DESIGN AND DEVELOPMENT OF SIMPLIFIED ROAD CLEANING MACHINE WITH MODIFIED TECHNOLOGY SUITABLE TO INDIAN ENVIRONMENT

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Abstract

A novel method of road cleaning application for Indian roads has been thought of and developed a "Simplified Road Cleaning Machine with Modified Technology Suitable to Indian Conditions". This equipment can be used for cleaning the long distances and wide width reduces the human effort, so that the cleaning can be done in a single drive. This system has been used to clean roads and could clean various forms of papers, covers, food beverages, smooth dust and unwanted waste noticed on the roads.

It is seen at present that a human pushing machines and cleaning is doing with human effort, and it is always to be done when roads are operated without traffic. Large machines have been made to overcome this problem, but it is very costly. In order to make less effort and very efficient system we can use the scrubbing system.

But scrubbing system is also not possible because of due to large roads, with running traffic. So, I am having an idea and design. In this design, collection of objects from 250GMS to fine dust can collect from roads with high efficiency. I hope that it will emerge as a future cleaning system.

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By using this system, it can be regulated with respective cleaning speed with the speed of the vehicle. So, it is easy to clean in the traffic also because this system/machine is very efficient at all speeds. i.e., slow (or) high (or) even at moderate speeds of the vehicle. The cleaning ranges from the objects to dust. So, it covers all requirements of Indian roads. The system can be filled with additional accessories and mountings to make it feasible to clean the roads of large width and the interact corners. Even though this system works on the vacuum cleaner principle its range of cleaning area, sizes of particles are much larger with low cost.

Literature review

Roads sweeping, either manual or mechanical, has been a normal operation for most municipalities for hundreds of years with aesthetics and sanitation purposes. Therefore investigation on street sweepers efficiency have been focused on the minimization of transport of pollutants (PAH, metals) to receiving waters. Currently, street sweeper types fall into three main categories: mechanical broom, vacuum-assisted broom and regenerative-air units. Schilling (2005) provides a list of sweeper manufacturers for US, available models and common specifications for such equipment. Vacuum-assisted and regenerative air sweepers are generally better than mechanical sweepers at removing finer sediments, while mechanical sweepers are better at removing larger debris (FHWA 2007).

The vacuum cleaner was invented by Hubert of England in 1901. As Booth after decades later, that year he attended "a demonstration of an American machine by its inventor" at the Empire Music Hall in London. The inventor is not named, but Booth's description of the machine conforms fairly closely to Thurman's design, as modified in later. Booth watched a demonstration of the device, which blew dust off the chairs, and thought that " if the system could be reversed, and a filter inserted between the suction apparatus and the outside air, whereby the dust would be retained in a receptacle, the real solution of the hygienic removal of dust would be obtained." He tested the idea by laying a handkerchief on the seat of a restaurant chair, putting his mouth to the handkerchief, and then trying to suck up as much dust as he could onto the handkerchief. Upon seeing the dust and dirt collected on the downside of the handkerchief, he realized the idea could work.

A hand-powered pneumatic vacuum cleaner was designed in 1910. An early electric-powered model is also shown

The first vacuum-cleaning device to be portable and marketed at the domestic market was built in 1905 by Walter Griffiths, a manufacturer in Birmingham, England. His Griffith's Improved Vacuum Apparatus for Removing Dust from Carpets resembled modern-day cleaners; – it was portable, easy to store, and powered by "any one, who would have the task of compressing a bellows-like contraption to suck up dust through a removable, flexible pipe, to which a variety of shaped nozzles could be attached.

In 1906 James Kirby developed his first of many vacuums called the "Domestic Cyclone" It used water for dirt separation. Electric vacuum cleaner by Electric Suction Sweeper Company, circa 1908.

In 1907 department store janitor James Murray Spangler (1848-1915) canton invented the first portable electric vacuum cleaner, obtaining a patent for the Electric Suction Sweeper on June 2, 1908. Crucially, in addition to suction from an electric fan that blew the dirt and dust into a soap box and one of his wife's pillow cases, Spangler's design utilized a rotating brush to loosen debris. Unable to produce the design himself due to lack of funding, he sold the patent in 1908 to local leather goods manufacturer Henry Hoover (1849-1932), who had Spangler's machine redesigned with a steel casing, casters, and attachments, founding the company that in 1922 was renamed the Hoover Company. Their first vacuum was the 1908 Model O, which sold for $60. Subsequent innovations included the

Beater bar in disposal filter bags in the 1920, and an upright vacuum cleaner in 1926.

Minton et al., (1998) tested a high efficiency sweeper equipped with a strong vacuum coupled with mechanical main and gutter brooms using a dry system combined with an air filtration system (down to 2.9 µm). The pickup performance for < 63 µm range was higher (70%) than regenerative air sweeper (32%). For the > 63-70 µm particle size ranges instead very similar.

Duncan et al., (1985) tested the performance of an improved vacuum sweeper (ISS) for finer particles by adding partial hoods to the gutter brooms, and venting air stream through a spray venturi scrubber. The new vehicle clearly eliminated the dust plume during the sweep and increased the sediments pick-up efficiency to 80%. As compared with the regenerative air sweeper, the advantages offered by the ISS were only concerning particles smaller than 500 µm, since for larger particles the efficiency were similar. Moreover the residual sediments left by the ISS were constant, independently from the initial load. With respect to the initial PM10 load, the emission, at the head of the venturi scrubber was within 2-40%, with an average of 10%. No evaluations were made on air quality.

Captive Hydrology technique was developed to clean airport pavement surfaces (http://buyersguide.dsvr.co.uk/ profiles/a/associated asphalt/ or http:// www. veegservice.nl/). The pick-up heads may include a high-pressure washer system followed by intensive vacuum pressure. Relatively small amounts of water are entrained leaving a nearly dry pavement surface. Water is recycled within the machine. Mobility is a big advantage, as cleaning can be done where and when needed. A captive hydrology machine is currently being used as the pollutant control device for the controversial Cross Israel Highway. The initial application of this technology was for airport runway resurfacing (rubber and paint removal) to increase skid resistance and industrial applications where very clean surfaces are required. The City of Olympia (Washington) has included it in its 2005 budget (Olympia, City of., 2005). However the Captive Hydrology technique has yet to be reported extensively for routine worn surfaces with cracks and uneven sections. The units have a high capital cost. In Nevada local protocols establish to remove residual abrasive within four days following the drying out of the road surface; during one of these intervals Gertler et al., (2006) could compare emission potential before and after broom sweeping event. They found a slight increase of PM10 emissions after the road sweeping. For PM2.5, there was a more dramatic increase after sweeping (from 133 to 211 mg/km). These results are consistent with the study conducted in Idaho by Kuhn's et al. (2003), where the authors found by means of TRAKER (testing re-entrained aerosol kinetic emission from road) an unexpected mean increase of 16% of emission potential after a road sweeping and vacuuming (Table 2), even if authors indicated a possible displacement of dust, from the curb to the active lane, induced by the sweeper. They outlined the importance of considering, beside a negative effect on the short term, a long term effect of sweeping. Indeed although the sweepers are ineffective for reducing PM10 road dust emissions in the short term, it may be premature to conclude that street sweeping has no effect on the urban scale PM10 emission inventory. If street sweeping can remove large particles, that may evolve into PM10, then sweeping may have a beneficial effect on air quality over the long term. This mechanism, not examined by the studies reviewed, should be studied since it may have important implications for the effectiveness of street sweeping programs in PM10 emission reduction.

Impact of road dust emissions on health

Brunekreef and Forsberg (2005) concluded in a review of a number of epidemiological studies that ‘there is some evidence for effects of coarse PM on mortality, mostly in arid regions’. Transition metals embedded in road dust, such as Cu. Fe, Mn, Ni and Ti contribute to the oxidative capacity of PM (Prahalad et al., 1999; Clarke et al., 2000). Valavanidis et al. (2005) demonstrated that redox-active transition metals act synergistically with redox cycling quinines and PAHs to produce reactive oxygen species, and that particularly ferrous ions in PM play an important role in the generation of hydroxyl radicals. Schlesinger et al. (2006) indicated that transition metals such as Cu, Zn, Fe, Ni, Cr and Mn, which may act as redox compounds, are likely related to PM toxicity. Moreover coarse particles can elicit inflammatory effects (Schins et al., 2004; Schwarze et al., 2007). Association between high levels of coarse man-made particles and daily mortality in Barcelona (Spain) has been shown by L. Perez et al. (2008) who also found a worsening during outbreaks of Saharan dust. In a more recent work L. Perez et al. (2009) found that cardiovascular and cerebrovascular mortality were associated with increased levels of both PM1 and PM2.5–10. De Kok et al. (2006) found a positive correlation between the cytotoxicity of TSP and the sum of transition metal concentrations. A recent study in Sweden, found that PM10 generated by erosion of road pavement by studded tires provoked an inflammatory responses in cells as potent as the response caused by diesel particles (Gustafsson et al., 2008). Comparisons of six European cities (Jalava et al., 2007, 2008; Happo et al., 2007) evaluated the cytotoxic and inflammatory activities of atmospheric PM in contrasting air pollution scenarios.

Coarse particles showed higher inflammatory effect than the other PM size fractions, especially in Southern Europe. This high activity for these samples was attributed to the lack of rain, which may account for the poor washout of road dust and the consequent accumulation of coarse PM (with high levels of brake pads metals) on the road pavement.

Recent developments

A British company in 2004 released arider, a hovering vacuum cleaner that floats on a cushion of air. It has claimed to be light-weight and easier to move over (compared to using wheels), although it is not the first vacuum cleaner to do this the Hoover Constellation predated it by at least 35 years.

British inventor has developed a new cleaning technology known as Air Recycling Technology, which, instead of using a vacuum, uses an air stream to collect dust from the carpet. This technology was tested by the Market Transformation Programmer (MTP) and shown to be more energy-efficient than the vacuum method. Although working prototypes exist, Air Recycling Technology is not currently used in any production cleaner.

Scrubbers

Scrubbers are machines used to clean large surface areas such as walkways, roads, factory floors, and parking areas. Scrubbers can be used in either indoor or outdoor applications, and include small walk-behind machines and larger, rider-based machines.

Scrubbers use brushes, scrub heads, and squeegees to clean surfaces of dust, dirt, oil spills, glass, and stains. Scrubbers typically come with a squeegee and vacuum system that effectively removes much of the water used to clean, leaving the floor almost dry. The vacuum system also helps to remove small objects and debris as well as draw water back up in to the scrubber. A scrubber consists of a solution tank that contains a cleaning fluid. Some scrubbers come with recycling solution tanks that are able to reuse the cleaning solution, minimizing the time needed to refill the tanks. Scrubbers are also used to sanitize surfaces in medical buildings, biological and pharmaceutical research laboratories, and production facilities.

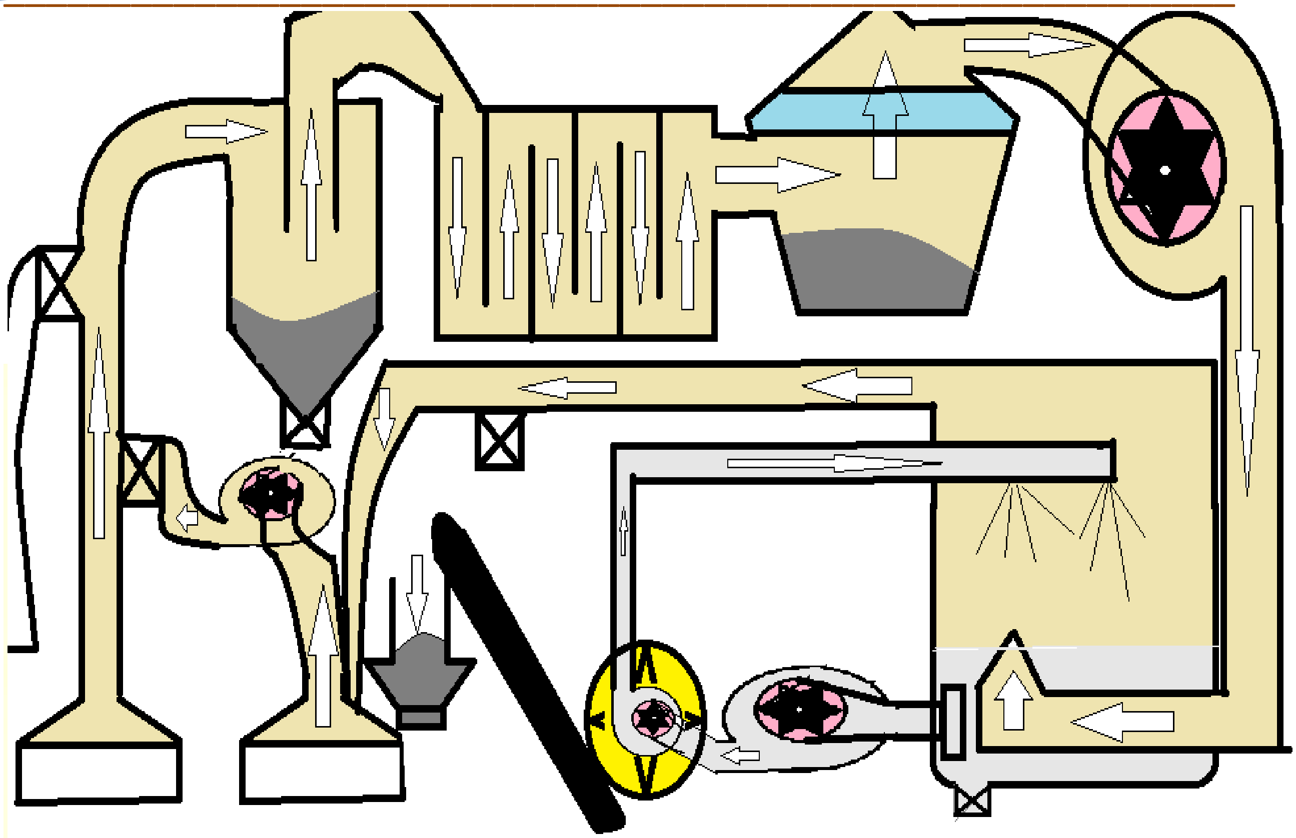
Scrubbers are used to maintain floors in high-traffic public areas such as shopping malls, hospitals, schools, cafeterias, and office buildings. A hall scrubber is typically a walk-behind machine that cleans corridors and walkways. A floor scrubber is used to clean factory and warehouse floors, school gymnasiums, and manufacturing facilities. Scrubbers use electronic sensors to maintain brush pressure on floors, even on irregular surfaces.

Large scrubbers are used to clean roads and parking lots, and may also incorporate a sweeping mechanism. A sweeper scrubber machine includes a combination of dry brushes for sweeping up and removing debris and wet brushes or scrub heads for washing surfaces. A road scrubber is often used by municipalities for maintaining clean streets and parking areas.

Explanation

It is a system consisting of equipments like

- Suction Basin
- Cyclone
- Muffler
- Blower
- Filters
- Wet scrubbing system
- Pumping system
- Belt conveyor
- Brushing system
- Magnetic system



SIMPLIFIED ROAD CLEANING MACHINE PROPOSED DESIGN

Process

This system consists of two suction cups which sucks dust and air through them. Then air flows through the cyclone, muffler, filter and in to blower. Then the air stream is pushed through wet scrubbing system and in to recyclable system.

Each and every equipment working and usage in the system are explained clearly below.

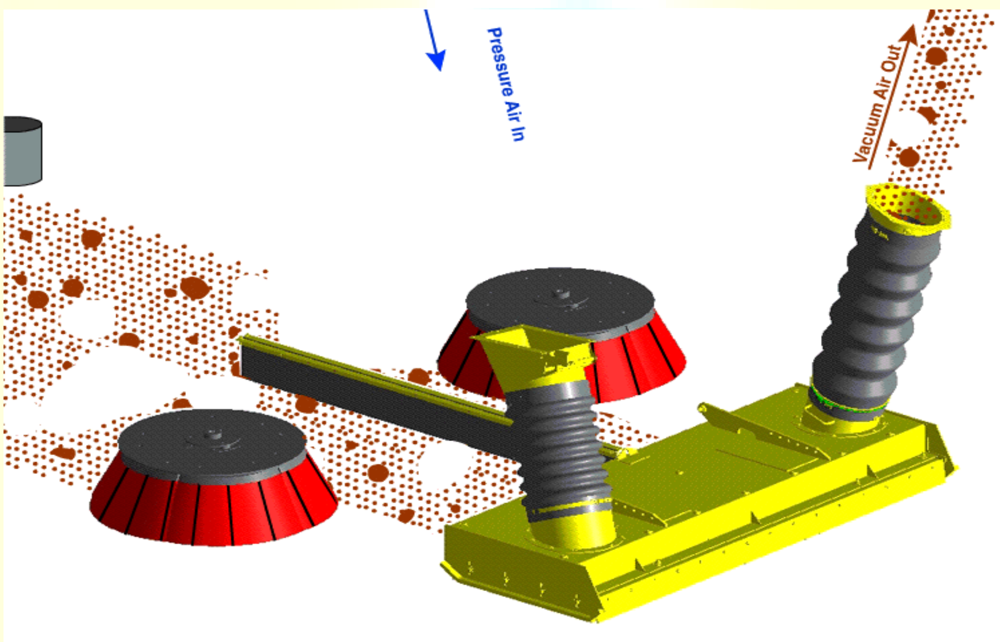
Suction Basin

Suction basin contains the area that is used for sucking the particles from the grounds from small particles to fine dust particles. It is where we can regulate the width of cleaning area. Suction takes places in the form of recyclable dust cleaning and Suction mode.

Recyclable mode:

In the recyclable system the air is obtained from blower in to the suction basin. In recyclable system air enter from one side and air goes to the blower from other side.

Then the moving air carries all the dust particles in the way with high pressure and no air comes outside the cycle. Due to air strikes the incoming area stuffed dust will be removed from the road and cannot be done with the regular systems.



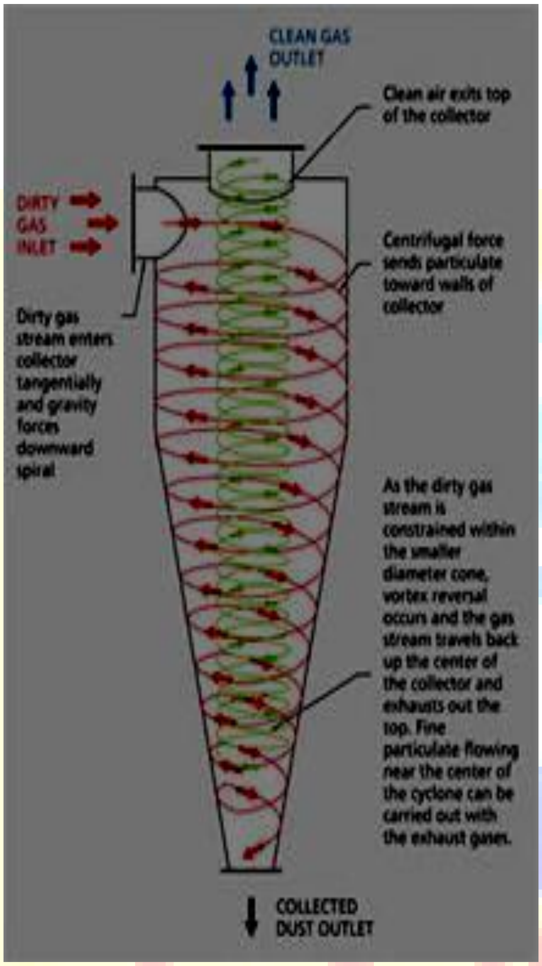
Suction type

Suction type model is a system that carries away the dust due to the vacuum created in the cyclone. In this system it carries the dust particles in the range of all papers to dust.

Based on the requirement the process for the system can be changed it from one mode to other by using pipe lines and valves.

Cyclone

Cyclone is equipment used to regulate flow and separate dust particles by using swirl motion. To improve this system, generated swirl motion is designed by using screw type structure in the cyclone, around the delivery pipe. When flow enters in to the pipe in a swirl structure, regulates the flow to circulate within the system to get fine particles entrapped in a cyclone. But the disadvantage in this system is, it increases the load on the blower. This swirl technology system can collect maximum amount of dust in to the cyclone. Dust collected in the cyclone can be removed by using the vent provided in the bottom when cleaning is completed. Care has to be



taken while designing a pitch of swirl screw, which may affect the working of the cyclone, blower. Regular flow of the system can be damaged when pitch is unequal throughout the screw.

Muffler

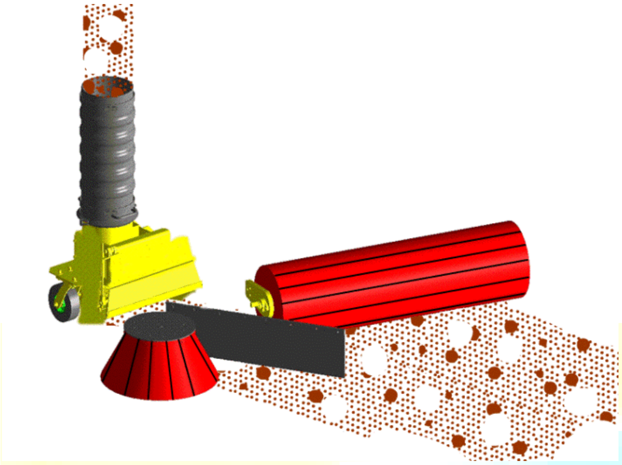
Muffler is a device in which baffles (or) walls are placed in the same way as cyclone was altered, in the previous section the design of muffler is also altered to get required output. Actually mufflers are used to reduce the sounds produced by the flowing gases, in opposite directions throughout the flow. This dust cleaning machine is designed to collect fine particles and dust from flow. Obstacles (walls) in a muffler reduce the flow rate which will be helpful to collect large amount dust in to it. Plates are joined together to with stand. So, when bottom plate is opened to collect the dust from it. Bottom plate is packed with the rubber lining to avoid air leakage. This system is placed in between the cyclone and the blower in a cycle.

Blower

Blower is a device used to produce air. Actually the air producers are divided in to three types depend up on the compression ratio. I.e., pressure produced by the equipment. They are

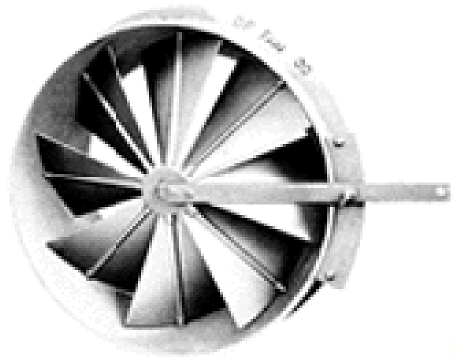
- Fans
- Blowers
- Compressors

Fans are used to produce the pressure up to the 2000 PSI and blowers are used to generate a pressure up to 12000 PSI and compressors are used for more than12000PSI. Fans and blowers are designed in the same way but the volume clearance in the fan is more than the blower. So, the fans can produce high flow rates and low pressures. The blower produces high pressures for the same impeller. While designing an impellor, the considerations to be taken depending up on the usage of impeller in the particular situation. These impellor can be designed as the following according to need.



Even though the impellors are divided in to three, their design is altered by taking slight change in the vanes. It leads to drastic changes in the suction; like one type can suck high flow rate with low pressure and one can suck weighing objects with low flow rate. So, selection of forward vane system with over bend in the angle can be satisfied. So, it can be used for sucking of heavy objects with medium flow rates.

EQUIPMENT	SPECFIC RATIO	PRESSURE RISE (MM.WG)
FANS	UP TO 1.11	1136
BLOWERS	1.11 TO1.2	1136—2066
COMPRESSOR	MORE THAN 1.2	--------



RADIAL FAN

FARWORD CURVED FAN

BACKWORD CURVED FAN

Filters

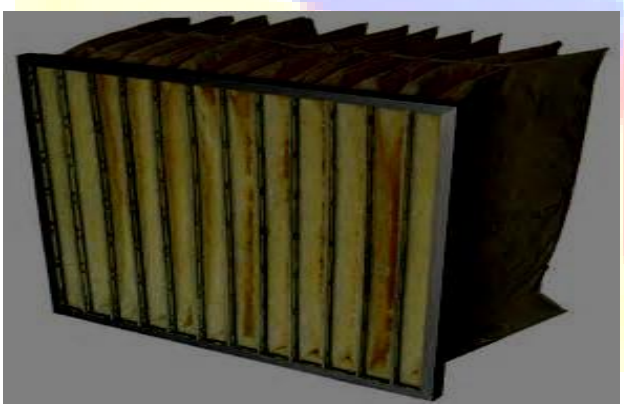
This is main part which plays a key role in this system. When sweeping is done on the roads dust disturbs and floats in the air, which causes air pollutes leads to damage the human lungs. In order to collect the dust particles filters are used to trap them in a system.

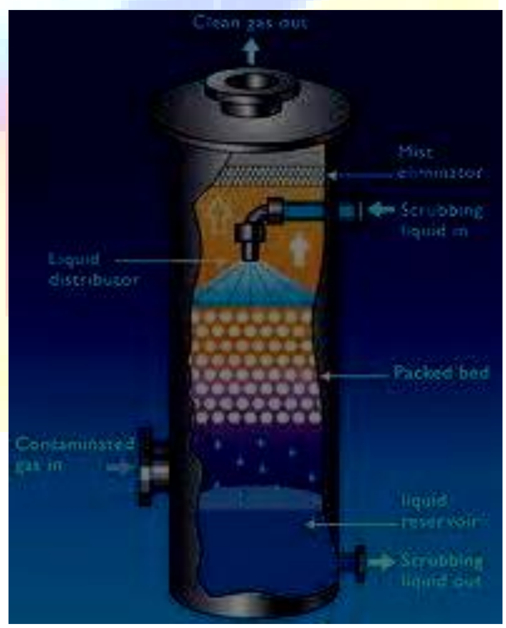
Filters are of many types which are available today in the market. We can select them according to the requirements. Requirements like space availability, fineness of dust in area of cleaning, cost, and effectiveness. They are like

- Bag filters
- Lobe filters
- Sac filters
- Paper filters

- Grill filters
- Sponge filters

Filters are specified by fineness of the dust particles that can obstruct in microns. When we go for the industries bag filters are being used, made up of cloths and fiber to collect fine particles. In blowers section it will be grill system. When speaking about dust cleaning machine we are satisfied with sponge type of filters. In this system sponges are used as filters. Sponges consisting of small spores through which air flows and dust particles are obstructed through it. Maintenance of this system is very less when compared to other systems because of particles entrapped in the sponge can be removed by using a splash of air on it. When a pressurized air is intended to flow through filters dust particles are removed. In cleaning machine blower is being used which will produce the pressurized air to clean it. So, the total maintenance cost reduces.

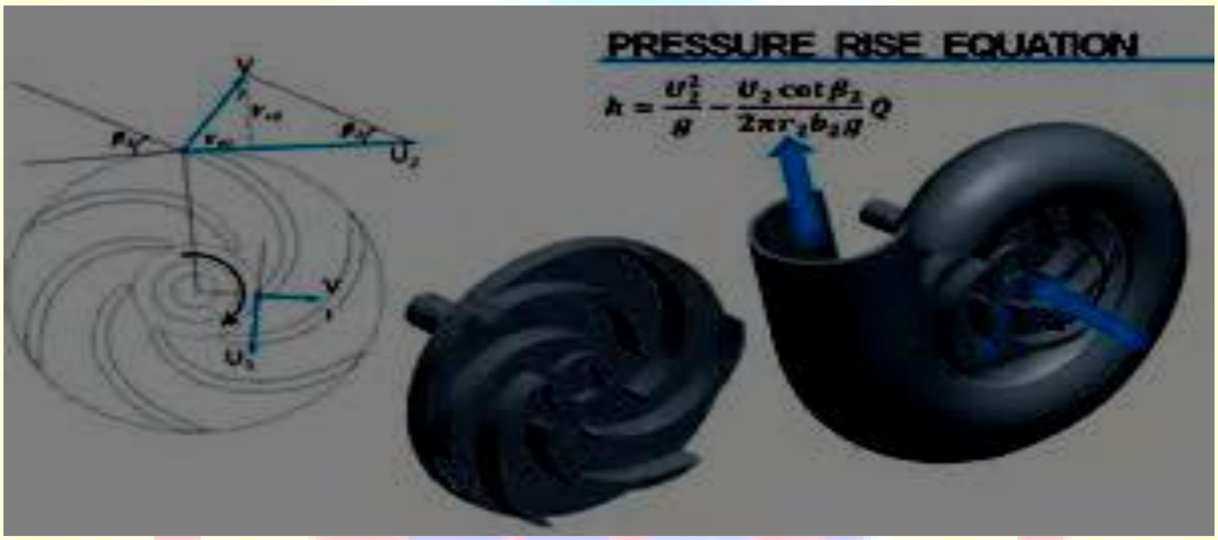




Wet scrubbing system

The name says the entire working system of a machine. This system consists of a pump which pumps the water by sucking from the sump. Strainer is being used at the sucking point to restrict the entrance of soiled particles. This pressurized water is used to regenerate the mechanical energy which is used to rotate brush placed in front of the whole system. Outlet of turbine (which is placed in the brushing system) enters in to the pipes which act as a shower. Waterfalls as a small droplets from the top and air flows the vice-versa. The water droplets catch the fine particles and falls in to the sump. The process is continuous till the end of the cleaning.

Water is drained after the entire process of cleaning is completed (as per the given flow rates, hours of working sump capacity, etc). In order to use the re circulated water we have to use the



equipment named as “filter press”. But due to lack of space and energy we have to change water regularly.

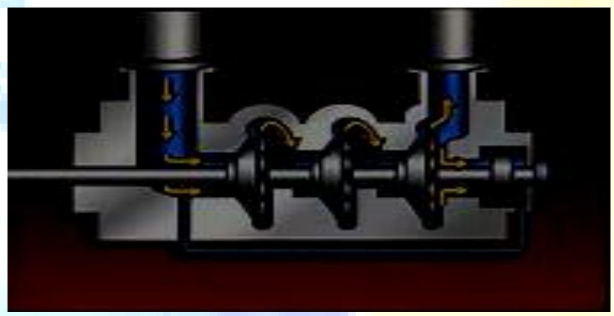
Pumping system

As explained in the before section the pump works on the power generated by the vehicle. Pump shaft is coupled with the shaft connected to the bull gear shaft. The change in the drivers speed regulates the pumping speed. The speed required is fixed by using the ratio of coupling. This pump used should be at most efficient condition, because it has to move the brushing shaft with mechanical energy. It will reduce the complexity in a structure and cost of bearings. Normally we choose the pump specifications depending up on the head or pressure. Head and pressure are related to each other by 10MTS of head is equal to 1 kg of pressure. In the same way the horizontal running of 10MTS is equal to the 1MT head. R.P.M of the pump should be high in order to work efficiently. Medium and low speeds R.P.M cannot produce the required effects.

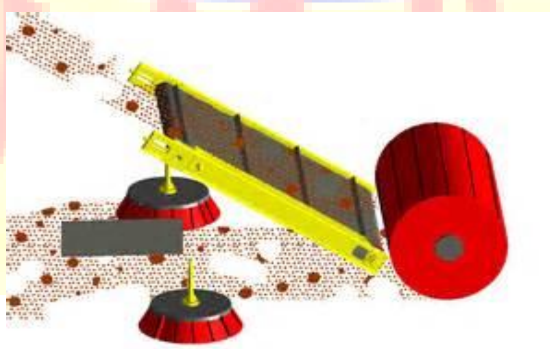
Belt conveyor

Belt conveyor is equipment used to carry the objects from one place to another through the belt. In this system we use the belt conveyor to move the objects (or) to move collected dust in to hopper.

Objects are pushed by the brush which is in front of the belt conveyor. Belt carries object from brush to hopper placed on the top. This belt conveyor can be made up of many materials like wood, metals, rubber, nylon ropes, etc. Design of this belt conveyor is to be in such a way that the belt should contact a road at a single point to collect the objects. Belt should be nearer to brush as it was touching to work effectively. It should carry away the loads, papers, stones,



covers, etc. (heavy particles that are on the roads).



Brushing system

Brushing system is a part which is used to brush the roads to collect the object. Size of the brush should be cleaning width of the vehicle. Cleaning area can be extended by using the various brushes placed in front of the main brush. They are placed outside and in front of the main roller brush to push outside dust in to main brush. Main brush pushes it in to the belt conveyor and it goes to hopper. So, brush plays a key role in the cleaning of the heavy objects.

Magnetic system

Magnets are used in front of the vehicle to collect iron particles on the roads.

Nails are main cause of patches for the vehicles. So, they must be removed from the roads. Large powerful magnet with the width of the cleaning stroke is placed in front of the vehicle to collect magnetic objects.

Calculations

This system is carried out by the driving shaft connected to the bull gear shaft of the vehicle. We can normally use all types of vehicles which can produce more than the requirement power of the system. We have to convert the required horse power (H.P) in to the cubic centimeter (C.C) and then select the amount of required powered vehicle. We should add the required C.C of the system to the required C.C of free moving vehicle and C.C for the load carrying backside of the vehicle i.e., when we put it in to the equation we can obtain a equation as

Horsepower Formulas

Air Horsepower = CFM X TP/6356

Brake Horsepower = CFM X TP/(6356 X ME fan)

Where ME fan = Mechanical Efficiency of Fan

Total required power = (power required by the system) + (power required by vehicle to move) + (power required by vehicle to carry the system)

Total required (H.P) = H.P (system) + H.P (vehicle) + H.P (load)

H.P (system) = H.P required by 2 blowers + pump + belt conveyor

H.P (vehicle) = H.P required by the vehicle to move in the high speed

H.P (load) = H.P required to carry the system weight

When we add the losses to the system like driver weight and other weights the load equation will be changing to

H.P (r) = H.P (s) + H.P (v) + H.P (L) + L

When factor of safety is considered for the system, due to fluctuations in a system and transformed equation will be

H.P (r) = f (H.P (s) + H.P (v) + H.P (L) + L)

F = factor of safety.

Estimation for normal machine:

Cost for suction basin:

Suction basin is made up of galvanized sheet of 22gauge; rubber supports pipe lines costs of 12,000/- including fabrication cost.

Cost for cyclone:

Cyclone is made up of mild steel 20" pipe and 5" pipes pipe lines it costs 10,000/- including with fabrication cost.

Cost for muffler:

Muffler is made up of mild steel sheet of 2mm costs of 4000/- including fabrication cost.

Cost for filter:

Filter consisting of sponges and a trey to hold. Total costs of 5000/-

Cost for 2 blowers:

Total material and fabrication cost for 2 blowers are around 20,000/-

Cost for pumping system:

Normal pump with minimum of 25M head will be around 25,000/-

Cost for wet scrubbing system:

Wet scrubbing consists of pipes, strainer, trey and a nozzle total approximately costs of 20,000/-

Cost for brushing and belt conveyor:

It consists of brush, extra fittings, belt conveyor, rollers, hopper and a turbine. These all costs of 40,000/-

Cost for truck:

Truck should at least consisting of 4 wheels, a structure to support the system, shaft and coupling systems approximately costs of 20,000/-

Cost for a vehicle:

While deciding a vehicle, considerations have to be taken as said before. Total H.P required by system, truck and self vehicle load have to be calculated. Normally vehicles costs of 3, 00,000/- to 5, 00,000/-.

Total cost of system will be approximately around 5, 00,000/- to 7, 50,000/-.

Conclusion

Using this Simplified Road Cleaning Machine with Modified Technology, Suitable for Indian Conditions, because of its reliability and expendability. Due to total cost of the system is very low and only one time investment has to be made for reducing labor charges. It will reduce human efforts drastically and very helpful to clean roads even in traffic. Due to these benefits, usage of this system helps in cleaning roads. I think there may be chance of using this machine in future of India.

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