Vacuum Based Multipurpose Material Transfer Machine

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Abstract

Vacuum units are capable of handling the most difficult of materials and feature a unique delivery system. Powered by compressed air, the pneumatic units easily move products such as sludge & sand (grain density max up to 2.5 $\frac{g}{cm^3}$) agricultural grain, plastic resin, different size pellets and bins, are capable of delivering them to any desired location. Our vacuums have been used in a number of applications, from mining solutions to environmental and factory spill clean-ups. There are endless possibilities and applications. For plastic & agriculture industries material or product different machinery are uses. In this machine plastic bin or agriculture grains is use as a raw material for manufacturing final product. In this project system industries processes become more fast compare to manually or other system like stoker, conveyor etc. and time of filling of raw material affected by surrounding moisture. This system is special focusing for small scale industries.

Keyword: - *Vacuum Blower & Cyclone, Reducing Cost, Saving Energy*

INTRODUCTION

In the plastic and pharmacy industry the raw material like polycarbonate plastic resin grain industry is manufacturing plastic machinery parts and products in with good quality, but among of them they required one new system for mainly two problems in production.

1. Moisture effect on raw material.

2. Loading & Unloading raw material.

Due to this problem sometime company is not maintaining good quality & quantity at the time production rate is decrease. This production rate is directly affected to the cost of product as well as the profit rate. Available system is very costly so small scale industries are not possible for buying this available system. As per our knowledge, this system is available at the price of 150,000 to 800,000.

IDEA & MARKET SURVEY

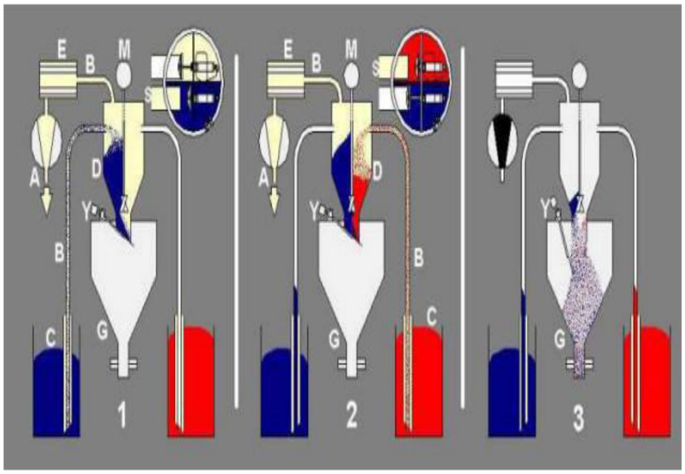
In today sites and industry for material loading, unloading and transfer the machinery used is given below:

1. Bucket Conveyor
2. Belt Conveyor
3. Mini JCB

These ideas involved high costs, not portable and required high maintenance and research analysis.

PROJECT PRINCIPLE

Vacuum loaders are widely used in the plastics & agricultural industry to transfer polycarbonate plastic resins, agricultural grains from storage sources to processing machines. A blower {A} sucks large amounts of air through the loading system at high speed creating a low pressure. The pipe{B} is immersed in a storage bin{C} containing the material to be transferred to the processing machine and the material is sucked in to the pipe due to the vacuum. Material-separating cyclones {D} with a filter {E} are installed at the end of the pipe.



(Fig Principle diagram) [1]

COMPONENT & DESIGN

VACUUM BLOWER

In this stage based on Pressure requirements and material transfer capacity, a combination of blower and motor is used of similar capacity. Blower provide high suction rate due to the large air channel volume.

1. **EXPERIMENT 1:** Constructed a machine with 0.5 HP blower and motor combination with a pipe connection for suction of sand material.

   Pressure achieved: 100 mm Wg

   RESULT: Design failed to meet pressure requirements and vacuum.

2. **EXPERIMENT 2:** Upon finding the faults in working pressure, we decided to add the following

   > A hollow cone > an half open drum
   > An internal connection from blower to cone
   > An external connection from cone to suction pipe
   > A 2 HP Blower with Motor

Conclusion of work:-

1. Decreasing the area, higher the pressure
2. Vacuum plays a role in suction process
3. Blower CFM may not be essentially important
4. Suction Pressure = Positive Pressure

- By reference of research & analysis we got the machine specification by comparing the parameters like vacuum pressure. Further for picking up 10 times greater particle we adjust specification as below.

1. Blower motor capacity: Around 1400w with 2800 rpm
2. Blower vacuum pressure: 0.0294 bar
3. CFM: 60 $[{ft^3}/{min}]$
4. Pickup grain: grain density max up to 2.5 $\frac{g}{cm^3}$
5. Suction pipe diameter:- 35/40 mm

Design depends on the following parameters:-

1. Inlet & Outlet Pressure: The effectiveness of the component comes with equal positive and negative pressure. Material suction and throw becomes more effective with right pressure.
2. Measuring CFM: Cubic Feet per Minute are a measure of the volume through which the material passes through. Blower CFM is the measure of air flow occurring within the blower. Higher the pressure, the more the

gasses will be compressed and therefore higher will be the CFM.

3. Impeller Design: These are rotating blades through which air passes. K.E. of Impeller increases due to Pressure increases of air.

   Higher rotating speed = more pressure of blower

4. Weight and Durability of Blower: The weight was considered to be heavy and bulky. Light weight material is considered as a part of it.

CYCLONE SEPARATOR

Cyclone separator or simply cyclone is separation device (dry scrubber) that uses the principle of inertia to remove particulate matter from the air.

It works to separate air and the materials. Air is being low in weight moves upper side & material with high density moves downside thereby separating air and the material.

Design and analysis of cyclone dust separator BY Muhammad Taiwo, Mohammed Namadi, James B. Mokwa

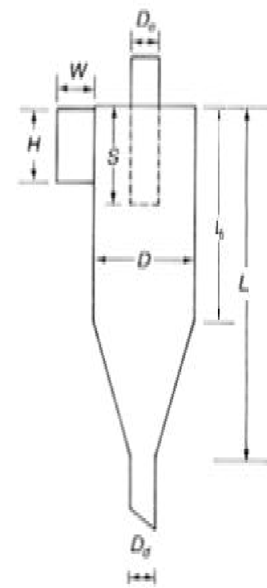
CYCLONE SIZING: Parnell (1996) addressed problems associated with the design of cyclones using the classical cyclone design (CCD) process and presented the Texas A&M cyclone design process (TCD) as an alternative. The TCD approach to design cyclones was to initially determine optimum inlet velocities (design velocities) for different cyclone designs. The design inlet velocities for 1D3D, 2D2D, and 1D2D cyclones are 16 m/s ±2 m/s (2800-3200 ft/min), 15 m/s ±2 m/s (2300-2800 ft/min), and 12 m/s ±2 m/s (1800-2200 ft/min), respectively. This design

Process allows an engineer to design the cyclone using a cyclone inlet velocity specific to the type of cyclone desired. Knowing the design inlet velocities, a cyclone's dimensions could easily be determined by:

$D = \sqrt{\frac{8Q}{Vi}}$ Where $V\,i$= inlet velocity , Q = Volumetric Inflow

Standard cyclone dimensions

	Conventional
Body Diameter, D/D	1.0
Height of Inlet, H/D	0.5
Width of Inlet, W/D	0.25
Diameter of Gas Exit, D_e/D	0.5
Length of Vortex Finder, S/D	0.625
Length of Body, L_b/D	2.0
Diameter of Dust Outlet, D_d/D	0.25



SOURCES:
column and sketch - Lapple, 1951.

- **Design Calculation of Cyclone (TEXAS method):-**

By using duct CFM chart and According to texas method and literature of Design and analysis of cyclone dust separator **by inventor**: - Muhammad Taiwo, Mohammed Namadi, James B. Mokwa.

Q (Volumetric Inflow) = 60 CFM ($^{ft^3}/_{min}$)

Vi (Inlet Velocity) = 2300 $^{ft}/_{min}$

According to above equation (1) from literature review,

Body diameter, D = $\sqrt{\frac{8Q}{Vi}} = \sqrt{\frac{8*60}{2300}}$ = 0.4568 ft = 0.1393m ≈ 0.14m

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Height of inlet, H = 0.5D = 0.5*0.14 = 0.07m

Width of inlet, W = 0.25D = 0.25*0.14 = 0.035m ≈ 0.04m

Diameter of Gas Exit, D_e = 0.4D = 0.4*0.14 = 0.056m ≈ 0.06m

Length of Vertex Finder, S = 0.625D = 0.625*0.14 = 0.08m

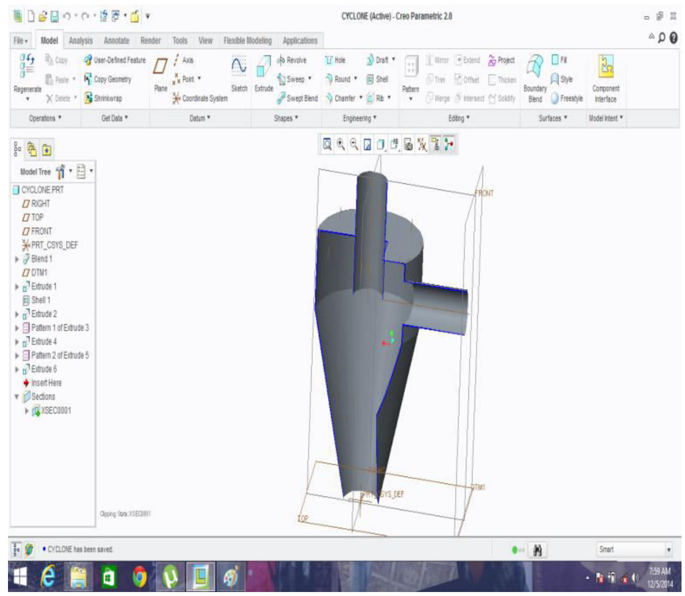
Length of Body, L_b = 2.0D = 2.0*0.14 = 0.28m

Diameter of Dust Collector, D_d = 0.25D = 0.25*0.14 = 0.035m ≈ 0.4m

DISCUSSION AND CONCLUSION: For the purpose of design analysis the cyclone needs to be chosen for a given task. A target performance is imposed. And the designer should know the amount of air flow & characteristics of particles to determine the type of cyclone needed and the required size of the device. Cyclones have often been regarded as low-efficiency collectors, However, efficiency varies greatly with particle size and cyclone design. Advanced design work has greatly improved cyclone performance. Some cyclone manufacturers advertise cyclones that have efficiencies greater than 98% for particles larger than 5 microns, and others that routinely achieve efficiencies of 90% for particles larger than 15 –20 microns.

According to above conclusion and calculation our cyclone separator dimensions are below:

- Diameter- 0.14m
- Height of inlet- 0.06m
- Width of inlet- 0.04m
- Diameter of gas exit- 0.06m
- Length of vortex finder- 0.08m
- Length of body- 0.28m
- Diameter of Dust outlet- 0.04m
- Total Length of Cyclone- 0.44m



(fig. Design of Cyclone in Creo)

<u>Following are the design considerations:-</u>

- <u>Bernoulli's Rule:</u> Pressure varies with Diameter change. When there is low diameter, high pressure is obtained and subsequently low pressure with greater diameter.

  <u>Bernoulli's equation:-</u>

  $$P + \frac{1}{2}\rho V^2 + \rho g h = constant$$

  Where p is the pressure, ρ is the density, V is the velocity, h is elevation and g is gravitational acceleration

- <u>Cross Sectional Area:</u> Area of the cyclone at top helps the material fall into the drum. Improper area cuts down the useful pressure.

- <u>Vacuum Creation:-</u> When suction takes place, vacuum is created in the inlet pipe in which cyclone is attached. This strong vacuum under

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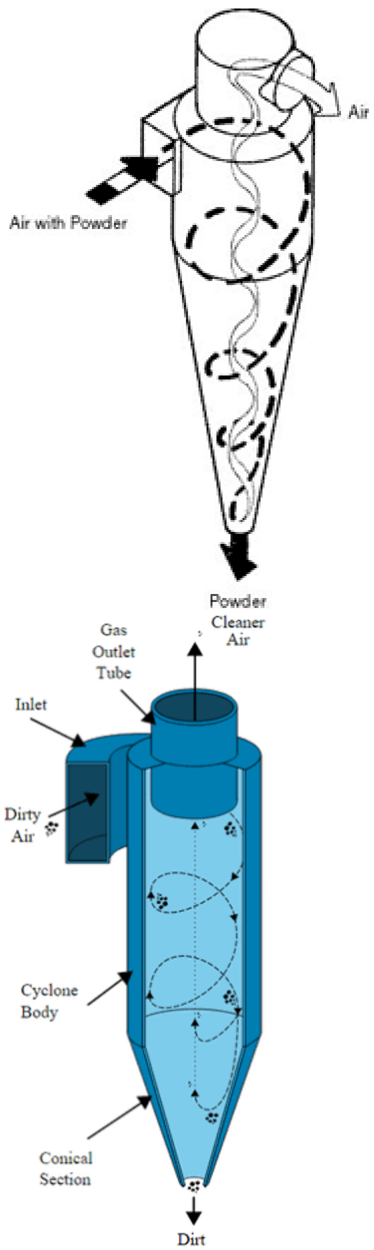
high pressure creates the required suction and hence to the rotary valve.



(fig. Cyclone with shown whirl motion) [2]

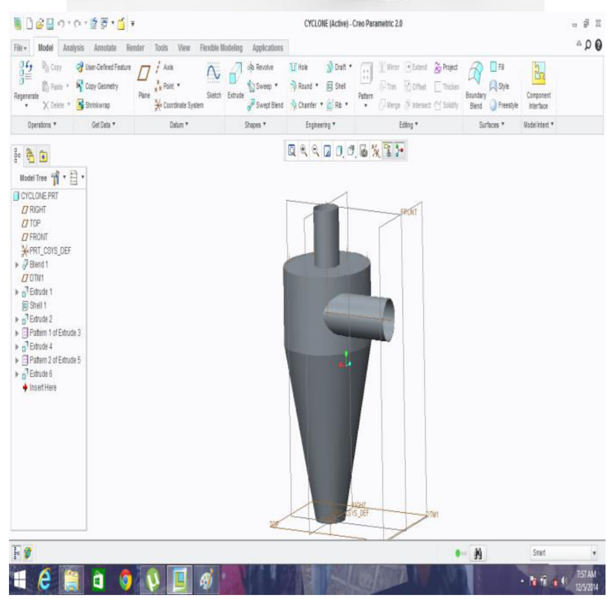
FILTER

Use of Air Filter in the suction line prevents sand particles to enter the main blower. Use a combination of net, metal sheet and cloth piece as filter. It maintains the longevity of the machine.

SUCTION PIPE

The suction pipe used in connection with cone should be movable and flexible to take it into any direction.

Only slight loss in pressure was observed during the processing. We can use single-ply lightweight vinyl/polyester, PVC coated 180° F temperature resistant has been considered as the pipe material.



(fig. Different grain size metal filter) [3] Design)
(fig. Suction Pipe & Vacuum Chamber

DATA TABLE & RESULT

Output Data Table:

BLOWER CAPACITY	1400w WITH 2800 rpm
SUCTION VACUUM PRESSURE	0.0294 Bar
SUCTION PIPE DIAMETER	35 – 40 mm

First of all we take the reading when the time is constant where, t (time) = 30 sec

No.	Material	Grain Density	Transferred Quantity(kg)	Avg. Transferred Quantity
1	Wheat	0.79 $\frac{g}{cm^3}$	2.5	2.69
			2.8	
			2.76	
2	Rice	0.83 $\frac{g}{cm^3}$	1.85	2.03
			2.05	
			2.20	
3	Construction Brown Sand	1.22-1.50 $\frac{g}{cm^3}$	1.44	1.48
			1.54	
			1.46	

Then after we fixed the mass of the transferred material and take down the time, M (mass) = 5 kg

No.	Material	Grain Density	Transferred Time(min)	Avg. Transferred Time
1	Wheat	0.79 $\frac{g}{cm^3}$	1.19	1.28
			1.25	
			1.40	
2	Rice		1.27	1.33
			1.30	
			1.42	

		0.83 $\frac{g}{cm^3}$		
3	Construction Brown Sand	1.22-1.50 $\frac{g}{cm^3}$	2.01 2.12 2.06	2.07

- **Result:**

- By using the convectional vacuum design (Lapple, 1951) we can further searched that vacuum with cyclone separator generate 95% efficiency for small grain (5-10 micron) and around 90% efficient for large grain size particle (above 20 micron).
- After analyzed the output data we also conclude that lower density grain takes less time, more quantity for material transfer and its vice-versa. For higher grains transfer like gravel, we have to proportionally increased machine blower capacity and cyclone design.

(Fig. Model Schematic)

CONCLUSION

This system is applicable at small scale industry and it is less costly than other system. After the market survey and research we can conclude that the vacuum base material transfer machine is highly efficient, time saving and require less maintenance then conveyer and stoker. We can further say that the machine is more reliable and gives continuous supply then pneumatic transfer system.

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