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Analysis of modern Rail problems and Designing of Multi Operational Railway Track Cleaner

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Abstract: **-- In this present era, people live a very busy life. Number of people travel around every day via trains. As more people move around, the waste deposition is more. This is causing risk of unhygienic environment that may result in several diseases. This paper is an initiative to decrease that risk by designing vehicle which can run on railway tracks and clean the wastes like used bottles and papers etc. present on tracks and to remove the foul smell in order to keep the environment hygienic.**

Key words**: Track Cleaner, Design, Types of waste, Blower**

I. INTRODUCTION

1.1 Track Cleaning

Track cleaning is one facet of a solid waste management system in which public education and public relations play critical roles. The wastes deposited on the tracks create a negative visual impact, particularly on travellers, and thus indirectly affects the economy of the city. A considerable amount of the work associated with track cleaning is due to inappropriate behaviour on the part of the public, such as discarding litter on the tracks. Additionally, in major stations, a high proportion of unhygienic wastes are generated from deficiencies in the refuse collection system. Due to the poor coverage of the collection system, a number of people opt for discarding their wastes on the tracks. In essence, this situation merely transfers the responsibility for removing the wastes from the refuse collection crew to the cleaning crew. Other causes that lead to the large quantities of litter that may be observed insome stations are improper or no clean-up activities after completion of public works, lack number of dustbins on platforms or trains, inadequate or inappropriate products sold on stations bought by general public, accumulation of packaged materials as well as used bottles on the tracks, and spillage of wastes set out for collection by either scavengers or animals.

1.2 Types of track wastes

For purposes of solid waste management, track wastes can be classified into two main categories, depending upon the type of generator. The classification is as follows:

a) Wastes generated by natural causes as the name implies, these wastes are generate by natural phenomena and are difficult to avoid. They include dusts blown from unpaved areas, and leaves and flowers that fall from trees and plants nearby the tracks. Since wastes produced by natural events cannot be avoided, the method of management must be controlled, for example, by cutting down the plants nearby the tracks that are already dead or not planting the trees or plants near the track.

b) Wastes generated by the public

As previously indicated, a large fraction of these wastes can be controlled, provided that an efficient and reliable refuse collection service is in operation and that dustbins are provided for use by daily travellers. These two conditions should be complemented by a continuous program of public education, combined with strong legislation and enforcement procedures. Another potential solution to reducing the amount of wastes is to offer a free or relatively inexpensive program to collect non-conventional wastes such as bottles, packaged items, bulk papers and others.

II. LITERATURE REVIEW

Augustus Day 1890*has* ***analysed*** that class of track cleaners which are attached to the pilot of an engine and sweep or scrape the rail to free it of any slight obstructions .The objective of this paper wasto provide means for sweeping or scraping all light, low, and small obstructions from the rail and leave it in such a condition that the driving-wheels of the engine will come in direct contact with the metal of the rail. To provide means for lifting the operating parts of the track-cleaner from the rail when not required for use, and to so construct the cleaner that the operating parts can readily and easily be exchanged when broken or worn out, and it consists in the devices for attaching the cleaner to the pilot of the engine and in the means for operating it, in the means for attaching the broom or sweeper to the plate of the cleaner, so that it can readily be inserted or removed, and in the construction of the broom by which the working parts may be removed and replaced when broken or worn out, and in the peculiar construction, arrangement, and combination of parts, as hereinafter more specifically set forth. Similarly

Edward Sheilds 1933analysed a device for cleaning away from the tracks any sand or other loose dirt which is 'character to be distributed through the air by the Violent air currents created by trains passing over the tracks Another object of the invention is to provide a1 mechanism which is designed to be periodically drawn over track lines to thoroughly clear away sand-or dirt from the track so that no matter of this character will be present to be sucked up into, the mechanism of trains or discharged into passenger cars which may pass over the liner the invention broadly contemplates the provision' of a wheeled structure which traverses the tracks and which carries a hood which lies in close proximity to the tracks and into which fluid under pressure, preferably steam or air, is discharged so as to stir up the dirt immediately .surrounding the track to facilitate the ready carrying of the same through a discharge head or nozzle by means of which the dirt may be discharged to one side of the roadway.

Henry Hefter 2004patented a paper wherehe proposed **a**model ofrailroad track cleaning car having a cleaning element suspended between a pair of wheeled trucks. The cleaning element is an abrasive material that is affixed to the underside of a weighted chassis that is suspended from a pair of articulating arms connected to the respective wheeled trucks. The cleaning material is easily replaced by removing a pair of fasteners from the chassis. A spring tension apparatus is positioned between the articulating arm and the cleaning element chassis to selectively position the cleaning element over the model railroad tracks. A retaining wire is captured in the articulating arm and engages the corresponding truck to turn the articulating arm with the truck, thus positioning the cleaning element over the model railroad tracks even when traversing a curve. A thumb wheel is formed with a notch that receives the articulating arm to lock the thumb wheel into a selected position. One mode of cleaning the railroad tracks is to manually clean the surface of the tracks with appropriate cleaning material, usually wet with a cleaning solution, but this is a rather slow and laborious process. Providing a railroad car properly equipped with cleaning material will effect a surface cleaning of the railroad tracks while the model train is being run around the tracks.

Frank L Warner 1917 has patentedhis theory where his invention relates to roadbed cleaning devices and has particular reference to means for cleaning streets, roadways or the like by pneumatic means. Among the objects, therefore, of this invention is to provide a machine including one or more mouthpieces adapted to be moved along the surface to be cleaned, and each comprising means to create botha suction and air blast within or beneath such mouthpiece, together with auxiliary agitating means to facilitate the loosening up and delivery of the dirt.

Another object of the invention is to provide a self-contained machine having one or more of the aforesaid mouthpieces and power means for creating a continuous current of air acting upon and through the mouthpieces both as a blast and as suction, means also being provided in the current of air to separate the dust there from without stopping the current of air.

III METHODOLOGY

- ***Study of Existing track cleaning machines***: In this step it was observed various track cleaning machines that are available with the Indian Railways. For cleaning Various techniques were used by different machines ,For instance one of the track cleaning machine observed was a machine which used vacuum power to clean the tracks but this system was very expensive.

- ***Selection of mechanism for the Track Cleaning Machine***: By observing various other tracks cleaning machines available it was observed the way in which each of these machines removed the dirt from the tracks. At the end the conclusion of using a blower, roller brush and a collecting chamber was determined in order to collect the dust material.

- ***Preparation of rough model***: In this stage observation of different mechanism started to find out into how our machine would look and the way in which it would collect the dust particles. A lot designs were looked into and then a particular model was adopted.

- ***Selection of Appropriate Materials***: Selection of the appropriate material is necessary to build an efficient system where in the cleaning activity of the machine is fast and effective. Material used to build the system was mostly mild steel and nylon which was used to make the rotary brush.

- ***Calculations and 3D Modeling***: Calculation design of the shaft and blower required for transmission was calculated. Accordingly a 3D model was prepared using

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modeling software NX CAD. Modeling in solid edge gives the dimensional pictorial view of the track cleaning machine which was to be designed.

- ***Fabrication and Assembly of the Track Cleaning Machine***: After preparing the 3D model of the track cleaning machine operations like arc welding, spot welding, drilling, grinding were carried out using different machines. The full system was then fitted using bolts and nut.

4.2.1 Design Considerations

The main issues that would be considered to design and fabrication of machine are:

a) Economic consideration
b) Environmental consideration

a) ***Economic consideration***: It goes without saying that engineering practice involves utilizes scientific principles to design components and systems that perform reliably and satisfactorily. Another critical driving force in engineering practice is that of economic, simply state, the company or institution must realize a profit from the product it manufactures and sells. The engineer designs the perfect component, however a manufacturer must offer the product for sale at price that is attractive to the Institution and in addition return a suitable profit to the company. Three of the main sectors where economy could be a factor are:

- **Component design:** A major portion of the cost of a component is associated with its designing. In this context, component design is the specification, size, shape and configuration, which will affect in the component performance. Component design is a highly intensive proves which involves many compromises and tradeoffs. The engineer should keep in mind that an optimal component design might not be possible due to system constraints.

- **Material involved:** In terms of economy, we generally reject the materials having the appropriate combination of properties, which are the least expensive. Once the material has been selected that should satisfy the design constraints and cost comparison among the various materials that are used for fabrication of similar equipment.

- **Environmental consideration:** In the modern technologies and the manufacturer of products, impacts the society in a variety of ways, some of which are positive or beneficiary while others are adverse.

4.3DESIGN OF THE MACHINE

4.3.1 DESIGN OF SHAFT:

The C-45 steel was used as shaft material in the present equipment. The properties of the C-45 steel are;

Yield stress (σ_y) : 353 N/mm^2

Shear stress (τ_y) : 176.5 N/mm^2

$$\text{Design stress } (\tau_{ed}) = \frac{\text{Shear stress}}{\text{Factor of safety}} \text{ --------- (i)}$$

: $\frac{176.5}{5}$ (FOS=5)

: 35.3 N/MM^2

$\boldsymbol{\tau_{ed}}$: **35.3 N/mm^2**

Torque transmitted for a speed of 700 rpm

$$M_t = \frac{(9.55 * 10^6 * P * c_s)}{N} \text{ ------------- (ii)}$$

Where,

N = 700 rpm

P =750 W = 0.75 kw

C_s = Service factor = 1.5

$$Mt = \frac{9.55 \text{ x } 10^6 \text{ x } 0.75 \text{ x } 1.5}{700}$$

Mt = 15348.21 N-mm

Thus, diameter can be given by the relation,

$$D = \sqrt[3]{\left(\frac{16 \text{ x T x } k_t}{\pi \text{ x } \tau}\right)} \text{ -------------- (iii)}$$

Where, K_t= Endurance factor = 1.5

$$D = \left(\sqrt[3]{\frac{16 \text{ x } 15348.21 \text{ x } 1.5}{\pi \text{ x } 35.3}}\right)$$

= 14.93 mm ~ 15 mm

Considering uniformity and standard availability, a shaft of 20 mm is selected.

4.3.2 Design of V-Belts:

Diameters of both pulleys are,

d = 60

D= 100 mm

1. Cross section of belt:

Equivalent pitch diameter of smaller pulley

= $d_e = d_p K$ ....(iv)

Where d_p = d = 60 mm

$\frac{N1}{N2} = \frac{100}{60} = 1.66$

for the value of 1.66, K = 1.12

Therefore d_e = 60 x 1.12 = 67.2mm

The cross section of belt selected corresponding to the equivalent pitch diameter d_e = 67.2 mm is **'A' cross section belt**

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2. *Velocity*

$$v = \frac{\pi d n_1}{60000} \text{-------------------------- (v)}$$

$$= \frac{\pi \times 60 \times 2800}{60000} = 8.796 \text{ m/s}$$

3. *Power capacity*: For A cross section belt,

$$N^* = .7355v \left\{\frac{0.61}{V^{0.09}} - \frac{26.68}{d_e} - \frac{1.04\, v^2}{10^4}\right\} \text{----(vi)}$$

= .624 KW

4. *Number of v belts:*

$$i = \frac{P\, F_a}{N^* F_c F_d} \text{ ------------- (vi)}$$

Correction factor F_a= 1.2

P=0.75 KW N* = .624 KW

Pitch length of the belt

$$L = 2C + 1.57\,(D+d) + \frac{0.25\,(D-d)^2}{c} \text{--------(vii)}$$

Centre distance = 615 mm, D=100, d=60mm

Therefore, **pitch length of the belt = 1481.85 mm**

For this length and A cross section belt, correction factor for length F_c = 0.98

Angle of contact,

$$\phi = 2\cos^{-1}\left(\frac{D-d}{2c}\right) = 176.27^0 \text{ ---------------- (viii)}$$

For this degree, correction factor for angle of contact F_d = 0.99

Therefore, ***number of belts i = 1.02~1***

4.3.3 Calculations for Blower:

1. ***The Ideal power consumption*** for a Blower (without losses) can be expressed as.

$P_i = p \times q$ ----------------------------- (1)

Where,

P_i = ideal power consumption (W)

p = total pressure increase in the blower (Pa, N/m^2)

q = air volume flow delivered by the fan (m^3/s)

650 = p × .05

Therefore,

Pressure increase = 13000 N/m^2.

2. ***Blower Efficiency**:*

The Blower efficiency is the ratio between power transferred to airflow and the power used by the blower. The blower efficiency is in general independent of the air density and can be expressed as:

$\mu = pt \times q / P$ --------------------------- (2)

Where,

μ = Blower efficiency (values between 0 - 1)

pt = Total Output Pressure (Pa)

q = Air Volume delivered by the Blower (m^3/s)

P = power used by the fan (W, Nm/s)

$\mu = 29453 \times 0.05 / 650$

μ = 0.4413

4.3.4 Calculations for Nozzles :

Container Capacity = 3 Lt

Diameter of Hose pipe = d_{hose} = 5mm

Diameter of Nozzle = d_{noz} = 3mm

We know that,

Continuity equation = Q = $A_1V_1 = A_2V_2$

Where,

Q = Discharge

A_1 = Area of hose

A_2 = Area of nozzle

V_1 = velocity of water via hose

V_2 = velocity of water via nozzle

Now to find

$V_1 = Q/A_1$

$A_1 = \frac{\Pi}{4} \times d^2$

$A_1 = \frac{\Pi}{4} \times .005^2$

$= 1.96325\times10^{-5}$ m^2

$Q = 5.5248\times10^{-6}$ m^3/s

$V_1 = Q/A_1$

= 0.28m/s

$A_2 = \frac{\Pi}{4} \times d^2$

$A_2 = \frac{\Pi}{4} \times .003^2$

$= 7.0677\times10^{-6}$ m^2

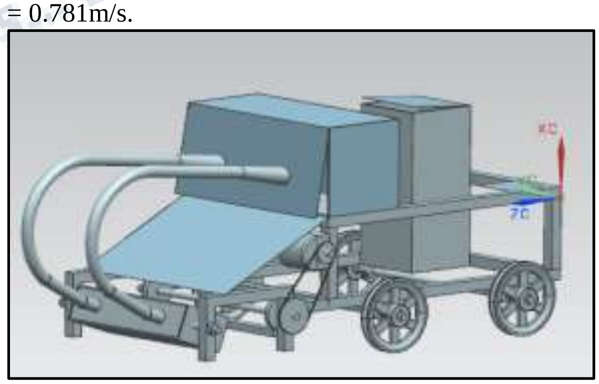
Hence,

$Q = 5.5248\times10^{-6}$

$A_2 = 7.0677\times10^{-6}$

Therefore,

V_2 = 0.781m/s.



IV RESULT

After the fabrication of the railway track cleaner several tests were done with the track cleaning machine to check whether the track is being cleaned effectively or not. At first, test was done for amount of wastes the machine would collect in the collecting chamber. The wastes taken were mostly bulk papers and few bottles with small amount

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of sand in it. These wastes were dumped in the collecting bin. First the Wastes from the collecting bin was emptied on the scaled railway track then the wastes were deposited according to the different cases. The machine was used to clean the wastes and they were collected in the collecting chamber of the machine which was emptied into another bag. The mass was then weighed. Same steps were followed for different weight of wastes and the efficiency was found for the percentage of waste collected by the machine.

Case 1: Concentrated Wastes.

Wastes were mostly concentrated in the centre of the track and also mostly to the centre portion of the rotary brush. The waste was deposited on a length of four meters and a width of .8 m for the concentrated approach.

Sl NO	Mass of Wastes deposited on the track in kg s	Mass of Wastes collected in the collecting chamber in kg s	Efficiency $= \frac{\text{Mass of waste in the collecting chamber}}{\text{Mass of waste on the track}} \times 100$ in %
1	0.30	0.250	83.30
2	0.40	0.370	92.30
3	0.50	0.489	97.80

Table5.1 Concentrated Wastes

Case 2: Scattered wastes

Wastes were scattered on the track and were deposited on a length of four meters and a width of 6m for the scattered approach. The same steps were followed and the following table shows the details.

Sl NO	Mass of Wastes deposited on the track in kg s	Mass of Wastes collected in the collecting chamber in kg s	Efficiency $= \frac{\text{Mass of waste in the collecting chamber}}{\text{Mass of waste on the track}} \times 100$ in %
1	0.30	0.217	72.30
2	0.40	0.323	80.75
3	0.50	0.447	89.40

Table 5.2 Scattered Wastes

Case 3: Intermediate deposition of Wastes

Wastes were scattered and some of them was concentrated at the centre of the rotary brush. The same steps were followed and the following table shows the details.

Sl NO	Mass of Wastes deposited on the track in kg s	Mass of Wastes collected in the collecting chamber in kg s	Efficiency $= \frac{\text{Mass of wastes in the collecting chamber}}{\text{Mass of wastes on the track}} \times 100$ in %
1	0.30	0.225	75.00
2	0.40	0.341	85.25
3	0.50	0.460	92.00

Table 5.3 Intermediate deposition of Wastes

CONCLUSION

A Multi-Operational Railway Track Cleaner has been designed and fabricated to be used in cleaning of Railway Tracks effectively. Track Cleaning in India is generally done engaging manual labourers .According to the estimates done by various workers, an average of 10 womanlabourers are required to clean a stretch of 2 KM. Considering the existing local wages at the rate of Rs300 perlabour per 8 hour's work, the total cost of cleaning a road 2 KM long engaging 10 labourers comes to Rs.3000.

Further, it was found that there will be a considerable scarcity of labourers in the future and also the cost of employing labourers will also increase as it has shown in the past ten years. Considering the above points, the Track cleaning machine has been developed. This cleaner consists of a main frame to which a blower, a rotary brush, a prime mover of .750W DC motor , a geared motor for transmission Manually controlled water spraying system and a pulley system to transfer the power to the rotor.

Also Power consumed by the presently available track cleaner is too high and are costly, hence in contrast with the present track cleaners available with Indian railways the proposed model consumes less power, is cost efficient and reasonably sized.

SCOPE

The following suggestions were made to further improve the railway track cleaner;

(a) A vacuum suction device can be fitted to both the ends of the rotor shaft region so that the dust that is blown out through the sides can be collected effectively and hence will improve the efficiency of the track cleaning.

(b) The collecting chamber can be clamped to the main frame using certain type of clamps and hence can be conveniently removed and the dust particles be removed. This system can also be automated with censors so that when the dust collected inside the collecting chamber reaches its maximum then it can indicate this information on a LCD or LED screen that can mounted close to the handle.

(c) The motor can be provided with a speed controller so that according to the dust particles present the speed of the rotary brush can be changed. So if there are stones on the road then the speed of the rotor can be decreased so that it does not hit the metal end of the collecting chamber hence ensuring life of the chamber as well as the user.

(d) A universal joint can be incorporated to the machine so that the brush can be moved in the desired angle.

(e) A pump can be adjusted in the water tank to control the speed of water sprayed by the nozzles.

(f) A pneumatic system can be used for dumping the collecting chamber.

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