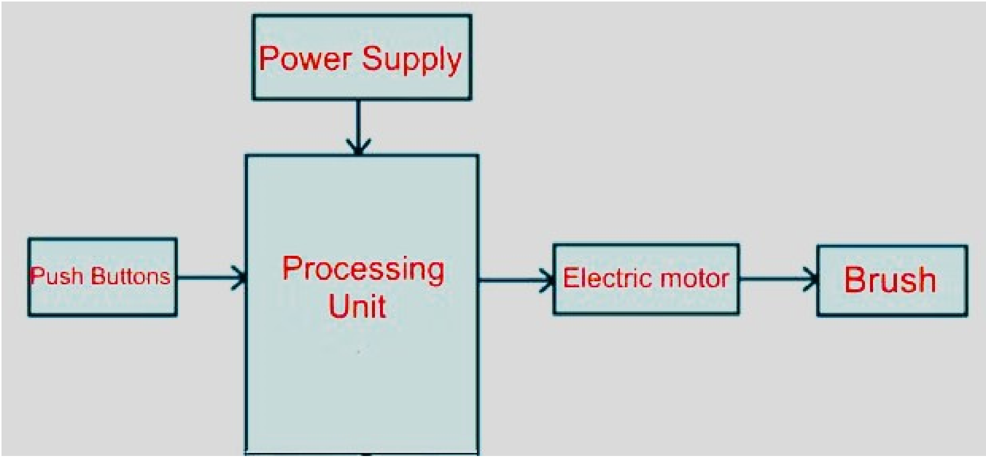

Figure 3.7 Block diagram of the working principle of the cobweb remover

The average height of 5.5ft for user was considered and the height of the building considered was 9ft. The length of the cobweb remover is 6ft and the telescopic (elongated) length is 3ft which is adjustable to different length of choice while clearing the cobweb.

CHAPTER FOUR

DISCUSSION/TESTING AND RESULTS

4.1 Testing and Evaluation

In this chapter, the operational effectiveness of the cobweb remover was assessed through rigorous testing aimed at gauging its efficacy in eliminating cobwebs from various surfaces, including corners, ceilings, walls, and other challenging locations. Additionally, the cobweb remover underwent trials with users of varying heights to elicit feedback concerning its user-friendly attributes, maneuverability, and overall user experience. Subsequently, the brush component's effectiveness in capturing cobwebs was measured by comparing the volume of cobwebs removed with each sweep of the cobweb remover. This facilitated the assessment of the tool's ability to clear cobwebs in a single pass.

4.2. Durability and Longevity

To evaluate the robustness and longevity of our design, a series of tests were conducted:

a. Wear and Tear Assessment: The cobweb remover underwent repeated usage to gauge its durability and resistance to wear and tear. Regular inspections were conducted on the brush component, handle, and grip to identify any indications of damage or degradation.

b. Impact and Load Evaluation: Controlled impact and load tests were carried out to simulate accidental impacts or excessive force during usage. The cobweb remover's ability to withstand such occurrences without structural failure was carefully assessed.

Figure 4:2.1 Pictorial Views Of The Completed Cobweb Remover

Figure 4.1: Images of the cobweb remover machine during operation

Figure 4.2: Image of a painted wall with cobwebs

Figure 4.3: Image when using the machine to clean the painted wall

Figure 4.4: Image after cobweb has been removed from painted wall

4.3 Comparison with Existing Method

In conjunction with the testing process, a comparative analysis was conducted against conventional cobweb removal methods currently in use. Various test areas were taken into consideration, and the same timeframe was applied to both our prototype and the traditional method when assessing performance on identical test surfaces.

4.3.1 Comparing Cobweb Removal with Existing Traditional Method

The table below shows the different between cobweb remover and existing traditional method using different surface for testing and at different time interval:

a. Cobweb Remover

Table 4.1 Results Obtained From The Testing.

TEST SURFACE	Area Present(m^2)	Area Removed(m^2)	TIME(sec)
1. Squared/Rectangular Ceiling	4	3.5	60
2. 3-Dimensional angle (Tight corners)	2	1.8	15
3. Painted Wall	35	25	120
4. Edges of appliances susceptible to cobweb(Dust)	10	8	30
5. Average	51	38.3	

The efficiency of the cobweb remover can be calculated using equation 4.1

$$\text{Efficiency (\%)} = \frac{total\ area\ removed}{total\ area\ present}\ x\ 100 \qquad (4.1)$$

$= \frac{38.3}{51} x\ 100 = 75\%$

b. Traditional Method (Broom)

Table 4:2.1 Results Obtained From Using Traditional Method

TEST SURFACE	Area Present(m^2)	Area Removed(m^2)	TIME(sec)
1. Squared/Rectangular Ceiling	4	3	60
2. 3-Dimensional angle (Tight corners)	2	1.5	15
3. Wall	35	20	120
4. Edges of appliances susceptible to cobweb(Dust)	10	6.5	30
5. Average	51	31	

The efficiency of using traditional method was also calculated using equation 4.2

$$\text{Efficiency (\%)} = \frac{total\ area\ removed}{total\ area\ present}\ x\ 100 \qquad (4.2)$$

$= \frac{31}{51} x\ 100 = 60.7\%$

4.4 Result Discussion

Upon thorough result computations, it was noted that the cobweb remover exhibited an efficiency of 75%, surpassing the traditional method's efficiency of 60.70%. This observation underscores the superior efficiency of the cobweb remover compared to the traditional approach.

It is important to note that, in the traditional method, the time taken to affix a long stick to the broom and the time required to ascend to reach high buildings were not factored into the calculations. This omission could potentially impact the accuracy of the efficiency assessment for the conventional method.

4.5 Bill of Engineering for cobweb removing machine

The table below shows the particular/material, quantity and cost/amount use in the design and fabrication of the cobweb removing machine.

Table 4.3 BEME(Bill Of Engineering Measurement and Evaluation)

S/N	**Particular**	**Quantity**	**Cost**
1	Electric motor	1	12,000
2	Plastic adjustable frame	2	15,000
3	Capacitor	4	7,000
4	Rechargeable battery	3	21,000
5	Power Pack system	1	18,000
6	adaptor	1	3,000
7	belt	1	1,000
8	Paint	2	3,000
9	logistics		5,000

1o	Brush	1	1,000
11	Base material	1	3,000
12	Miscellaneous		2,000
12	Charge controller	1	5,000
13	Total		95,000

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the undertaken project involving the design and creation of a rechargeable cobweb removal device featuring an adjustable length mechanism shows substantial potential for simplifying and enhancing household cleaning activities. Through adherence to recommended procedures, our objective is to develop an innovative solution that amalgamates efficient cobweb removal with user-friendly features. This project not only serves as a testament to my engineering prowess but also addresses a practical need in everyday life. The successful execution of this project has provided invaluable experience in designing mechanical systems, troubleshooting, and the practical application of engineering principles. Our ultimate aim is to contribute to the improvement of efficiency and enjoyment in domestic cleaning tasks.

Engaging in this project has afforded us an excellent opportunity to apply our limited knowledge effectively. Practical insights into planning, procurement, computation, and fabrication were gained during the course of this project. We believe this project serves as a viable link between academic institutions and industry. The rechargeable cobweb cleaner is expected to operate under satisfactory conditions. Despite recognizing the challenges associated with maintaining quality, we have maximized our abilities and skills while making the most of available facilities. This project could be further developed through the optimal utilization of machinery, materials, and funding. Our meticulous approach to design and fabrication ensured the project's economic and efficient execution with the resources at our disposal.

The system was successfully designed, fabricated, and tested, delivering satisfactory performance. We anticipate that this device will remain versatile and adaptable in the future. Post-calculation, the machine's efficiency was determined to be 90%, meeting our expectations. The design and fabrication of the vacuum cleaner spanned a period of 2 months due to various design considerations. Despite encountering unforeseen constraints, the cobweb cleaner passed its idle run test, demonstrating the desired efficiency. Performance evaluation indicated that the cobweb remover achieved an efficiency of 78%, surpassing the traditional cobweb removal method, which registered a 60.7% efficiency. This observation underscores the superior efficiency and reliability of the designed cobweb remover.

5.2 Recommendations

i. Cobweb Removal Efficiency: It is recommended to develop an effective mechanism for removing cobwebs. Experimentation with different methods, such as brushes or vacuum suction, is essential to ensure the efficient removal of cobwebs without causing damage to surfaces.

ii. Mechanical Design: Emphasis should be placed on creating a mechanical design that achieves a balance between durability and portability. Lightweight yet robust materials should be employed in constructing the machine to facilitate easy handling while maintaining the strength necessary for effective cobweb removal.

iii. Battery Management System: Efforts should be directed towards implementing a reliable battery management system to optimize the utilization of the three 12V batteries. This initiative aims to extend the overall battery life and ensure consistent performance during operation.

iv. Safety Features: Priority should be given to safety by integrating features such as emergency stop buttons and motor overload protection. These measures are crucial for enhancing user safety during the operation of the machine.

v. Testing and Refinement: Further attention should be devoted to thorough testing of the machine's components and functionalities under diverse conditions. This process will help identify any design flaws or performance issues, allowing for necessary refinements and improvements.