" "SPILL CLEANING WITH APPLICATION OF VENTURI"" "

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Abstract

Vacuum equipment that operates on a higher level than commercial vacuums is needed in industrial setting like wood working, metal working or other processes that create a constant flow of debris, a cleaner which could serve both of wet and dry pick-up needs. Thus as a solution for this high powered vacuum requirement Pneumatic Venturi Vacuum Cleaner is applicable.In this paper, experimental studies were conducted to investigate the effects of inlet and throat diameters of the venturi tube, pipe length downstream of the venturi tube, diameter of the suction pipe at the throat portion of the venturi tube, angle of the pipe downstream of the venturi tube, flow velocity at the inlet portion of the venturi tube and density and viscosity of the liquid injected into the venturi tube on air and liquid injection rate. It was observed from the results that venturi tubes had high air and liquid injection efficiencies.In industries such as Pharmaceutical, Plastic & Rubber, Mining, Chemical, Beverages, Pulp & Paper and various other industries cleaning with hazardous material. Where question of spill recovery arises Pneumatic Venturi Vacuum Cleaner proves a boon. It helps in decanting liquids, cleaning up spills, cleaning plant and equipment to storing radiator coolant hence proves to be a perfect industrial cleaning tools.As name suggest it works on vacuum created with help of venturi (vacuum generator) which is its vantage points as it safe to use operating hazardous materials as there are no internal moving parts, also beneficial in case of saving time of cleaning spills & maintenance.

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Index Terms: *Venturi, Vacuum container, Bernoulli's Theorem, etc.*

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1. INTRODUCTION

This instrument uses compressed air as a working medium. The compressed air is supplied by a compressor, which needs external energy source. When the compressor reservoir is fully filled with pressurized air, then the air can be used whenever required. During this period the compressor is switched off. This saves valuable electricity, thus saving working cost. The equipment is highly efficient in comparison with the other vacuum cleaners which do not use venturi- tube as their working principle. It is because, the moving part of the conventional vacuum cleaner (i.e. pump) is replaced by a venturi- tube (i.e. ejector) in the 'Pneumatic Venturi Vacuum Cleaner'.

1.1. Need of Industrial Vacuum Cleaner

In small scale as well as large scale industries of chemicals, beverage, mining, pharmaceutical, textiles, Agricultural industries, food, automotive there is prime requirement during accidental spills, maintenance of spill recovery, decanting liquids, transportation. These operation look for high static lift in industrial vacuums as the lift is required to pick-up various liquid as an alternative solution to these requirements Pneumatic Venturi Vacuum Cleaner is having a conceivable potential.

As it has no moving parts ensures long life with low maintenance also venturi vacuum cleaner is air powered which require no electrical power source or lubricant hence they can be operated in hazardous environment where regular industrial vacuum cleaner has limited usage.

1.2.Main Objectives

1) To construct a vacuum cleaner without use of electricity directly.
2) To reduce the friction, this leads to high maintenance.
3) To construct a vacuum cleaner, which can handle inflammable fluids.
4) To facilitate spill cleaning in the areas where electricity is scares.
5) To promote cleaning on a new level.

2. DESIGN

2.1.Vacuum Container

- Thickness Of The Shell:

Material selected=AISI 1018(mild steel)

σ_{ut} = 440 Mpa

Corrosion allowance (C) = 1.5

FOS = 3

η_l = 0.85

p_w = 1000 torr = 1.3334 N/mm^2

p_i = 1.05 xp_w

= 1.05 x 1.3334

= 1.393 N/mm^2

- $\sigma_{all} = \frac{\sigma_{ut}}{FOS} = \frac{440}{3}$ = 146.6 N/mm^2
- $t_s = \frac{p_i X d_i}{2 X \sigma_{all} X \eta_l - p_i}$ + C

$= \frac{1.39 \ x \ 340}{2 \ x \ 146.6 \ x \ 0.85 - 1.39}$ + 1.5

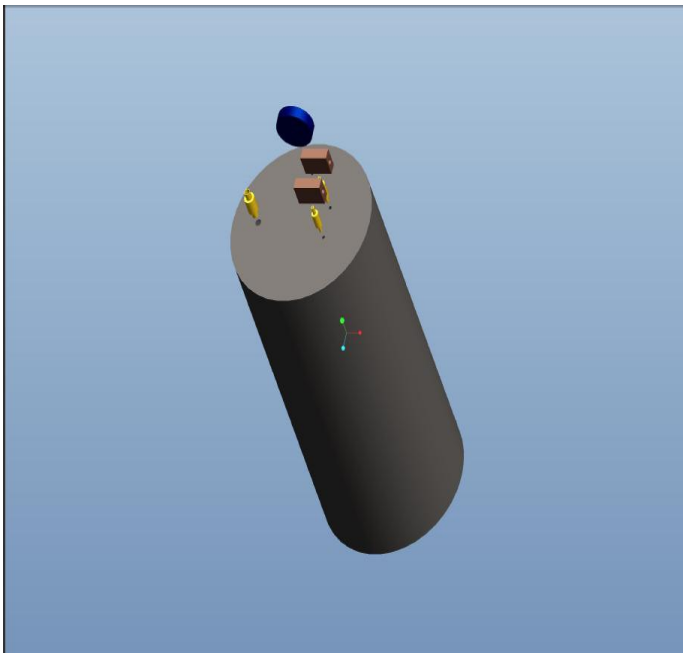
t_s= 3.4 = 4mm

- 2 . Thickness Of Head And Base:

Flat Head:

t_s= 0.4 x d_i x $\frac{\sqrt{p_i}}{\sqrt{\sigma_{all}}}$ + c

= 0.4 x 340 x$\frac{\sqrt{1.393}}{\sqrt{146.6}}$ + 1.5= 10mm



2.2.Base Plate

We have selected C40 (plain carbon steel) as our raw material for trolley of tank to sustain weight in full load condition about 80kg.

80 kg = 80 × 9.81

= 784.8 N

Material Selection is C40,

Syt= 680 N/mm^2

FOS = 5

$\sigma_b = \sigma_t = \frac{S_{yt}}{FOS}$

$= \frac{680}{5}$

σ_b = 136 N/mm^2

- Dimensions For L Angle

Assume b = 5d

$$I = \frac{bd^3}{12} = \frac{db^3}{12}$$

$$= \frac{(bd)d^3}{12} + \frac{d(5d)^3}{12}$$

$$= \frac{130d^4}{12}$$

$$I = 10.38d^4$$

Considering y = 0.016 for 784.8 N for 784.8 N

$$\frac{\sigma_b}{y} = \frac{M}{I}$$

$$\frac{136}{0.016} = \frac{59.361 \times 10^6}{10.83d^4}$$

$$136 \times 10.83d^4 = 59.361 \times 10^6 \times 0.016$$

$$10.83\, d^4 = \frac{59.361 \times 10^6 \times 0.016}{136 \times 10.83}$$

$$d = \sqrt[4]{644.843}$$

$$d = 4.91 \cong 5 \text{ mm}$$

Now,

$$b = 5d$$

$$b = 5 \times 5$$

$$b = 25 \text{ mm}$$

- The diameter of our tank is 420mm so length of trolley is 430mm

$$L = 430\ mm$$

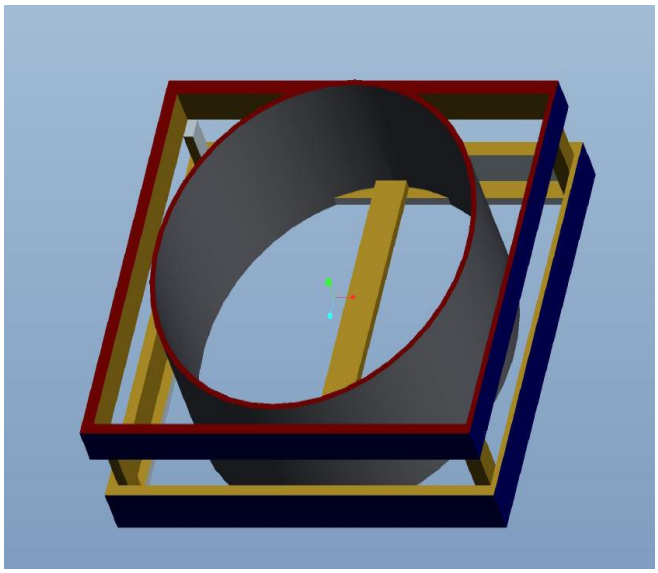
So dimension of trolley is,

For L angle,

$$b = 25 \text{ mm}$$

$$d = 5 \text{ mm}$$

$$L = 430 \text{ mm}.$$



3. CONSTRUCTION

1. It consists of a FRC (filter, regulator and control) unit. One end of which is connected to the compressor outlet and other end goes to the inlet of ejector.
2. To allow the flow of air in the tank, adaptors are used. Four adapters are used which are situated at the lid of the tank. They are used in combination and possess threaded joints.
3. On one of the pair of adapters ejector is placed and the extended opening of it from the throat reaches the tank with the help of adapter.
4. The inlet of ejector is supplied with compressed air through pipes and the outlet is kept freely open to atmosphere in order to avoid obstructions to flow of air.
5. The other pair of adapter is fixed just in the opposite side of the ejector on the lid of the tank.
6. A hose is attached to the other pair of the adapter with the help of hose clip for ensuring air tight fitting.
7. Special care should be taken to maintain the air-tightness of equipment. The only opening is the mouth of the hose.
8. The whole assembly of parts is done the tank and all the joints are threaded. Tank is placed in a trolley with wheels for mobility.

4.WORKING PRINCIPLE AND WORKING

4.1. Working Principle:

The working principle of pneumatic venturi vacuum cleaner' is based on the application of Bernoulli's theorem. So to know the working principle better the Bernoulli's theorem should be known and the theorem is given below.

4.1.1. Bernoulli's Theorem:

Bernoulli's theorem states that in any stream flowing steadily without friction the total energy contained in a given mass is the same at every point in its path of flow.In other words kinetic energy, potential energy and pressure energy each may be converted into either of the other two form of energy without any loss.

4.1.2. Application Of Bernoulli's Theorem:

A venturi is a cone shaped tube. It mainly consists of three parts as stated below

1. A short convergent cone.
2. A throat.
3. A long divergent cone.

The basic principle of venturi tube is by varying the cross-sectional areas pressure difference is created. The inlet section of a venturi tube is of the same diameter as that of pipe. The convergent cone is a pipe of decreasing diameter from connecting end of pipe to throat which is a small piece of uniform diameter, that of small end of convergent cone. The divergent cone is a tapering pipe from diameter of throat to diameter of pipe
In the convergent cone because of gradual decrease in diameter there is increase in velocity which can be checked by continuity equation.

$$\mathbf{Q = a_1 v_1 = a_2 v_2}$$

In divergent cone decrease in pressure is again increased to its original value and then liquid is reached in the pipe. In convergent cone the velocity of fluid is increased. This acceleration of flowing fluid may be allowed to take place rapidly in relativity. This small length of pipe without resulting in appreciable loss of energy, However if decrease in velocity of flow (in the Divergent cone) is allowed to take place rapidly in small length, then the fluid flowing will not remain in contact with the boundary of delivering flow passage, flow will be separate from walls and eddies are form. Generally length of divergent cone is 2-3 times the convergent cone.
The eddies which are formed near the walls of the divergent cone because of the high velocity are nothing but vacuum. To fill up this vacuum the venturi sucks the outside air and this brings the liquid along with it.

4.2. Working:

1. The compressed air from the compressor is given to the FRC (filter, regulator and control) unit, where air is filtered and pressure can be regulated by means of a regulator.
2. This compressed air is further given to the ejector situated over the adapter. This is the main function on which the equipment is all dependent.
3. When the compressed air enters the ejector, the convergent cone increases the velocity of air decreasing the pressure.
4. The situation remains unchanged when air passes through the throat.
5. Further when the air reaches the divergent cone it experiences sudden expansion in the cross-sectional area because of this the velocity suddenly drops thereby increasing the pressure. This is the theoretical concept.
6. As the outlet is kept open to atmosphere, so practically the air fails to give away all its velocity with fraction of a second and hence in the divergent cone it continues to flow with a very little decrease in velocity.
7. Due to this air is driven out very rapidly through the outlet at the end of the divergent cone and hence the air fails to make contact with the walls of divergent cone.
8. This failure of air results in the formation of eddies, these eddies are nothing but vacuum.
9. As per construction the extended outlet of the ejector from its throat is given to the reservoir (tank).
10. As there is need of filling up of the vacuum the free air from the tank is utilized because there is no other opening.
11. From the outlet air escapes with sonic velocity so this road becomes one way, no air can return back and due to this limitation all the free air in tank is utilized by ejector.
12. According to Newton's law air travels from high pressure to low pressure, hence all air in tank is utilized and now the tank is acquired with vacuum.
13. So to fulfil the vacuum in the tank, atmospheric air is used. The hose attached is exposed to atmospheric air, so air rushes into the tank because the tank is filled with vacuum. This air brings along the spill to be cleaned- up.
14. This works in a cycle. Compressed air is supplied till the whole spill is cleaned up. This leads to constant vacuum formation in the ejector at first and then the

tank. To fill this empty space, spill to be cleaned collects inside the tank.

15. This lasts till the compressed air is being supplied. More the pressure of compressed air more is the vacuum produced.

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CONCLUSION

To conclude, it can be said venturi vacuum cleaners are the future for industrial cleaning and maintenance equipment as it proves itself as a better option when compared with single stage compression unit or multistage unit used in regular industrial vacuum cleaner as it avoids complications, saving utility bills by maintenance free operation.

Much of the practical knowledge was gained about industrial environment, its cleaning and maintenance need. Survey of standard parts helped to accommodateeconomical purchasing. This Paper will develop professional practice but also technical knowledge.

FUTURE SCOPE

The proposed pneumatic venturi vacuum cleaner is now using one ejector (vacuum generator) of size ¼". But in order to achieve high speed operations, a ejector (vacuum generator) of size 3/8" can be used in combination. This implementation of this method enables the operator to clean up a large spill with great speeds. This method of bringing venturies ejector in use will considerably reduce the evacuation time. This will facilitate the use of large reservoir to ensure large storage capacity. Then by using a pneumatic venturi vacuum cleaner having more than two vacuum generators it will take only half time for cleaning up the same amount of fluid. This will save energy of compressor increasing the efficiency on the other hand. This will boost up the usage of pneumatic venturi vacuum cleaner.

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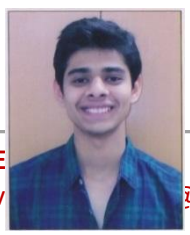

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