

Design and Development of Dust Cleaning Machine for Cleaning Of Dust beside the Road Divider

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Abstract – Once our father of nation said that sanitation has more values and importance than independence. Normally, we seen that dust on the road causes uncleanliness. Various studies shows that 33% of air pollution can be creates by dust on road in India which will cause health and accident problem for people travelling on road. Hence, it is necessary to keep clean road from dust and dirt. In this project an effort has done to design and development of dust cleaning machine for cleaning of dust beside the road divider by altering manual process with cost effective method. This machine consist of scrubber brush which provide sweeping action, at the same time vacuum dust collector is provided which will clean the dust. Also, by introducing this project our aims to fulfill the goals of Swachch Bharat Abhiyan.

Key Words: Sanitation, Independence, Scrubber, Vacuum dust collector.

1. INTRODUCTION

A clean environment ensures the continual existence and survival of all life on Earth. Cleaning the environment reduces pollution, protects unique ecosystems, prevents the extinction of endangered species and conserves resources. A clean environment ensures the protection of biodiversity and ecosystems upon which human life and all other life on Earth depends. Similarly, cleaning of roads also important for healthy environment and road safety. Normally, we seen that Dust on the road separated beside the road divider due to moving vehicles. This dust causes health problem and accident problem for people travelling on road. This dust particles present on the roads are danger to the road safety. In our country cleanliness is becoming an important factor for the betterment of the nation and so, to support the cause we have conducted a study, prepared Design and Development of Dust Cleaning Machine for Cleaning of Dust beside the Road Divider. The cleaner is an approach to deliver easy and time efficient cleaning of roads, by reducing human efforts. There are in numerous functions of the remote operated cleaner mainly.

- 1) Cleaning of dust beside road divider by brushes or broom like structures which is operated by Motor.
- 2) Removes the dust from roads with the help vacuum dust collector.

2. PROBLEM STATEMENT

2.1 Present Process

The present method of cleaning dust beside road is manual process. In manual process, the road cleaning is done with the help of broom to clean off dirt and dust. A person continuously does a swiping action by a broom in the hand and other person carry trolley which collect the dust and dirt as shown in figure below. If we observing this process, then we could find the following limitations which are given below:

1. This process renders fatigue to the hand and even it cause damage to the shoulder.
2. As it is a continuous process, it produces mental fatigue and hazardous to the health of sweeper.
3. It is time consuming, and laborious process so, no one wants to do it.



Figure : Manual Process

2.2 Effect of Dust on Road

1. The dust particles present on the road, when mixes with the fog and forms smog, this decreases the visibility on the road, which results in mishandling and fatal accidents.
2. The contact between the road surface and the surface of tyre reduces due to the presence of dust particle layer between them, during the braking and turning of the vehicle, it causes the problem like skidding.

3. Foreign dust particles when entering in the eyes of the driver or the rider causes discomfort and Irritation which is a critical problem when driving or riding on a busy road.

2.3 Objectives

The main objectives of our project work are follows

- 1) To provide the alternative method for cleaning road side dust.
- 2) To reduce human efforts and time.
- 3) To provide healthy environment.
- 4) To support "SWACH BHARAT ABHIYAN".

3. LITERATURE REVIEW

3.1 Ashish Patil[1], Pranav Patil[2], Jaywant Patil[3], Rohit Ingawale[4], Sanket Nalawade[5], Amar Patil[6].

Summary :- This paper present the design and development of road side cleaning machine in which they use scrubber operated by petrol engine and speed amplification mechanism for collecting the dust.the objective of author develop machine for cleaning roads to reduce cost , time and human efforts.

3.2 Dhananjay kuchay[1], yodnesh Kulkarni[2], Manoj Bauskar[3].

Summary: - This paper is related to design and development of manually operated mechanical road cleaner. They used chain drive mechanism for cleaning of street.

3.3 Sandeep J. Meshram[1], Prof. G.D.Mehta[2].

Summary: - This paper deals with design and fabrication of tricycle operated street cleaning machine suggesting that we have few foreign automated machines that are used in our country according to the road conditions. The objective of the author is to propose semi- automatic machine for rural and urban areas in order to reduce human efforts and time.

3.4 Renae Kuehl[1] and Michael Marti[2].

Summary: - This paper developed a series of information sheets as a resource for implementing a Street Sweeping Best Practices. These sheets are designed to provide technical staff, policy and decision makers with guidance on a number of topics including: 1. Best Management Practices Overview 2. Types of Sweepers 3. Reasons for Sweeping 4. Sweeping and Roadway Function .In preparing this resource it is acknowledged that there are numerous research studies and reports on Street Sweeping.

4. MAIN COMPONENTS

4.1. Frame

It is main component of the machine which support and carry all parts like Motor, Vacuum dust collector, battery etc. the frame is made of mild steel and CAD model of frame is shown below.

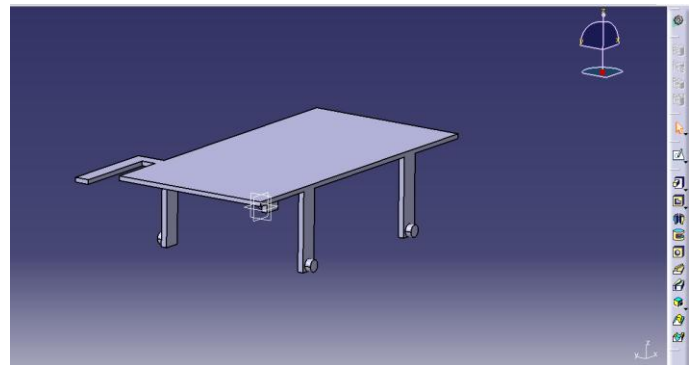


Figure: Frame

4.2 DC Motor

Motor is prime mover of driving mechanism through which scrubber is rotated and clean dust beside the road. For efficiently scrubbing of dust from road we selected 24V Geared DC motor having 97.8N-cm Rated Torque. This motor is operated by Battery.



Figure: Dc Motor

4.3 Scrubber Brush

The scrubber brush is another main component our machine which is directly connected with motor through spindle shaft and rotated at motor speed. Scrubber brush is provide the sweeping action which clean dust beside the road divider.



Figure: Scrubber Brush

4.4 Cyclone Vacuum Dust Collector

Cyclone vacuum dust collector is device that provided suction in order to remove dust from divider and collect the dust in collector tank. In this vacuum collector system, air is pulled through the chamber of dust collector towards the vacuum conveying pump at high speed, it spins in cyclonic motion. The centrifugal force created by this fast, circular air flow

drives the heavier particles, fines and dust outward towards the wall of cyclone chamber. They hit the wall lose velocity and fall down into the collector tank.



Figure: Cyclone Vacuum dust Collector

5. WORKING

In our dust cleaning machine, Motor is mounted on arm which is fixed at right side of frame as shown in frame and motor is operated by battery through which scrubber brush is rotates and provides sweeping action, this makes dust which is stick on the road is removed. Then this dust is sucked by cyclone vacuum dust collector and collected into the tank. Our machine is operated by pushing manually or easily attach to any vehicle like motor cycle, moped and bicycle. This project has approach to deliver easy and time efficient cleaning of roads by reducing human effort with cheapest and effectively.

6. Design Calculation

6.1 Motor Power

Our literature study findings: -

1. Force applied by sweeper for sweeping manually is normally 7-8 kgf.

Let we assume,

Sweeping force = 8 kgf

= 8 × 9.81

Sweeping Force = 78.48 N

For efficient cleaning operation, we selected Geared motor having following specification:

24V geared Dc Motor

Motor speed – 3000 rpm

Reduction speed – 340 rpm

Torque – 97.8N-cm

6.2 Spindle Shaft

The spindle shaft is design on rigidity basis.

Given data:-

Material: - SAE 1030

Modulus of rigidity, $G = 79 \times 10^3 \text{ N/mm}^2$

Torque transmitted,

$T = 97.8 \text{ N-cm} = 9.78 \times 10^3 \text{ N-mm}$

Speed, $N = 340 \text{ rpm}$

Assume, angular deflection of shaft,

$$\theta = 0.25^\circ = 0.25 \times \pi / 180$$

$$\theta = 0.00436 \text{ rad}$$

Length of shaft, $L = 48 \text{ cm} = 480 \text{ mm}$

As we know torque transmission,

$$\frac{T}{J} = \frac{G \times \theta}{L}$$

$$J = \frac{9.78 \times 10^3 \times 480}{79 \times 10^3 \times 0.00436}$$

$$J = 13629.079 \text{ mm}^4$$

Now,

$$J = \frac{\pi}{32} \times D^4$$

$$13629.079 = \frac{\pi}{32} \times D^4$$

$$D = 19.3 \text{ mm}$$

Selecting Std. Diameter of shaft,

$$D = 20 \text{ mm}$$

6.2 Cyclone Dust Collection Efficiency

1. The Number of Effective Turns (N): The number of effective turns in a cyclone is the number of revolutions the air spins while passing through the cyclone outer vortex.

N = number of turns inside the device

H = height of inlet duct = 65mm = 0.065m

L_b = length of cyclone body = 80mm = 0.08m

L_c = length (vertical) of cyclone cone = 320mm = 0.32m

$$N = \frac{1}{H} \times (L_b + \frac{L_c}{2})$$

$$N = \frac{1}{0.065} \times (0.8 + \frac{0.32}{2})$$

$$N = 3.69$$

The Number of Effective Turns (N) = 3.69

2. Cut-Point (d): The cut-point of a cyclone is the aerodynamic equivalent diameter (AED) of the particle collected with 50% efficiency. As the cut-point diameter increases, the collection efficiency decreases. The Lapple cut-point model was developed based upon force balance theory.

a) particle diameter (dp) :- d_p is the size of the smallest particle that will be collected if it starts at the inside edge of the inlet duct. Thus, in theory, all particles of size d_p or larger should be collected with 100% efficiency.

$$d_p = \left(\frac{9 \times \mu \times W}{\pi \times N \times V_i \times (\rho_p - \rho_a)} \right)^{1/2}$$

where,

dp = diameter of the particle

W = width of inlet = 120mm = 0.12m

ρ_p = density of the particle = 1600 kg/m³

ρ_a = density of the particle = 1.1459 kg/m³

μ = air viscosity = 1.8915×10⁻⁵ kg/m³

V_i = air flow velocity

Q = air flow through vacuum = 216m³/hr = 3.6 m³/sec

For air flow velocity , $V_i = Q/WH$

$$= 3.6/0.12 \times 0.065$$

$$V_i = 7.56 \text{ m/sec}$$

Now,

$$dp = \left(\frac{9 \times 1.8915 \times 10^{-5} \times 0.12}{\pi \times 3.69 \times 7.56 \times (1600 - 1.1459)} \right)^{1/2}$$

$$dp = 1.2074 \times 10^{-5} \text{m}$$

$$dp = 12.07 \mu\text{m}$$

b) Particle diameter (dpc): It is diameter of particle collected with 50% efficiency.

Similarly,

$$dpc = \left(\frac{9 \times \mu \times W}{2\pi \times N \times V_i \times (\rho_p - \rho_a)} \right)^{1/2}$$

$$dpc = \left(\frac{9 \times 1.8915 \times 10^{-5} \times 0.12}{2\pi \times 3.69 \times 7.56 \times (1600 - 1.1459)} \right)^{1/2}$$

$$dpc = 8.5378 \times 10^{-6} \text{m}$$

$$dpc = 8.53 \mu\text{m}$$

3. Cyclone Dust Particle Collection Efficiency:

The efficiency of collection of particle is given by

$$\eta = \frac{1}{1 + \left(\frac{dpc}{dp}\right)^2}$$

$$\eta = \frac{1}{1 + \left(\frac{8.53}{12.07}\right)^2}$$

$$\eta = 66.69 \%$$

The efficiency of cyclone dust collection is 66.69 %.



Figure: Dust Cleaning Machine

7. METHODOLOGY

- 1) Identification of Problem
- 2) Literature Survey
- 3) Study of different road cleaning machine available
- 4) Force Calculation and Design of Different Part
- 5) Fabrication of Model
- 6) Testing of Model

8. CONCLUSIONS

From this Project we conclude that, our machine is safe, eco-friendly and reduce the cost and time of dust cleaning done by manual process. This is the best alternative method for cleaning road side dust.

In our cleaning machine when motor starts, Scrubber brush scrubs the dust separated on road divider and cyclone vacuum collector collect that dust into the collector tank. Only one person is required to operate machine and cleaning is done at very less human effort.

9. REFERENCES

- [1] Ashish Patil, Pranav Patil, Jaywant Patil, Rohit Ingawale, Sanket Nalawade, Amar Patil (2018). "Design & Development of Road Side Cleaning Machine", International research journal of engineering and technology, ISSN: 2395-0056, Volume 05, Issue 4.
- [2] Meshram, S., & Mehta, G. (2016). "Design and development of tricycle operated street cleaning machine", Journal of information, knowledge and research in mechanical engineering, 4(1), 702-706.
- [3] Akshay nighot, Yogesh jadhav, Pritam jagadale, Ishwar jadhav, Avinash bharate (2019). "Design & Development of Low Cost Manually Operated Sweeping Machine", International research journal of engineering and technology, ISSN: 2395-0056, Volume 06, Issue 6.
- [4] Shuzai kalam, Jatin Sekhri, Twinkle Bauddh, Shivam Kumar, Sarthak Jha (2018). "Road Side Dust Collector Machine", International research journal of engineering and technology, ISSN: 2395-0056, Volume 05, Issue 3.
- [5] Muhammad I. Taiwo . Mohammed A. Namadi. and James, B. Mokwa (2016). "Design and analysis of cyclone dust separator", American Journal of Engineering Research (AJER), ISSN: 2320-0847, Volume-5, Issue-4.

- [6] The Design of Machine Elements by V.B.Bhandari.
- [7] Machine Design by RS Khurmi.