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Design and Development of Multipurpose Cleaning Machine

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ABSTRACT
Multipurpose floor cleaning, grass cutting, and vacuum cleaning are essential indoor and outdoor activities that require specialized equipment. These activities can be time-consuming and physically demanding, but with the right tools, they can be completed quickly and efficiently. The purpose of this project is to developed effective and innovative multipurpose equipment available for floor cleaning, grass cutting, and vacuum cleaning. Multipurpose floor cleaning requires equipment that can effectively remove dirt and stains from surfaces that can be done by a rotating floor mop. The rotating mop is used to agitate and lift dirt and stains from hard surfaces. As water tank and the nozzle are inter connected to each other and available for sprinkling of water on floor through nozzle so that the mop further clean the surfaces. The Design and Development of Multipurpose cleaning machine is not only applicable cleaning the floor but also applicable for cutting the grass from garden or lawn and it is develop for indoor and outdoor activities. for that a grass cutting blade installed at the front of the project assemble which efficiently cut the grass from the lawn. In this project we have installed and developed vacuum cleaner which applicable to collect the dust and trash from the floor and wall surfaceses. Bluetooth technology is used in this project is help to operate the system remotely using RC controller.

Keywords : *Vacuum Cleaner, Grass Cutting, Mopping*

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I. INTRODUCTION

The design and development of a multipurpose floor cleaning, grass cutting, and vacuum cleaning machine is an innovative solution to the problem of maintaining different household surfaces. This machine is designed for cleaning and maintaining of households, commercial spaces, The idea behind this machine is to create a versatile system that can perform multiple functions without compromising on its efficiency and effective performance. The machine is equipped with various attachments that can be easily suit different cleaning requirements. The machine comes with interchangeable attachments for cleaning floors, cutting grass, and vacuuming. The floor cleaning attachment has a rotating mopes that effectively cleans different types of flooring, including tiles, and hardwood floors. The grass-cutting attachment has sharp blades that can trim grass to a uniform length, while the vacuum attachment can suck up dirt from different surfaces. This machine has a grass-cutting feature that allows it to cut grass and other vegetation on lawns and gardens. With this feature, the machine can be used for both indoor and outdoor cleaning tasks, making it a valuable machine for homeowners and businesses alike. A multipurpose cleaning machine is a versatile system that can be used to clean a wide rang surfaces and areas. Whether you need to clean floors, walls, carpets or hard-to-reach areas, a multipurpose cleaning machine can help you get the job done quickly and effectively.

In addition to its versatility, a good multipurpose cleaning machine should also be efficient, sustainable, safe, durable, easy to use, and cost-effective. By choosing a high-quality cleaning machine that can save time and effort while achieving excellent cleaning results.

A comprehensive literature survey has been carried out in order to locate and investigate the research gap, which is going to be covered in the following chapter. The aim and objectives of this research work have been formulated and will be explained in the following section. These have been determined based on the research gaps that have been identified.

II. METHODLOGY

The design and development of a multipurpose cleaning machine involves several stages of methodology. The following is a general outline of the steps involved.

1. **Define the Problem:** The first step is to define the problem and the requirements of the cleaning machine. This involves identifying the types of surfaces to be cleaned, the type of contaminants to be removed, and the desired cleaning effectiveness.
2. **Research:** Once the problem is defined, research should be conducted on existing cleaning machines and their features. This will help in identifying the strengths and weaknesses of current machines and finding ways to improve upon them.
3. **Conceptual Design and Systematic Implementation:** Based on the research, a conceptual design should be developed that outlines the basic features of the cleaning machine, which includes the cleaning mechanism, and various elements such as mopes, water sprinkling nozzle, vacuum cleaner equipment, grass cutter, Aurdino Nano micro-controller which help to control the machine with the help of a Bluetooth module and the battery power source which provide actuation to the entire system.. all the components involved in this project is systematically arrange over the chassis design in order to effective functioning.
4. **Prototype Development:** With the detailed design in place, a prototype is built to test the functionality and effectiveness of the machine. This involves building a physical model of the machine and testing it under different conditions.
5. **Testing:** After completing the design and assembly we have tested this project by considering the various actual parameters for its proper and effective functioning and performance. Prototype is built, it should be tested and evaluated for its performance, reliability. This involves running the machine under different conditions and measuring its cleaning effectiveness and durability.

III. Components Description

1. DC Motor :

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. A DC motor is a mechanically commutated electric motor powered from direct current (DC). The current in the rotor is switched by the commutate to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees, which generates the maximum torque. DC motors have a rotating armature winding (winding in which a voltage is induced) but non-rotating armature magnetic field and a static field winding (winding that produce the main magnetic flux) or permanent magnet.

Different connections of the field and armature winding provide different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current. Modern DC motors are often controlled by power electronics current and the torque produced by the motor is 12V, 60RPM.

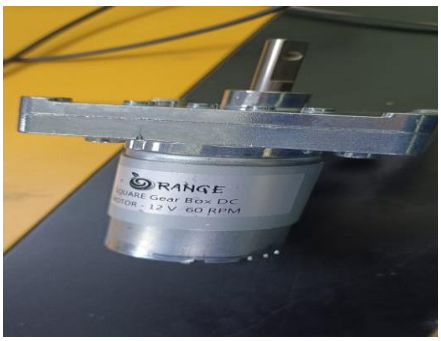

Figure 1: DC Motor

The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems called DC drives.

2. Battery

Figure 2: Battery

A lithium-ion batteryis a type of rechargeable battery composed of cells in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge and back when charging. Li-ion cells use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. Li-ion batteries have a high energy density, no memory effect (other than LFP cells) and low self- discharge. Cells can be manufactured to prioritize either energy or power density. They can however be a safety hazard since they contain flammable electrolytes and if damaged or incorrectly charged can lead to explosions and fires.

The battery is of 12V which we are using in our multi-functional cleaning machine. Research areas for lithium-ion batteries include extending lifetime, increasing energy density, improving safety, reducing cost, and increasing charging speed, among others. Research has been under way in the area of non-flammable electrolytes as a pathway to increased safety based on the flammability and volatility of the organic solvents used in the typical electrolyte. Strategies include aqueous lithium-ion batteries, ceramic solid electrolytes, polymer electrolytes, ionic liquids, and heavily fluorinated systems.

3. Water Nozzle :

Figure 3: Water Nozzle

A water nozzle is a device used to control and direct the flow of water. It typically consists of a handle a nozzle head that determines the shape and intensity of the water stream. The working of a water nozzle can vary depending on its design and purpose,

4. Spray Pump :

Figure 4: Spray Pump

A spray pump, also known as a pressure sprayer or hand pump sprayer, is a device used to create pressure and disperse liquid in the form of a fine spray. It is commonly used for various applications such as gardening, pest control, cleaning, and applying chemicals. The pump is made of high-quality engineering plastic that is corrosion-resistant and has thermal overload protection, built-in pressure switch, and self-priming function. The pump has a noise level of less than 70 decibels . It is suitable for spraying pesticides, herbicides, fertilizers, and other chemicals in agricultural, horticultural, and lawn care applications.

5. Mopes :

Material of the mope head is typically made of the absorber material arrival such as cotton micro fiber and synthetic fiber and size of the mopes head can vary. Diameter of mope is 10 cm and Rotation speed is 60 rpm (or adjustable within a certain range Material durable and lightweight plastic or metal Mop head made of microfiber or other absorbent material that can effectively clean floors and surfaces

Figure 5: Mopes

6. Vacuum Cleaner

Figure 6 : Vacuum Cleaner

A vacuum Cleaner is 12 volt DC outlet (Cigarette lighter socket) the suction power of vacuum cleaner determine the cleaning effectiveness it have efficient suction power to pick up the dirt, dust, of floor and carpets and floor mats a vacuum cleaner have a filtration system to trap and remain dust particles.

The filter are considered highly efficient and capturing small particles .the noise level of the vacuum cleaner is being quitter the vacuum cleaner with easily accessible power control that allow us to adjust the speed of the suction power as needed .

7. Wheels The material used for wheels is rubber and plastic and the dimensions are 4cm and we use two wheels and one rolling wheel, the load carrying capacity is maximum is up to 12 kg and bearing of wheel is help to reduce friction and make them easier to move. The locking mechanism are used to prevent them from rolling when not in used. This is useful for equipment that needs to kept stationary.

Figure 7: Wheels (a)

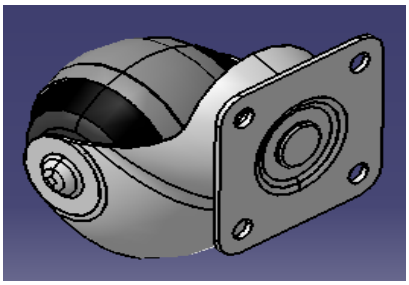

Figure 7: Wheels (b)

8. Frame:

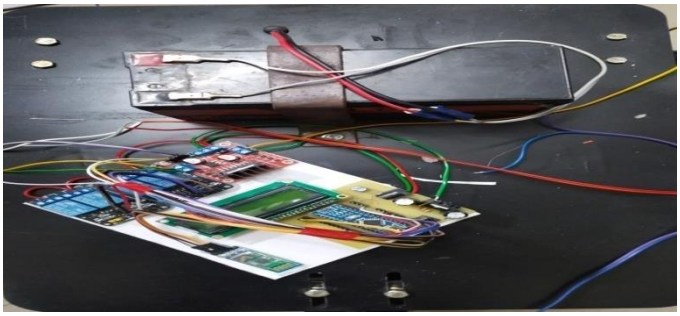

Figure 8: Frame

The frame is made up of mild steel material , and the dimension of the plate is 30 to 40 inch and thickness varies from 1/8 inch depending on the load carrying capacity required . The weight is range from 3kg depending upon the thickness and size.

IV. Design and Calculations

1. Grass Cutter Calculations :

Long Flat / Straight flat bar Making, Craft, T316
Overall Dimensions: Long 24.7cm * Breadth 1.8 cm * Thick 0.01cm
Made By Material Stainless Steel Material
Speed: 60 RPM
Coefficient of friction of Grass = 0.35
Weight – 125 Gm. = 125/1000 = 0.125 Kg
Current- 0.2A
Operating Voltage: 12 V

a) Force required by cutting blade to shear the grass is given by;

$F = T/R$….(1) Where,

$F=60/9= 6.6$ N

T = Shaft torque

R = Radius of cutting blade But shaft torque is given by;

$T = P/2\pi N$ … (2)

$60=P/2\pi 1000 =16W$

b) Electrical Power is given by;

$P = I * V$ …

$P=8*12= 96W$

c) Torque of motor is given by;

$P= 2\Pi NT / 60$ …

$P=62.83W$

d) $T= (P*60) / (2\Pi N)$

$T= 0.9167Nm$

i.e. Torque = 916.7Nmm

2. DC Motor

DC Motor Attached to the system e.g. L-Type, Grass Cutting and Mopping Motor.
L-Type Motor : 12V,
Speed = 60RPM,
T = 8 Kg = 8 * 9.81 = 78.48 N
Shaft Diameter – 6cm
Weight – 125 Gm = 125/1000 = 0.125 Kg
Current -0.2A
Operating Voltage: 12V
Motor Drive – L298 using for Drive the DC Motor

3.Spray Pump and Water Nozzle
Pump Type – Diaphragm Pump
Pressure of Spray Pump, P = 30 * 10^5 Pa
Voltage = 12V
Pressure= Flow Rate /Nozzle area
= 30/ 6.2
P = 4.83 Pascal

4. **Battery**

Voltage 12 V
Current 7 Amp.
Power is generated by Battery, P = V * I
P = 12 * 8
P = 96W

5. Mopes Calculations

Mopes Voltage = 12V ,
Load = 10 Kg
Torque – 1.5 * 9.81 =14.71 N
Coefficient of Friction = 0.8
Mopping Motor : 12V,
Speed = 60RPM,
T =1.5 Kg
Force, F = 0.35*10*9.81
F = 34.33 N
Torque T = F * R
T = 34.33 * 0.20
T = 6.86 Nm
Torque Requirement T = 6.86 Nm
Both are rotates at Clockwise Direction with the help B.T. Module
B. T. Module HC – 05 using Arduino Nano Software
Mopes are adjusting 45 degree inclined at an angle both the sides.

6. Chassis Calculations

C = 2*9.81 = 19.62 N

D = 10*9.81 = 98.1 N

B = 0.13*9.81 = 0.013 N

RA + RB = 19.62 + 98.1+0.013

= 117.73 N

Taking Moment at RA we get,

19.62*0.05+98.1*0.34= RB*0.43+ 0.013*0.53

RB = 79.83 N

Therefore RA=37.9 N

Bending moment at various points

MA=0

MC=RA*0.05=37.9*0.05=1.895 N-m

MD=RA*0.34=37.9*0.34-19.62*0.05=11.90 N-m

ME=0

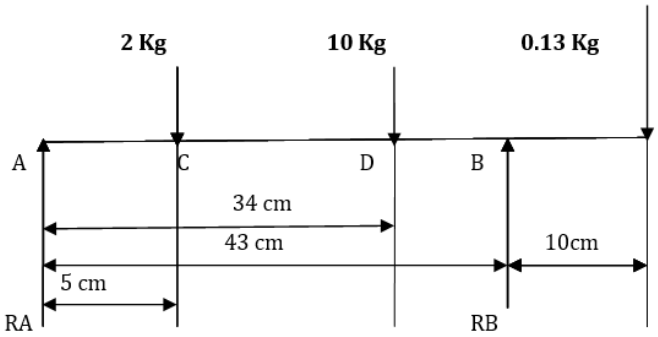

Figure 9: Design Calculations

Max bending moment is at point D of 11.90 N-m
By Formula,
(Bending Moment)/(MI)=(Bending Strength of Mild Steel)/Y
Bending Moment/0.526=370/1.005
Bending Moment= 193.65 N-mm
MI= π*2.01/12
MI=0.526 Kgm^2
Where MI=π*d^3/12 (Moment of Inertia of rectangular section)
Bending strength of Mild Steel = 370 n/mm^2
Y=distance between neutral axis to the edge = d/2
=2.01/2
Y =1.005mm
d = 2.01mm hence, here we have taken 6mm standard strip which is easily available in market.

6. Vacuum Cleaner Calculations

Weight of Vacuum Cleaner = 0.02 K
Power Consumption = 50W
Vacuum Cleaner Capacity = 1.5 lit
Suction Pressure = 8 Kpa

- **Drafting by CATIA Software**

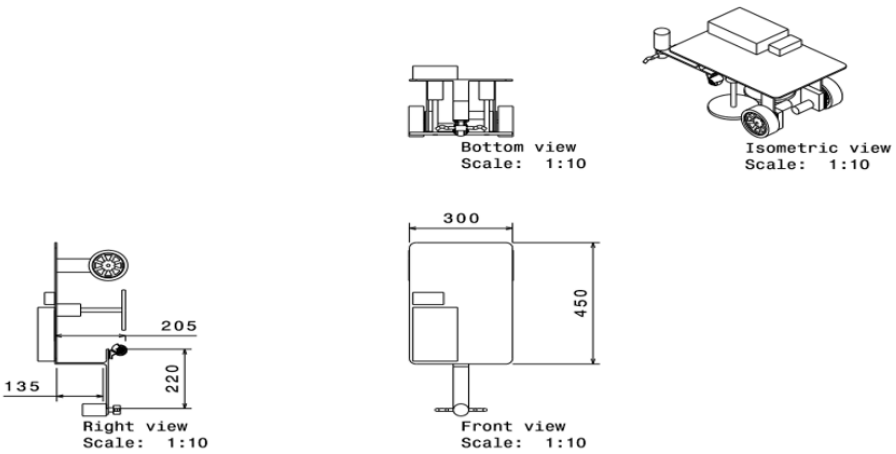

Figure 10 : Drafting of Multipurpose Cleaning Machine

V. Result

❖ **Time-saving**: With a multipurpose cleaning machine, users can clean various household I indoor and outdoor surfaces quickly and efficiently which ultimately leads to saving time and human efforts required for cleaning process.

❖ **Cost-effective:** A multipurpose cleaning machine is cost-effective project. As it eliminates the need to purchase various separate equipment's for separate cleaning work. So the overall expenses of project is reduced.

VI. Conclusion

The design and development of a multipurpose cleaning machine require a thorough understanding of user needs, technical knowledge, and creative thinking. A well-designed machine is versatile, efficient, user-friendly, durable, and cost-effective. It is also consider the environmental impact of the machine and strive to be energy-efficient and eco-friendly. The development process involves several stages, including defining the purpose and requirements, researching and analyzing existing models, creating design concepts, developing detailed designs, prototyping and testing, evaluating the machine's usability and user experience, and preparing for production and deployment.

The successful design and development of a multipurpose cleaning machine can provide significant benefits to users, including increased cleaning efficiency and effectiveness, reduced cleaning time and effort, and a cost-effective cleaning solution. Ultimately, a well-designed and developed cleaning machine can meet the specific cleaning needs, offering a valuable product that improves the quality of life.

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