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Design and Optimization of High Rise Building Cleaner

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Abstract

Recent days cleaning of high rise building glasses took too much cost and manpower. The traditional way of cleaning high rise building glasses from outside require special tools, mainly for the crew safety. So the window cleaning process can be automated or brought under as an unmanned device which reduces the risk factors using the microcontroller. The proposed structure consists of a triangular frame, suction cups, and threaded shafts along with AC geared motor, DC motors, and water pumps. The machine movements are controlled by Arduino using a motor system. Creo is used as the designing tool. The cleaning machine has three degrees of movements (X, Y, Z). The weight of the cleaner will be approximately around 17–20 Kg.

INTRODUCTION

This paper is based on a climbing system aimed to clean the window glasses of the high rise buildings. Cleaning the windows of high rise buildings from outside is really unsafe. So unmanned device can be employed here.[1].

Figure. 1.1. Traditional cleaning

In India traditional way of cleaning high rise building glasses are dominant by using climbing equipment. But the time and cost consumption for this kind of cleaning process is comparatively high. There is an increasing demand for unmanned cleaning devices because of easy accessibility.

The available cleaners in the market are usually coming under two categories namely

- Cleaner with vacuum chamber

Figure. 1.2

- Cleaner with lifting cable.[2-4].

Figure. 1.3

The theme of the project is to build a small climbing cleaning machine using suction cups for adhering to the surface of glass windows. The idea is to combine both the above cleaners into one. By doing this the emerged problems from the above cleaners will be rectified.[3].The combination of two cleaners will yield greater efficiency in cleaning. The cleaner with vacuum chamber is costlier and too heavy, so it increases the critical chance of getting a failure when it moves over the glass surface. Also, it consumes much time to clean the surface. First, the suction is done on the glass window then the cleaning process starts with rotating brush or with wiper using soap and water solution.[6].

The cleaner with lifting cables is a rapid one. Even though the rate of cleaning is high the quality of cleaning is too low. The rapid lifting of the whole cleaner takes place with the rotating brush which cleans the surface of the glass windows of high rise buildings.[5].

This type of cleaners is mostly used for dry cleaning whereas the vacuum type cleaners used for dry cleaning as well as for wet cleaning. The amount of dirt wiped by the cleaner is low because of dry cleaning. In case of using it for wet cleaning, it results in wavy dirt formation over the entire surface of the glass. These unconventional cleaners will yield desired results by meeting optimized design.

The combined working of above two cleaners will yield satisfying results. The cleaner needs lifting mechanism, in some cases special rigging mechanism used. These movements can be automated or with manual interventions.

Then the cleaning portion requires suction cups to maintain stagnant position over the glass surface along with that it has two rubber wheels to support cleaner and to enhance the

cleaner motion smoothly over the glass surface.[6]. It has the rotating drum of a brush to clean.

The entire cleaning portion is controlled by the microcontroller. The lifting portion is manually operable by switching the motors ON/OFF.

The working model of the machine is shown below.

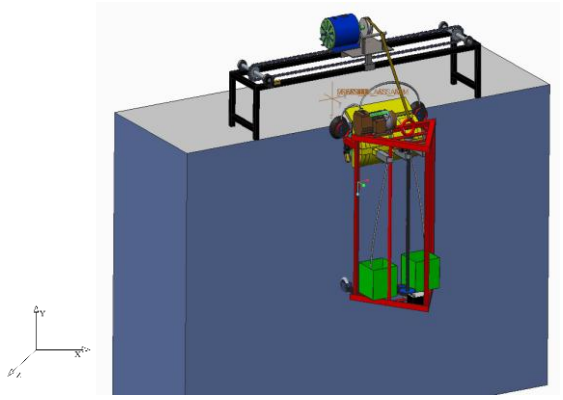

Figure.1.4.working model

It needs two working frames, first slider frame which is on the top of the building which must be fixed to the roof of the buildings. Then the cleaner tri frame which provides sufficient space for each and every component including the Arduino.[7]. The cleaner tri frame also has a battery of 6V for the microcontroller.

The tri frame will hold 15 – 18 parts. The weight assumption is about 17-20 Kg including all parts. The individual tri frame weighs about 10-13 Kg. The required components are listed as follows.

COMPONENTS

- AC geared motor
- DC motor
- Wiper motor
- Thrust bearings
- Lovejoy coupling
- Battery
- Vacuum pump
- Water pumps
- Spur gear
- Screw rods
- Wiper and brush
- Water tanks
- Arduino mega 2560
- Reed switch
- Microswitch
- PU ropes
- Rubber wheels
- Suction cups
- Chain and sprocket
- Permanent magnets
- Pulleys.[7]

WORKING OF SLIDER

The sequence of operation starts with the upper slider movements the X direction movements will be controlled by dc motor with the help of sprocket and chain. The slider frame must be fixed with the top of the building then the frame must have guider to move the motor setup. The AC geared motor is controlled manually. It can be totally automated with the help of delay timers with another Arduino, transmitter and receiver. When the upper motor moves it over the guides made over the slider frame. The DC motor which is used for the longitudinal motion can be at low rpm.[8]. The total chain sprocket will be duplex one according to the calculations but the standard pitch of 12.75 mm can be used here because of low power transmission and also it has sufficient factor of safety. [9].

Figure.3.1. Slider frame

PU ropes can be used instead of normal steel ropes because single slings of PU rope can be suitable to lift 500 lbs. Also, it does not require wire drum normally pulley can hold it with increased width.[10].

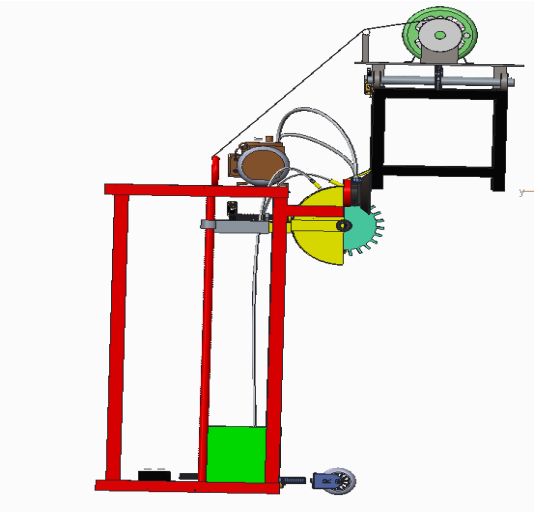

Figure.3.2. side view of the working model

WORKING OF CLEANER

After the slider moves the Arduino comes into the action with the help of delay timer. The tri frame consists of cleaning brush, vacuum pump, suction cups,

Water and soap tanks, two screw rods, spur gears, DC motor and a spraying nozzle.[10]. The wheel alignment little differs from brush because it has two motions, one is the vertical motion as well as Z or feed motion. A Voltage converter is used here to convert 240V-12V.

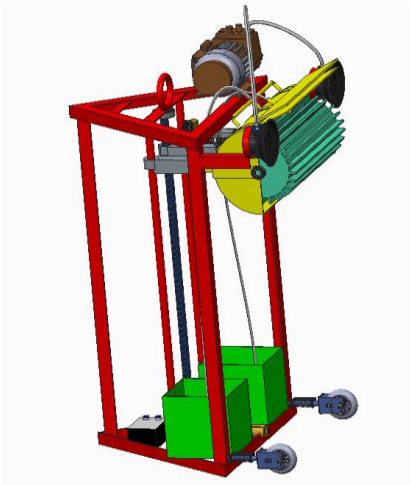

Figure.4.1. Cleaner frame

The Arduino mega 2560 has 54 I/O ports. After some time delay, the Arduino gives the command the wiper motor, the cleaning brush starts rotating and then to the screw rod motor for Z motion, which moves the total guard and cleaning drum towards the glass surface. After some extension of screw rod, the vacuum pump starts its work with the help of the suctions cups, which gives better adhering to the glass surface. Also, it helps to maintain the position of the cleaner against strong wind zones. The rubber wheels do not cause any damage to the surface. After this, the water pump begins to pump the desired solutions. First, the soap solutions are sprayed over the surface of glass through nozzle above the cleaning brush.

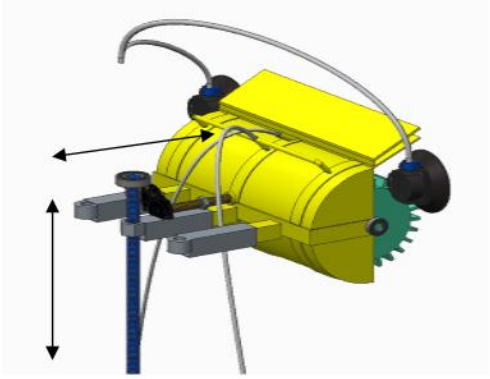

Figure.4.2. Cleaning brush

After the soap solution get sprayed over the surface, the main DC motor which is attached with the spurs gears starts rotating this will move the entire cleaning setup vertically downwards[7]. The screw rods can be connected directly to DC motor by using love joy coupling over thrust bearing. Reed switches are placed at the ends of the screw rods which gives the signal to the Arduino to change the direction of the motors with the help of microswitch. Reed switch will be closed in presence of magnetic field and becomes open when it lacks magnetic field. So permanent magnet is used to produce signals which are placed in the cleaner setup. Once the cleaner hits the bottom of the setup reed switch will get closed and it triggers the microswitch which changes the direction of the motor and also stops the soap solution's pump. Again it reaches the top of the setup reed switch does the same job as it did before, also it starts the water pump and water will be sprayed over the window surface. The cleaner will repeat the same procedure. After completion of two cycles, the final cycle which is swiping cycle will be carried out with the help of wiper.

Figure.4.3. Working model

After the completion of three cycles the vertical lead screw motor will be stopped then the suction cups will be withdrawn from the window's surface. After that, the cleaning brush will stop rotating then the cleaner is lifted vertically upward by the PU rope sling. After reaching the top of the building the slider will move the cleaner horizontally by the human intervention. Then the same cycle is repeated again and again to clean the entire surface of the building windows.

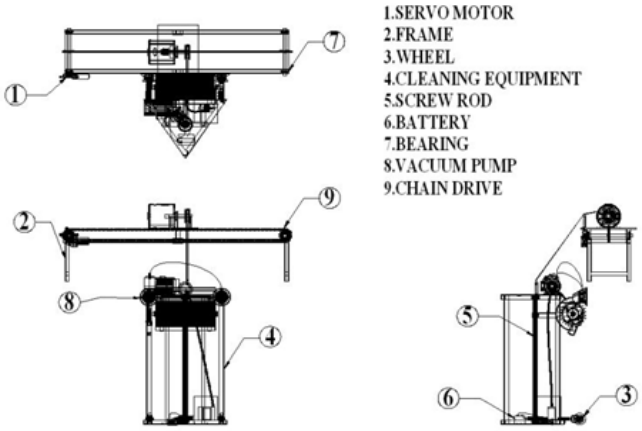

Figure.4.4. Outline of the model

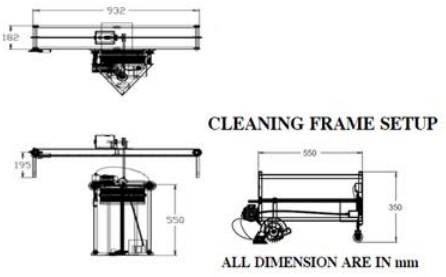

Figure.4.5. Dimensions of the model

SPECIFICATIONS

MICRO DC MOTOR - Model: SF-578VA

BATTERY- 12V

GEAR - Zp=25,D=32 mm (no of teeth and diameter)

Zg=49,D=62 mm

SCREW ROD - horizontal. d=10 mm, l=75 mm.

Vertical d=13mm, l=550 mm

SPROCKET - Z=13, pitch=12.7mm, t=5.85 mm.

CHAIN - 08A-1 R 40, pitch=12.7mm, l= 1.96 m

No. of links = 155.

PULLEY - Diameter= 48 mm.

VACUUM PUMP

Rated voltage: AC 230V.

Operating voltage: AC 220-240V.

Suction capacity: 25L/ min.

Water pump

Rated voltage: 12V DC

Max flow rate: 4L/MIN(1.06G/MIN).

Max Head(lift height): 3m

Pump material: ABS.

ARDUINO MEGA 2560.

SCOPE

These types of high rise building cleaners have a wide range of applications in the fields like

- Domestic purpose
- In hotels
- Hospitals
- Industries.

These kinds of cleaners will be made into unmanned device entirely.

ADVANTAGES

- Highly reliable.
- The cost of the system is low.
- Compact in size and the weight of the machine is also less
- No need for skilled operators to operate this system.
- Time taken for cleaning operation is less.

LIMITATIONS

- Maintenance is difficult.
- Most number of moving parts.
- The battery must be checked and replaced periodically.

CONCLUSIONS

This mechanical setup is designed with pneumatics and electronics to provide better cleaning. This contemporary design of these kinds of cleaners helps to overcome the limitations of the existing technologies in façade cleaning system. The rate of cleaning is moderate but the quality of the cleaning is much more superior.

Even the slider mentioned above can be even optimized by removing chain drive and implementing single row of chain and additional AC motor with sprocket where both the ends of the chain drive will be fixed to the slider frame which helps in the motion of cleaner horizontally by rowing over the fixed chain links. Image processing techniques can be used to identify the amount of dirt present over the surface of the window. Even more desirable with artificial intelligence.

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