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Road Cleaning Machine with UV Sanitization

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Abstract: *Due to unassessed industrialization and unmanaged construction & development projects in developing countries like India, the quality of air has been significantly compromised. People are being compelled to inhale polluted air a and significant amount of dust particles. Air quality has been sufficiently degraded below the standard set by World Health Organization (WHO), and this has become a serious issue. One of the major reasons is dust particles spread from the road to the atmosphere by vehicles plying on the road, where roads are dug up for construction purposes only to leave them uncompleted because of political, financial, and personal interests of the elite groups and construction company owners. This can lead to serious health hazards like severe allergy, lung cancer and other problems related to breathing. In order to address this problem, we have designed, fabricated and tested a 'Mechanically Operated Road Cleaning Machine with UV Sanitization' prototype that is financially viable and socio-economically beneficial. This machine works on simple principle of centrifugal motion of cylindrical brush throwing dust particles from road surface in the container, uses local materials and is cheap with respect to other machines and is efficient as well. This can be used in the side area of roads where dust has been piled up in maximal amount. We have performed detailed mathematical calculation and analysis for design specification of each and every part of the machine components and made a prototype design in CATIA V5. Then after we successfully fabricated using conventional fabrication tools and tested its performance.*

Keywords: Air, Pollution, Dust, Health, Hazards, Road Sweeper, Brush, Centrifugal Motion, Design, Analysis, Testing

I. INTRODUCTION

1.1 Background

Air is the element that has made life possible in this beautiful planet earth. Had there not been air none of the living species that we know exists today might not be here. We not only humans but all other living beings need air for their survival. Air is the most essential component for living being's survival on this planet earth. We may even survive for a week without food, couple of days without water but is it possible for us to be alive in the absence of air for a couple of minutes. The answer would be a big NO.

Air is what we need 24/7 for survival but the air that we breathe in sometimes causes some serious health hazards. The reason for our illness is polluted air. Polluted air has negative impacts on respiratory system of our body. So, do we stop breathing now? That choice might cost our life. So, the only possible choice that we are left with is to clean the air. The pollutants of air must be removed to make the air clean and harmless.

The air pollution has been the major problem since the last decade in world. Kathmandu being one of the most polluted cities in Asia has to be customized to get rid of the pollution. Pollution caused by dust and particles, poses grave danger to children, older people and people with respiratory illness. For this purpose, we the students of Mechanical engineering approached to build Road Sweeper for dust removal. Dust has evolved as a serious problem in Indian cities which has occurred due to road expansion, electrical and electronic installation in roads, and settlement of dust from air pollution. Therefore, Road Sweeper can play a vital role for maintenance and keeping the city clean.

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Figure 1.1: Air pollution (Adhikary, 1996)

Most of the air pollution is caused by the burning of fossil fuels, such as coal, oil, natural gas. Dust is generated by the undergoing road reconstruction, drinking water pipeline project and electrical installations and is piled up in the edge of the road. Dust and pollution particles mix in the atmosphere and can travel for days across long distance before settling on the ground surface. Dust are also produced from agricultural field operations, parking lots, waste cleanup sites, industrial facilities, construction activities, demolition activities, etc.

1.2 Dust Control Methods

Dust emissions can be prevented by limiting the creation of dust sized particles, reduce wind speed at ground level, etc. The majority of mechanical sweepers are mobile units that use a vacuum system to collect the waste materials. Generally, the suction action is complemented by one or more rotating brushes for dislodging residues that adhere to the surface of the road. There is a wide range of mechanical sweepers. They vary in size from very small units controlled by a pedestrian, to large mechanical sweepers mounted on a vehicular chassis. The large mechanical sweepers generally are equipped with an auxiliary engine to generate the vacuum and, in some cases, are fitted with a hose that can be controlled by an operator to pick up refuse from areas that are difficult to reach (i.e., dry leaves from drainage ditches). Mechanical sweepers are efficient for the collection of light litter, fine dust, and sand from roadways.

The conditions typically found in economically developing countries limit the role of mechanical sweepers to that of simply supplementing manual sweeping. Mechanical sweepers normally are found in the large metropolitan areas of developing countries. The degree to which mechanical sweepers are utilized for a specific application should be based on thorough analyses of advantages and disadvantages, as well as the costs associated with using them as opposed to using manual sweepers. In addition, mechanical sweepers have the tendency to be extremely maintenance-intensive units.

Dust particles vary in size from visible to invisible. The smaller the particle, the longer it stays in the air and the further it can travel. Large dust particles fall out of the air relatively close to where they are created. These particles form the dust layers you can see on things like furniture and motor vehicles. Large dust particles tend to be trapped in the nose and mouth when you breathe them in and can be readily breathed out or swallowed harmlessly. Smaller or fine dust particles are invisible. Fine dust particles are more likely to penetrate deeply into the lungs while ultrafine particles can be absorbed directly into the blood stream.

1.3 Objectives

1.3.1 General Objective

The main objective of road sweeper is to provide an efficient, eco-friendly and portable manually operated sweeping machine to collect the dust left on the road.

1.3.2 Specific Objectives

1. To develop the concept on mechanisms.

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2.To develop the design calculations.
3.To design assembly drawing, simulate and review.
4. To fabricate the machine parts and assemble
5. To test the fabricated sweeping machine.

1.4 Details of the Project

1.4.1 Problem Statement

How dust has become the major problem in the World? Air pollution is one of the emerging and exponentially growing problem. One of the major contributors of air pollution is harmful soil dusts particle. Soil dusts are generated due to heavily expansion of road, construction of buildings, electric and electronics maintenance pole in roads etc. These dusts are not cleaned in time by the metropolitan workers. Because of which, dust increases in huge amount and spread all around by vehicles, commuters and local wind. Therefore, observing this problem we tried to bring a solution by using local resource and technologies providing faster and efficient work with zero energy consumption.

During our search for the project, we found that in India cleaning the street is done in a traditional way. People perform the task of cleaning the street every morning and afternoon. The efficiency of this task is very low which ultimately results in loss of time, power and money. The number of sweepers is in decreasing order these days because of awareness among people about the necessity and importance of education, only older people perform their chores daily whereas theyoung generation is busy in their daily activities such as attending school, college and office. Aside the younger generation hesitate to perform the sweeping task resulting in a smaller number of sweepers. Technological advancements have been brought up and introduced in developed nations to perform the task of cleaning streets but we lack appropriate technologies and rely on traditional methods for cleaning the streets even in today's modern world. Though Indian Government has already introduceda sweeping vehicle in India earlier, the sweeper has turned to rubble after not being used for many years.

The sweepers that are used in developed countries consume fossil fuels to operate. As we know the fossil fuel reservoir is in its last stage alternatives of energy are being searched throughout the globe. So, a mechanical push on sweeper could be a solution to the energy deficient state in the world where we do not need fossil fuel for the operation of a sweeper as we can sweep the streets just by pushing the push on sweeper.

Figure 1.2: Air Pollution: Real-time Air Quality Index (AQI)

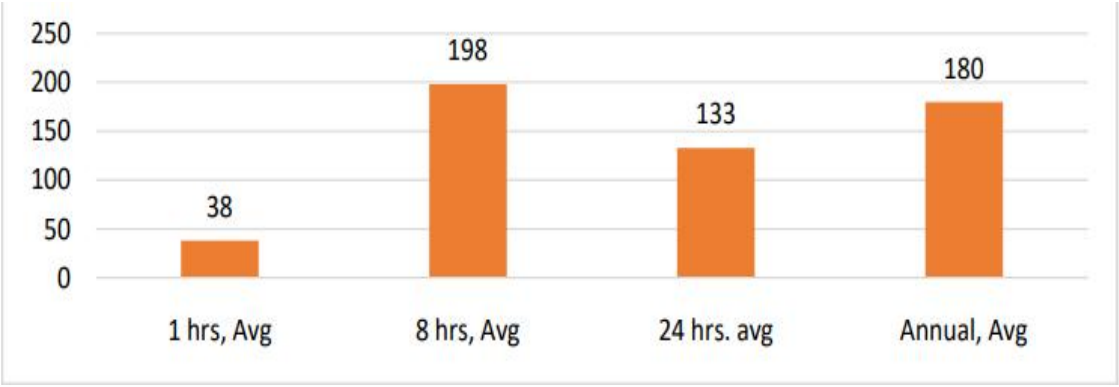

Figure 1.3: P.M at Delhi

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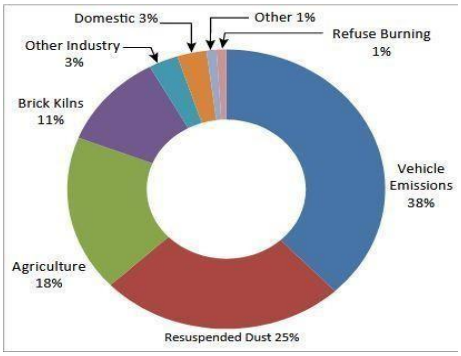

Figure 1.4: Sources of air pollution in Delhi

II. METHODOLOGY

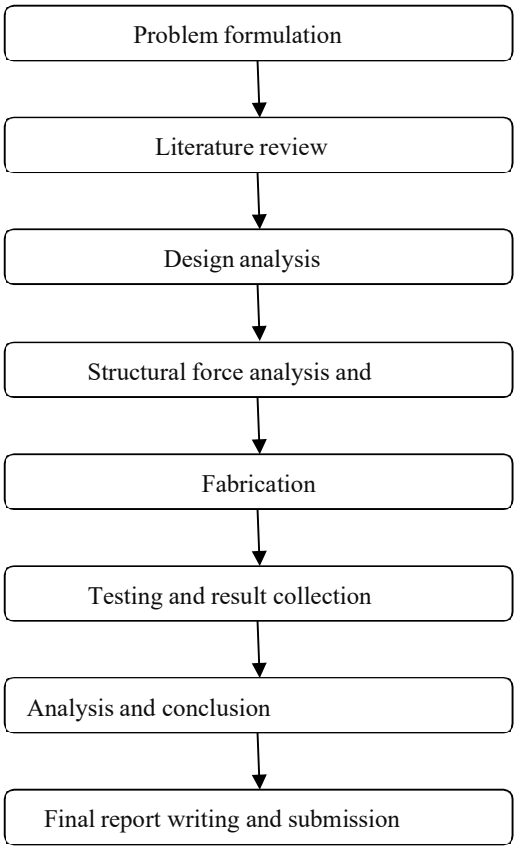

Figure 3.1: Flow process for methodology

a) Problem Formulation

Everyone has become the victim of air pollution in India due to urbanization and road expansion projects. The streets are full of dust and the effort to clean those dust is nowhere near our goal. Though cleaning operation is performed on daily basis, the practice has resulted to be time, money and power consuming which is inefficient. So a mechanical push on sweeper is designed to save money, time and power with high performance in cleaning the streets.

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b) Literature Review

The literature review was carried out through web–based research, expert interactions, and manual study. The literature related to the machines was studied on the internet. Analysis of the mechanisms that are used in the prototype of the push on sweeper were studied. Sweeping technologies used in the world and India were researched and certain information was extracted from them.

c) Design Analysis

The project will be undertaken by performing a series of experiments with the design of a machine. Different designs will be derived, analyzed and modified as necessary with the use of AutoCAD & CATIA V5 for 2D sketch, dimensioning and 3D modeling.

d) Force Analysis and Calculations

Force analysis and load calculations of different components of the machine will be done. The results will be used during the fabrication process and will help in maintaining structural balance and integrity of the machine after construction.

e) Fabrication

With the application of appropriate processes, resources and tools, a prototype of the mechanical push on sweeper will be fabricated with the selection of suitable material.

f) Testing and Result Collection

The fabricated prototype will then be tested to see if it performs the function as desired or not. The results of the testing will be collected and rectifications will be carried out if necessary.

g) Analysis, Conclusion and Recommendations

The prototype will then be analyzed from mechanical, economic and environmental perspective and necessary conclusions will be drawn out. Based on those conclusions recommendations will be given.

h) Final Report Submission

A final report will be prepared which will include overview of development of machine, detail information of processes that have been followed during the project. The final report will then be submitted to the Department.

Data Collection

A. Primary Data Collection

For primary data collection related to dust accumulation on the road, we visited various road section including Mid-hilly region road section (Ozar) of Nashik district and the link road of Nashik city and will also be visited more roads. Various workshops, labs, junkyards and hardware shops will be visited. Yantrasala was and will be visited for fabrication purpose.

B. Secondary Data Collection

The data handbook and design books were reviewed and will be used for the proper selection of machine elements required for the project. Different supporting reports, journals and other data reports will be visited and studied to get data and information. Others mechanical projects relevant to our project will also be visited and studied.

III. RESULTS

3.1 Solution concepts

a) Bevel Gear Mechanism

The bevel gear mechanism was to be used in order to make the position of the brush in an angle of 37 degrees. Bevel gear was also to be used in order to reverse the direction of rotation of brush with respect to the direction of rotation of the wheel. We thought of this concept in order to increase the cleaning efficiency of the brush.

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b) Pulley

In a two pulley system, the belt can either drive the pulleys normally in one direction (the same if on parallel shafts), or the belt may be crossed, so that the direction of the driven shaft is reversed (the opposite direction to the driver if on parallel shafts). As a source of motion, a conveyor belt is one application where the belt is adapted to carry a load continuously between two points.

c) Spur gear and parallel brush with Chain Sprockets

Spur Gear is used to reverse the direction and transmit the required torque whereas chain sprockets are solely used for increasing the angular velocity and the brush is kept parallel to the other shafts. The tangential force is used to propel the dust into the container.

d) Brush with roller

The roller brush will collect all the dust. The wetted wiper is arranged is circular frame and dust gets attached to the wiper. The collected dust gets bulky and is collected in container by hitting to a rod placed at the end.

Design Selection:

Mechanism	Safety	Cost	Material Availability	Ease of Fabrication	Total	Eff.
Bevel gear mechanism	3	4	6	7	20	75%
Wiper	7	8	8	9	32	75%
Bevel gear brush	4	5	2	5	16	85%
Brush with roller	5	6	8	6	25	50%
Water Spray	8	7	3	8	26	80%
UV Lights	2	8	9	8	27	90%
Submersible Centrifugal Pup	8	6	5	7	26	85%

Table 4.1: Factor rating method

Design details

Chassis:

The chassis is one of the major components on which the various components such as shafts, bearings, brushes, container and other components are mounted. It carries the load exerted on it due to various components and load of the dust particles collected during operation. The components for the chassis was selected such that it provides the load handling and easiness. The angle bar was used for the construction of the chassis. We selected this one because of the following reasons:

Specifications	length bar	breadth bar
Material	M.S.	M.S.
Length	1080 mm	550 mm
Breadth	20 mm	20 mm
Height	20 mm	20 mm
thickness	2 mm	2 mm
Mass	1300 gm	700 gm
Number	2	3

Table 4.2: Specification of chassis

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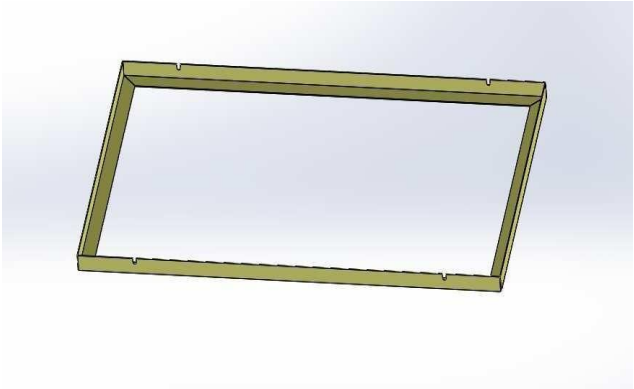

Wheel

The wheel is used to provide the rotational motion and torque to the machine due to friction between ground and the friction material of the tire while pushing in the forward direction of the machine. The tire used for the cycle is selected. It transfers the load on the chassis into the ground absorbing the vibrations and also providing the balance loads of the machine.

Figure 4.2: Wheel

Specifications:

Material of the tire	Rubber
Material of the rim	PVC
Diameter of the wheel	280 mm
Diameter of the central bore	20 mm
Diameter of the tire	320 mm
mass of the wheel	500 gm
Number of the wheel	2

Table 4.3: Specification of wheel

V. CONCLUSION

In conclusion, design, fabrication and testing of manually operated road sweeper was achieved with our laborious work. However, we came to the understanding that the range in the numerical data of size, shape and other variables is not permissible. The design data must be accurate and must have an alternative as well. Next, the fabrication process became very complex than we have estimated during design phase. The most important factor that affected and forced us to change

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some concepts in our design was the material availability and the manufacturability of the machine. After that, the testing was done and we learned that this machine have better performance level than manual traditional sweeping method and found that the benefit in the social level is very high and rewarding in terms of its cost. However, some design discrepancies were observed through our testing results. Some amount of dust spread and hovered in the air. Passing all these challenges we managed to complete this project and learned where the problems are likely to occur during design phase and fabrication phase. Moreover, we also learned about the significance of the material availability, skills and machine availability to design and fabricate the machine and get desired output.

Future Modification of the Project

Due to various constraints such as technical, financial, environmental, material availability etc., the project could not achieve 100 percent efficiency. Someone can further work on our project to improve the performance of the machine. The future modifications those can be made in our project are as follows:

1. Proper value analysis can be done for proper material selection reducing cost and weight increasing efficiency
2. The use of vacuum can also be made for collecting micro dusts
3. The manual drive can be replaced by motor drive to increase efficiency for the place where electricity is largely available
4. The advanced mechanism can also be added to collect organic and inorganic wastes.

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