

Design of Semi-Automatic Roof Cleaning Machine

¹Rohit Patil, ¹Tushar Parab, ¹Shubham Marathe, ¹Rajat Naroji, ¹Suraj Padji, Students, Dept. of Mechanical Engineering, Agnel Institute of Technology and Design, AssagaoGoa-403597, India.

²Dr. M H Nadaf, Head of Department, Dept. of Mechanical Engineering, Agnel Institute of Technology and Design, AssagaoGoa-403597, India.

³Shiva Krishna J, Assistant Professor, Dept. of Mechanical Engineering, Agnel Institute of Technology and Design, AssagaoGoa-403597, India.

Abstract— Roof cleaning is the process of removing algae, mold, lichen and moss from roofs. Cleaning of roof becomes very difficult when the height of the roof is very high also the surface of the roof becomes slippery during rainy season. To design and fabricate a semi-automatic roof cleaning machine which is capable of cleaning dirt, grime, algae etc. on roof having reliable slope. Enabling the machine in accessing hard to reach areas on the roof and at higher altitudes. To make the controlling of the machine user friendly such that person with less technical knowledge is able to use it. To make a machine which will take care of safety of persons, save time and also shouldn't damage roof structure. This method of roof cleaning can be used for cleaning roof of hotels, offices etc. which will give more appealing look. This method is suitable for small, medium as well as for large roof cleaning.

Keywords— *Roof Cleaning, Reliable slope.*

I. INTRODUCTION

The manual, chemical and mechanical cleaning methods cannot meet the needs of cleaning. Manual cleaning is the most widely practiced method nowadays. The roofs are cleaned using manpower to scrub it with the wire brush. This method is time consuming and tiring. In the Konkan region of India, especially in the states of Kerala, Maharashtra and Goa the houses usually have tile roofing, corrugated cement sheeting etc. This tiles/sheets are arranged along a reliable slope. The cemented sheets are usually used for garages, store houses and also in Industrial roofings. Upon fitting as the years go by, these tiles/sheets are covered with dust, dried algae, tiny shrub etc, which makes the roofs look dull and old.

By carrying out cleaning operation the roof are kept clean and at the same time is also increases the life expectancy of the tiles/sheets.

In conventional method of cleaning, cleaners have to climb on top of these roofs and carry out the cleaning operation by scrubbing with the help of wire brushes. This method is tiring and at same time it consumes a lot of time.

Also the person carrying out the cleaning operation can severely injure him/her self, if he/she falls off from the roof causing accidents. There are chances of person getting unconscious due to prolonged exposure to heat during hot weather conditions.

Cleaning of roof surfaces is a challenging task, as the surface is not even and also have tendency of breaking easily upon mechanical loading. However a no. of attempts have been made for cleaning the various roof surfaces at present, only few are dedicated towards household and industrial roof cleaning.

Another product which is based on roof cleaning, have used a rotor arm which has small openings at both ends towards roof surface, and this is mounted on a swivel housed inside a housing. The rotor arm rotates due to water pressure and does the cleaning operation as the machine is manually guided over the roof surface.

[2] Nopparat Seemuang have designed a cleaning robot for cleaning greenhouse roofs, the design involves a cleaning module to which a set of wiper blades are attached and a guiding module which guides the cleaning module structure over the roof surface. The design that is being proposed is of permanent fixture type that needs to be installed on the Curved surface greenhouses.

[3] Youhong Nie et.al. has developed a cleaning device for greenhouse film roofs, it involves a cambered support mechanism which arches across the greenhouse and the attached to it is the cleaning mechanism, which includes a set of nozzles and cleaning brushes. A driving mechanism traverses this devices along the roof surface with the help a set of guideways.

Another research papers speaks about the various spray pattern and the coverage areas obtained from a variety of nozzles. It takes into consideration the nozzles outlet angle

and the stand-off distance in-order to calculate the spray coverage. Spray coverage for multiple nozzles at different stand-off distance's are pre-calculated and presented in form of a table.

[5] Arunkumar S M et.al.has developed a 360 Degree wheel rotation vehicle which uses a single steering to rotate all 4 wheels at the same time. It involves a sprocket attached to the steering wheel column which is connected to the sprocket's of front and rear wheels by chain drive.This enables the vehicle to change direction without moving from the spot (i.e.vehicle has zero turning radius).

The objective of the cleaning machine developed in this study are to ensure easy and proper cleaning of roof surface, enabling the machine in accessing hard to reach area present at heights, reduce the risk to cleaners and reduced cleaning time.

II. CONCEPTUAL DESIGN

The design is made by taking in consideration its ease of operation, maintenance, set-up, and low cost. The most important parameter being the weight of the machine and its ability to move it across the roof surface more easily.

The design consists of a simple frame that is being mounted on a set of driving wheels. This entire structure will carry a common rail and high-pressure nozzles will be attached to it linearly. The principle of water jet pressure cleaning is the key element. The design is simple and portable.

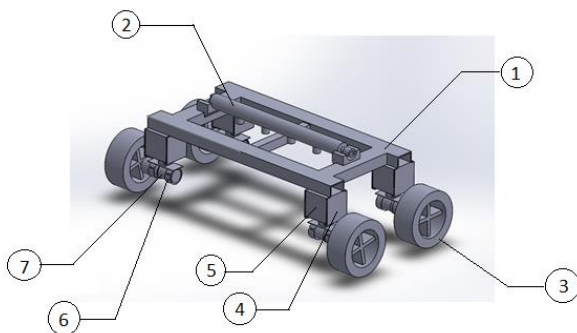


Fig. 1. Basic CAD model of Machine

1.Frame, 2.Common rail, 3. Wheels, 4.Stepper motor bracket, 5. Stepper motor, 6.Servo motor bracket, 7.DC Servo motor

III. DETAILED DESIGN

A. Frame

The frame consists of two longitudinal members and 3 supporting cross members.The Longitudinal members are rectangular in cross-section, purposely chosen to carry the weight of the other components that are to be mounted on top of it. Whereas the cross members are square in cross section

and this are provided to give the additional strength and support.

The overall length of the frame is 0.5 m and is 0.3 m wide and the net weight of the frame is approximately 4 kgs. The material that is used is Mild Steel, which is suitable enough to withstand the external force acting on it. The Frame is provided with brackets/attachments at desired locations for the mounting of the Stepper motors, common rail, control module and other auxiliaries.

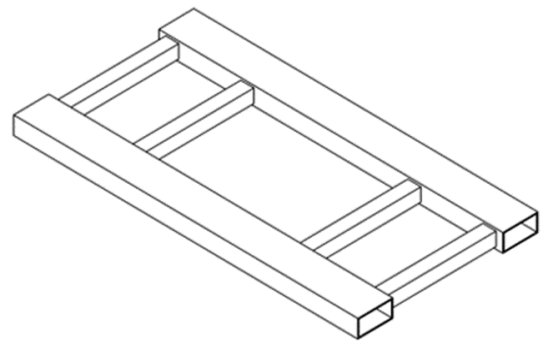


Fig 2. Frame structure

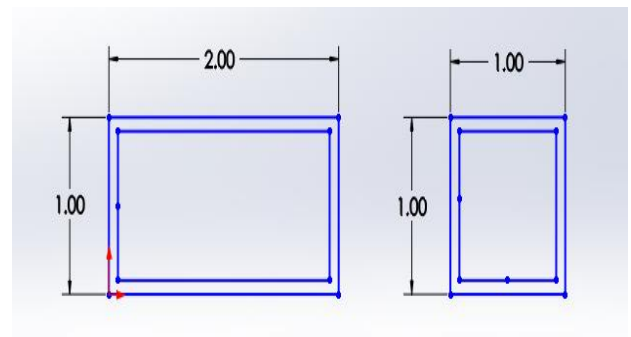


Fig.3. Frame member cross-section

B. Cleaning Module

The Cleaning module consists of 3 main components, namely:

- 1) Nozzles
- 2) Common rail
- 3) Pump

Nozzles are the once that will provide a proper water jet spray, which is very much necessary in carrying out the cleaning operation. In-order to know what kind of nozzle are suitable for this process, it is first recommended to know the area of cleaning, operating pressure required and the attachment facility provided.

Based on these parameters, a 40-degree flat spray pattern nozzle is best suitable, since it has a wider coverage area as compared to 25,15,10,0 degree nozzles. These nozzles are capable of withstanding pressures as high as 4500 psi.



Fig.4. Water Spray Nozzle

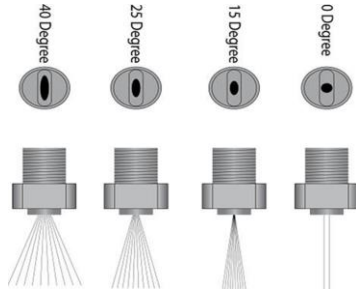


Fig.5. Spray pattern for various Nozzles

Common rail is the another most important component in the entire machine. The common rails are usually made from Cast Aluminium or Stainless steel material, which gives it the desired properties of withstanding high pressures and corrosion resistance. Usually these can withstand pressures as high as 4000-4500 psi.

The nozzles can be attached onto the common rail and this entire assembly as combined can be easily attached on a frame, in such a way that upon supplying high pressure water through the rail the nozzles can direct spray the water at velocity against the surface to be cleaned.



Fig.6. Common Rail

Pump is the final and the most important component under Cleaning module, the pump helps in delivering the right amount of pressure which is required to carryout the roof cleaning. Usually 1500-2000 psi pressure is required inorder to remove considerable amount of dirt, that is present on the roof tops.

C. Driving Module

The Drive mechanism consists of pairs of wheels, which are powered by High torque DC Motors. The wheels will hold onto the frame and each wheel house an individual motor. The choice of the motor is based on the load it has to pull and the traction required to hold the entire assembly on the inclined roof surface. The driving system consists of DC motor and Stepper motor.

The DC motors are the one which will drive the wheels and help the machine to move over the roof surface i.e Climbing over the roof. There are 4 DC motors in total which are attached at each end of the frame. DC motor will drive wheels in forward and reverse direction with the help of a (DPDT) Double Pole Double Throw switch, the function of the DPDT switch is explained under Control scheme. The motor produces more than required value of torque so machine will be able to climb the slope and also weight of DC motor is less which adds advantage on roof surface. Also the assembly of motor is easy.

The calculation for Torque required on each wheel, with respect to the overall weight of the machine is as shown below :

Considering the Gross weight of the machine to approximately 10 kgs,

> Weight on Each wheel = 2.5 kg

> Radius of Wheel = 6.25 cm

Based on this data, Torque can given as,

$$\begin{aligned} \text{TORQUE, } T &= (\text{WEIGHT}) * (\text{RADIUS OF WHEEL}) \text{ ----- (i)} \\ &= 2.5 * 6.25 \\ T &= 15.625 \text{ Kg-cm} \end{aligned}$$

This means that each wheel requires a minimum torque of 15.625 Kg-cm and by assuming there will be some slippage losses, the motors to be used is selected such that, it has much higher torque delivering capability to propell the entire machine structure.

Motor Specification :-Motor speed : 10 rpm

Motor rated torque : 140 kg-cm

Supply voltage : 12 V DC

The stepper motors are used to provide steering ability to the wheels. The wheels should steer 90 degrees so that the machine can easily switch to different area for cleaning in short period of time(i.e. move across the roof surface). The stepper motor is controlled by an external driver circuit or micro controller which will assist the wheels in rotating to the desired degree of angle. There are 4 stepper motors in total which are attached over DC motor so that DC motors along with wheels steers in particular direction.

Motor Specification :- Step Angle : 1.8 degree

Holding torque : 10.2 kg-cm bipolar

Operating voltage : 10V-35V DC

Steps : 200

D. Control Scheme

The cleaning machine will be controlled from a main console box. The control diagram is shown in the Figure below. Due to

working in wet condition, all motors, wires, controllers are well-protected within enclosures.

DPDT Switch

The switch helps in changing the polarity of current supplied to the motors, which in turn drives the motor shaft in either Clockwise or Anti-clockwise direction, thus enabling the machine to climb upwards or downwards along the roof.

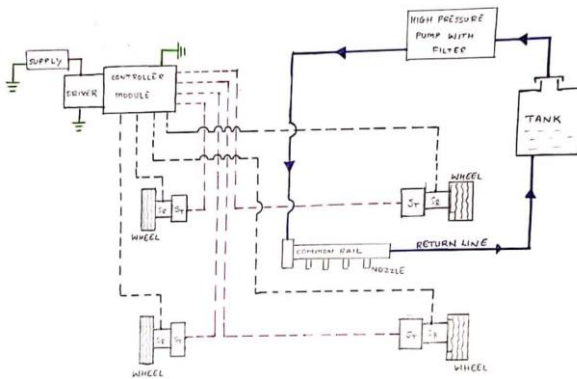


Fig.7. Machine work flow diagram

The stepper motors move in steps of desired angle, in order to achieve the required degree of rotation the motors need to be interfaced with an integrated circuit and are run via a coded program which is fed through a microcontroller circuit (such as ARDUINO). Based on the computer program the stepper motors will rotate in the desired direction by required angle. This overall system gives the machine the ability to steer

without any human intervention, thereby saving more time in the overall cleaning process.

IV. CONCLUSION

In the present day scenario the roof cleaning is not a common practice that is carried out in a country like India, and even if it is being carried out somewhere it is done with the help of labours. These labours are forced to climb on the roofs sometimes located at much higher heights without taking any safety measure. The ideology of bringing ahead the idea of a Semi-Automatic roof cleaning machine, is with due respect to the concern of safety of these workers. This machine will enable a person to carry out roof cleaning operation with minimum physical efforts and mainly without any labour dependency.

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