

Semi-Automatic Night Soil Cleaner in Railways and Multipurpose Applications

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Abstract: The Railways, which is one of the major transport agencies across the world and in all fairness is the faster and cheaper mode of transportation in India. Imagine the junctions left un-cleaned for a week, the stench alone would drive away all the commuters, cheaper or not. At this point in time, take a moment to think about people, who do all the cleaning up after us - it sure does instigate one to take actions to relieve them off their miserable nature of work. Though the Government of India has introduced laws pertaining to sanitation that restricts humans cleaning up the night soil, the Indian Railways are still open and awaiting technology that could once and for all resolve this for them. Here is the modest, yet most efficient machine that would replace the manual labor involved in cleaning up the night soil in the tracks/rails. So now what does this one do to help them - night soil cleaner cleans up the 700-meter odd length of the junctions which gets most soiled on a daily basis. This semi-automated machine, with simple mechanisms and efficient cleaning techniques, would surpass any emerging technique in its cost-effective budget and efficacy. The idea is to help the workers in sanitary disposal by introducing a compact and weightless machine that will help them to do the work quicker and with less human effort with the use of semi-automated machine to clean the night soil.

Key words: Innovative design, Fabrication of prototype, Semi-automated machine, Manual Scavenging

1. INTRODUCTION

One of the major shortcomings that Indian Railways faces today is the cleaning and disposal of night soil (human waste). Our honorable prime minister, Mr. Modi, is very much determined in setting things right to make our country clean when it comes to our society and surroundings. It's high time we joined hands in making his vision come true. Even with many prohibition acts and laws against manual scavenging very much present in our country [1], manual scavenging continues to be practiced and remains unaddressed. Lack of proper technology usage can be cited as one of the most critical reasons for this. This project is mainly focused on reducing human effort and the time consumed for this cleaning process. It is also targeted at preventing involvement of any manual

scavenging and thus in turn ensuring personal hygiene of the workers involved[2,3].

2. SCAVENGERS IN RAILWAY STATION

It is necessary to find a new technology in removing the night soil from the tracks of railway stations. Nowadays scavengers are using pipe water by forcing them on the night soil into the drainage present near the tracks. They are working for a shift of eight hours and they can clean only one and a half of railway tracks due to time consumption and frequent arrival of trains and the Fig 1 shows the manual scavenging of night soil.



Fig -1: Scavengers cleaning night soils

2.1 EFFECTS ON SCAVENGER SYSTEM:

The main objective to be noted is that it carries serious health dis-orders like skin problems, infection diseases, etc. Manual scavenging will take more time to finish the cleaning operation [4]. Water wastage is comparatively high and one given machine can clean the length of one and a half tracks in eight hours' time, operated by three workers. In scenarios where there is shortage of time needed for cleaning, the domestic workers dust the remnant night soil with limestone powder or bleaching powder to cover night soil, which is quite objectionable considering its toxicant nature.

3. EXISTING TECHNOLOGY

From the below, Fig: 2 is the image of the existing machine to clean the night soil on the tracks and the Fig: 3 is the image of the platform cleaner machine in railway stations used in current scenario. This machine uses the principle of high pressure water jet system which is connected through water hoses to clean the track with the help of electrically driven system.

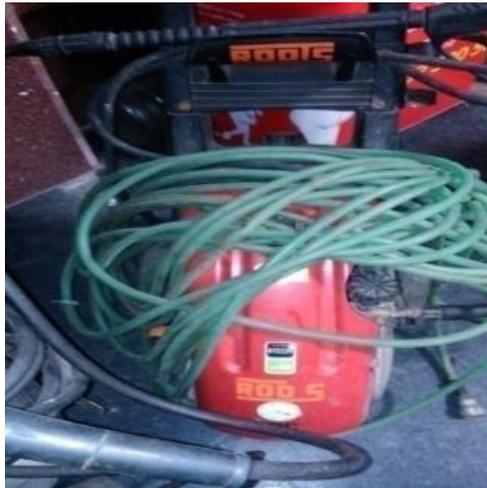


Fig- 2: Water jet for night soil



Fig -3: Platform cleaner

4. PROBLEM IDENTIFICATION:

4.1. Impediments Recorded at Railway Station

The impediments reported in employing the existing technology while taking a survey at Railway Stations are as follows:

- a) Cost of the machine is high
- b) Getting electricity and water supply to the machine is tedious (due to frequent power cuts)

4.2 Problems in Super-Fast Trains

It was observed that from the various categories of trains, the super-fast trains experience the following problems:

- a) Requires separate storage
- b) Mal-functioning of linkage will cause overflow of night soil
- c) Storage of night soil will effuse bad odor

4.3 Problems Recorded at Platform

Platform, which is termed as the base of a railway station, is where noncompliance of the government act is noted in a large scale resulting in the below-mentioned consequence:

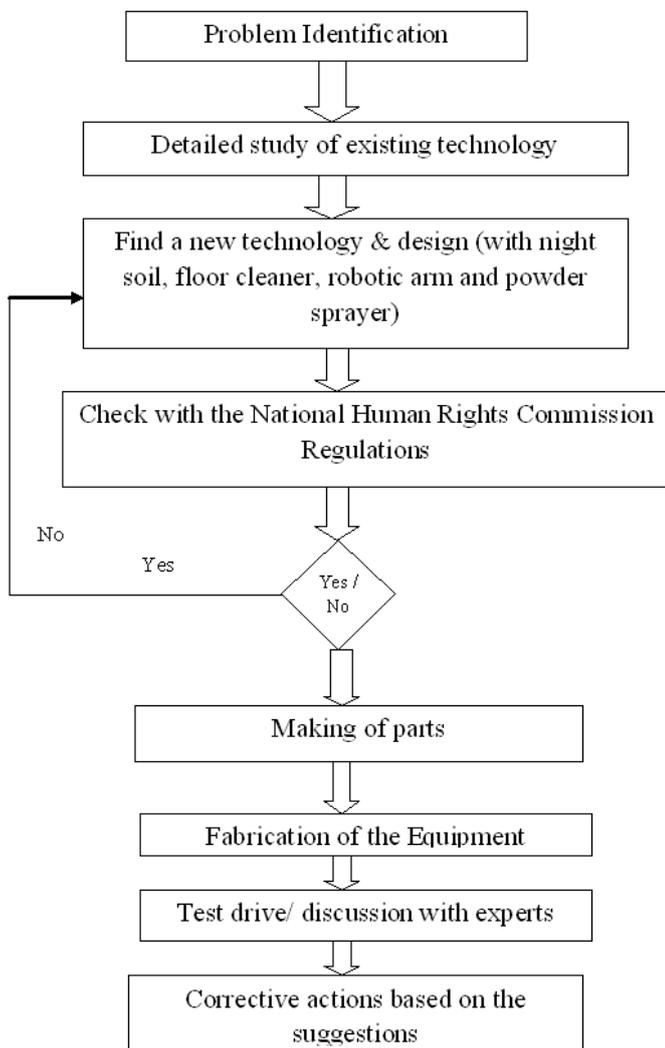
- a) Non-Hygienic environment
- b) Need of manual scavengers for cleaning.

4.4 Problems Faced by Railway Workers

During the survey in railway stations, the civic workers stated various difficulties that they face while operating the existing technology, which are listed below:

- a) Supply of power to machine was tedious and required constant monitoring
- b) Machine inoperable due to frequent power cuts
- c) Air lock is a frequent and major drawback in water jet machines
- d) Water wastage level is high
- e) Frequent replacement of hoses required
- f) Wires and hoses are often either trampled by the crowds when placed in open spaces or get damaged or worn out eventually.
- g) Cleaning operations are to be performed manually
- h) Cleaning the track takes long time
- i) Two or more workers are required at a time to operate the machine
- j) Cleaning one track requires more number of workers

5. APPROACH TO SOLVE THE PROBLEM



Flow Chart 1: Solving Methodology

This flow chart- 1 clearly shows the methodology adopted in the proposed work.

6. INNOVATIVE DESIGN

6.1 Features of new invention:

Very less cost, complies with standard safety rules, Economical water usage, No electrical power required during real time operation, Man power reduced up to 80%, No disturbance to the passage in platforms, No necessity of water tubes, power cable etc., Compact, Weight reduces by 50%. The new proposed design is shown in Fig 4 which has two circular brushes in the front and back side for cleaning the track easily.



Fig -4: New proposed design

6.2 DRIVE SYSTEM AND BATTERY POWER SOURCE:

The D.C. gear motors are the driving system employed in this machine which is used for the machine directional movements (steering mechanism) and as well as for the circular brushes. A 24 V and 64amps battery is using as a power source. D.C gear motors also used to achieve the multi - application system easily. The DC Gear motor are used for various systems in this model for drive system, rotation mechanism of circular and rolling brush, steering mechanism. It is the main element which supplies power to the shaft and make the system to move easily, this motor is operated with the help of battery drive. [7, 8]The stepper motor shaft is coupled with the gears to transmit power to the wheels which is shown in fig 5. The DC Gear drive and the battery specifications are follows:

| | |
|-------------------|---------|
| Number of motors: | 4Nos. |
| Weight: | 700 gms |
| Capacity: | ¼ HP |
| Power: | 24W |
| Voltage: | 12V |

Battery is the power source to this model which is fully controlled by a 12V and a 6V battery.

| | |
|----------------------|-----------|
| Type of battery: | Lead acid |
| Number of batteries: | 02 |
| Voltage: | 12V-DC |
| Current: | 7.2 A |
| Power: | 20W |
| Weight: | 2Kg |
| Charging: | 5hours |
| Discharging: | 20hours |



Fig -5: D.C. gear motor

6.3 HORIZONTAL ROLLING BRUSH

This brush is rotated clockwise direction and it's driven separately by a D.C. motor and with a belt drive. The brush is in direct contact with the night soil. Then the night soil is pushed over into the collecting tray when the brush is rotated. The fig 6 shows the fabricated model of the circular brush which removes the night soil from the track to avoid manual scavenging.



Fig -6: Horizontal Rolling Brush with driven belt drive

6.4 PLASTIC DUSTBIN:

This bin is used for storing the collected plastics paper waste in track as well as in the platforms by using a suction air which is placed at the top of the collecting tray for the night soil.

6.5 POWDERED SPRAYER:

Powered sprayer is a sub system to spray bleaching powder and lime stone after cleaning the night soil.

6.6 MIXING CHAMBER:

In order clean the platform, this mixing chamber is necessary to mix the water and soap oil for the floor cleaning attachment which is placed at the top of the collecting.

6.7 Disposal Pin / Ejection Pin:

Pin which is shown in Fig 7 is located at the bottom of the collecting tray acts as a lock. It helps to dump the collected night soil into the drainage where there is no physical contact between the night soil and manual scavengers.



Fig - 7: Disposal Pin / Ejection Pin

6.8 VERTICAL CLEANING BRUSHES:

The purpose of cleaning brush is to clean the platform after spraying the mixture of water and soap oil.

6.9 Surface Mount Device (SMD):

SMD is the controller which controls the drive system and also the rotation of the brushes. This is operated using battery. To handle this machine easily and efficiently. With the help of transmitter and the receiver the signals are passed to the circuits and the motor is actuated to perform operations required

6.10 Advantages:

No need of power supply, removals of plastics and night soil, No extension of cables and tubes, Zero corrosion in rails, No chance of blockage in drainage, Very low cost, reduced water usage, Ease of use as it is fully remote controlled even a physically challenged worker can operate this machine.

6.11 Limitations:

- a) Machine is heavy to lift by a single person
- b) Collecting tray as well as the plastic bin has to be cleaned regularly.

6.12 Applications:

Effective removal of night soil from railway tracks removal of litter on the track and in platforms, for cleaning the railway platforms and can be used for Industrial cleaning.

7. DESIGN CALCULATIONS

7.1 Selection of Belt:

From PSG Data Book Page no. 7.58, the selection of the cross section of a belt type is found depending on the power to be transmitted [5, 6, 8]

Diameter of the pulley (D and d)

$$D = d = 60\text{mm}$$

$$\text{Centre distance (C)} = 250\text{mm}$$

$$\text{Speed of the driver motor (N1)} = 1440\text{rpm}$$

$$\text{Speed of the driven pulley (N2)} = 60\text{rpm}$$

Determination of nominal pitch length (L):

Determine the length of the belt L (which is also known as nominal inside length) by using the formula,

$$L = 2C + (\pi / 2) (D + d) + ((D - d) ^2 / 4C)$$

Where

L = length of belt, in mm

C = Centre distance, in mm

D = Diameter of larger pulley, in mm

d = Diameter of smaller pulley, in mm

$$L = (2 \times 250) + (\pi / 2) (120) + ((60 - 60) ^2 / (4 \times 250))$$

$$L = (2 \times 250) + (\pi / 2) (120) + 0$$

$$L = 500 + 188.495$$

$$L = 688.495\text{mm}$$

For the selection of Belt-A

$$\text{Nominal pitch length of Belt-A} = 645\text{mm}$$

$$\text{Length correction Factor (Fc) of Belt-A} = 0.80$$

From PSG Design Data Book, Page No. 7.58, based on the range of nominal inside length the selection of belt - A are made.

7.2 Calculation of Power:

Based on the selection of belt – A, maximum power in KW at 1800 arc of contact for a belt of average length

$$\text{Power (P)} = (0.45 S - 0.09 - (19.62/de) - 0.765 * 10^{-4} S^2) S \dots\dots\dots (1)$$

Where

S = Belt speed, in m/s

P = power capacity, in kW

de = Equivalent pitch diameter

To determine belt speed (S):

$$S = (\pi d N1 / 60)$$

Where

d = Diameter of smaller pulley, in mm

N1 = Speed of the driver motor, in rpm

$$S = (\pi * 60 * 1440 / 60)$$

$$S = 4.52 \text{ m/s} \dots\dots\dots (2)$$

To determine Equivalent pitch diameter (de):

$$de = dp * Fb$$

Where

dp = pitch diameter of the smaller pulley, in mm

Fb = small diameter factor for speed ratio of 1 = 1.0

$$de = 60 * 1$$

$$de = 60\text{mm} \dots\dots\dots (3)$$

Substituting equation (2) and (3) in equation (1)

We get,

$$\text{Power (P)} = (0.45 S - 0.09 - (19.62/de) - 0.765 * 10^{-4} S^2) S$$

Power (P) =

$$(0.45 * 4.52 - 0.09 - (19.62/60) - 0.765 * 10^{-4} * 4.522) * 4.52$$

$$\text{Power (P)} = 0.20\text{KW}$$

7.3 Determination of Rear Drive Speed:

$$i = N1/N2 = Z2/Z1$$

Where

i = gear ratio

N1 = speed of pinion, in rpm

N2 = speed of gear, in rpm

Z1 = no of teeth in pinion

Z2 = no of teeth in gear

$$i = N1/N2 = Z2/Z1$$

$$2.25 = (60 / N2)$$

$$N2 = 26.66\text{rpm}$$

Hence the machine will drive up at a speed of 26.66rpm

8. DIFFERENCE FROM EXISTING APPROACH

Table -1: Difference from existing approach

| Category | Existing | Invention |
|------------------------|--|--|
| Application | a)One way Application (forcing the water jet on night soil) | a)Multi-purpose Application b).Efficient cleaning of night soil and litters in platforms c)Industrial Cleaning d)Powder sprayer |
| Manual Effort Involved | Manual Labor is still high | Relatively reduced human effort |
| Time Consumption | To be connected and disconnected from the power and water supply outlet frequently | Relatively quicker and efficient as it has to be directed through the controls |

| | | |
|---------------------|---|--|
| Safety | Cables and hoses may be unsafe for the passenger as it could make them slip | No cables or hoses used and hence can be safely kept aside from the platform after use |
| Real Time Operation | Runs on electricity | Runs in battery |
| Disposal System | Disposed into the nearby sewage/drainage pits | Disposed at any required location in a hygienic manner |
| Cost benefits | Equipment Cost (single application) Rs.100000-250000 | Equipment cost Rs.12750 |

9. TESTING AND RECOMMENDED SUGGESTIONS

9.1 Testing:

After the successful completion of the fabrication the prototype was displayed for trail in front of the railway engineers and the workers, Moreover this prototype was displayed in many institutions for their valuable feedback and suggestion for further improvements.

9.2 RECOMMANDATIONS AND SUGGESTIONS

- Usage of vacuum and suction
- Change of brush material
- Water storage tank
- Water jet to roller brush
- Ejection pin mechanism
- Sliding of circular brush in coordinate direction
- Controlling of stopper mechanism

10. CONCLUSION

The project focuses on eradicating one of the major disgraces that Indian Railways faces today – Manual scavenging. This has been a long-standing issue with no complete solution determined to this date. The Indian Government has taken steps in public interest and passed bills and acts to prohibit manual scavenging, but these could not be implemented effectively without proper technology to completely replace the manual scavengers.

For years now, there have been continuous efforts and studies put into developing a wholesome solution to this issue and to build the right kind of cleaning machine. This invention stands out and proves to be efficient and economical. The machine does not require active power supply, instead runs on battery and is semi-automated; therefore, powers cuts have no impact whatsoever on the cleaning process. The machine not only cleans the tracks off the night soil, but also can be used to clean the platforms where it will clean the dust and litter as well. The machine ensures that manual scavengers will be replaced and be alleviated off their deplorable nature of work once and for all. Unlike the existing technology, this machine can store the collected night soil for safe disposal later at any desired location. This semi-automated machine complies with the government acts in prohibiting manual handling of night soil, ensuring hygiene and improved working conditions for the civic workers. This project would most definitely be a small step, but a huge leap towards enacting these acts and bills in an efficient and complete manner for betterment of national sanitary standards.

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