The Design And Construction Of A Dust Extractor

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Abstract-An efficient motorized dust extractor was designed and fabricated for industrial use, using locally sourced materials. In designing the dust extractor, material sourcing, design calculations and detailed drawings of the design was considered. An axial fan to aid the suction of high volume of air and air filter for efficient dust separation were incorporated into the machine. The machine was tested by subjecting it to a cleaning process. Results from the test showed that the newly designed machine has an efficiency of 97.72%. The machine is capable of extracting 0.58kg of dust particle per hour. This newly designed industrial dust extractor will help in no small way in eliminating dust hazards by creating an enabling-friendly working environment that is free from dust.

Keywords—Motorized extractor, Axial fan, Air filter, Suction, Volume of air, Dust extraction.

1. Introduction

Dust extractor is a major appliance in homes and industries today. Different types of dust extractors have been produced over the years, but it all started out with a broom and dust pan. Meanwhile, Dust is a dispersion aerosol formed by grinding or atomizing of a solid, or the transfer of a powder into a state of suspension through the action of air currents or by vibration. A dust particle is formed by disintegration or fracture process, such as grinding, crushing, or impact (Kathleen, 2002). The Mine Safety and Health Administration (MSHA) (2001) defined dust as finely divided solids that may become airborne from the original state without any chemical or physical change other than fracture. A wide range of particle size is produced during a dust generating process. Particles that are too large to remain airborne settle while others remain in the air indefinitely. Dust is generally measured in micrometers (commonly known as microns). Dust is generated by a wide range of manufacturing, domestic, and industrial activities. Construction, agricultural, and mining processes are among the industrial processes that contribute mostly to atmospheric dust levels, (Middleton & Gordie, 2001). During the early part of 1700 once or twice a year people would take their carpet outside, hang them over their clothes line and knock it with a carpet beater. The carpet sweeper was just a box with a brush and a pulley that did not work very well. The dust extractor evolved from the carpet sweeper via manual dust extractor. The first manual models, using bellows, were developed in the 1860s, and the first motorized designs appeared at the turn of the 20th century. A carpet sweeper was invented by Daniel Hess of West Union, Iowa in 1860 that gathered dust with a rotating brush and a bellows for generating suction (Daniel Hess, 1860). Another early model (1869) was the whirlwind, invented in Chicago in 1868 by Ives W. McGaffey. The bulky device worked with a belt driven fan cranked by hand that made it awkward to operate. A similar model was constructed by Melville R. Bissell of Grand Rapids, Michigan in 1876. The company later added portable vacuum cleaners to its line of cleaning tools. The next improvement came in 1898, when John S. Thurman of St. Louis, Missouri, submitted a patent for a pneumatic carpet renovator. This was a gasoline powered extractor, although the dust was blown into a receptacle rather than being sucked in, as in the machine now used. Thurman offered his invention of the horse-drawn (which went door to door) motorized cleaning system in St. Louis. Thurman was offering built-in central cleaning systems that used, compressed air, yet featured no dust collection. The motorized dust extractor was invented by Hubert Cecil Booth of England in 1901. The inventor was not named, but Booth's description of the machine conforms fairly closely to Thurman's design, as modified in later patents. 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 underside of the handkerchief, he realized the idea could work (Wohleber and Curt, 2006). Booth created a large device, driven by an internal combustion engine. Nicknamed the Puffing Billy, Booth's first petrol-powered, horse-drawn dust extractor relied upon air drawn by a piston pump through a cloth filter and all the cleaning was done by suction through long tubes with nozzles on the ends. Although the machine was too bulky to be brought into the building, its principles of operation were essentially the same as the dust extractors of today. He followed this up with an electric-powered model, but both designs were extremely bulky, and had to be transported by horse and carriage (Wohleber, 2006). The first dust extraction 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 one person (such as the ordinary domestic servant), 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 B. Kirby developed his first of many extractors called the domestic cyclone. It used water for dirt separation (Cole *et a!.,* 2003). In 2004 a British company released Airider, a hovering dust extractor that floats on a cushion of air. It has claimed to be light-weight and easier to maneuver (compared to using wheels). A British inventor 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 source. This technology was tested by the Market Transformation Programme (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. This model of dust extractor was difficult to use because you had to hand crank it while using it. It was also very expensive and awkward to reposition from one room to the next. In 1876 Melville R. Bissell of Grand Rapids, Michigan, resolved the problems with the carpet sweeper. He went on to open the Bissell Carpet Sweeper Company. In 1899 John Thurman, of St. Louis, Missouri invented a gasoline powered vacuum called the Pneumatic Carpet-Renovator for the General Compressed Air Company. His invention was so large that he used it to go door to door and charged families four dollars to clean their houses. This device did not pull in air but propelled the dirt and dust into a dustbin receptacle. During this period people were becoming more conscious of dirt, dust, sanitation and health issues making these machines a commodity. In 1901, Hubert Cecil Booth of London England invented the electric vacuum, but this model was also large, horse draw and used a one hundred foot hose to clean people's houses. The device was also used at British naval barracks which ended a plague in the early 1900's. Dust extractor was in it infantile stages during the first half of the 20 century and the better they became the more people wanted to buy and use them. The dust extractor has been changed and modified to suit the people of their respective time periods and to see how it has evolved is really valuable because this invention was constructed by many people over time. Prior to establishing the dust standards, extensive epidemiological investigations were conducted to ascertain the exact mechanism of pneumoconiosis and to estimate the disease risk levels associated with different levels of dustiness. In England, 25 pits were studied over a period of 10 years to provide the data base for epidemiological studies (Jacobson, 1988). The German studies took place in ten coal mines over a 10 year period (Reisner & Robock, 1977). The studies suggested a close correlation between the degree of disease contracted and the mass of coal dust accumulated in the lungs. Based on these studies, U.S. Committee on Education and Labor (1970) reported that at 7.0 mg/m^3, the rate of development of simple pneumoconiosis per 1,000 miners, after 35 years' exposure, would be 360 (36%); at 4.5mg/m3 the expected rate would be 150 (15%);, at $3.0mg/m^3$ the expected rate would be 50 (5%); and at $2.0mg/m^3$ the expected rate would be 20 (2%). This shows that the probability of developing simple pneumoconiosis decreases with decreasing dust concentration. The aim of the work is to design and fabricate a low-cost motorized dust extractor for industrial use, using locally sourced materials and technology. The specific objective includes:

a. To improve upon dust extractors products in the market through the introduction of secondary air filtration system (air filter) to the existing friction and centrifugal method for optimum dust separation.
b. Reconfiguration of an axial fan for improved output

Dust extraction involves the removal or collection of solid particles from flowing air streams, for the purpose of eliminating nuisance dust, insuring the safety and health considerations of humans, product quality improvements and the collection of powdered products. A dusty shop compromises the quality of the finished product: Accurate measurements and cuts are more difficult due to lack of visibility; airborne dust finds its way into finishing areas causing defects in the final product; and larger particles cling to surfaces causing scoring and other defects. Installing an efficient dust extraction system should be a priority for the small shop as well as the large shop, whether the material being machined is wood, plastic, or a composite. Not only is this essential for health reasons and compliance with many national and local codes, but it is also good business because it saves money and helps to maintain the quality of the finished product. Dust extraction relies on mechanical (gravity, centrifugal force, inertia, perception, diffusion) and electrostatic forces. A dust extractor is an air-cleaning device used in commercial, industrial and home production shops for removing dust particles from a flowing air-stream prior to discharge. A typical dust extractor consists of a suction blower, suction hose, filter, filter-cleaning system, and receptacle or dust remover system (Khan and Bhuiyan, 2013).

1.2 Working Principle of a Dust Extractor

The working principle of a dust extractor remains almost unchanged and amazingly simple. A dust extractor works on the basic principle of capture, convey and collect. Firstly, the dust must be captured. This is accomplished with devices such as capture hoods to catch dust at its source of origin.

Secondly, the dust must be conveyed. This is done via a ducting system, properly sized to maintain a consistent minimum air velocity required to keep the dust in suspension, for conveyance to the collection device. Finally, the dust is collected. This is done via a variety of means, depending on the application and the dust being handled. It can be as simple as a basic pass-through filter, a cyclonic separator, or an impingement baffle. It can also be as complex as an electrostatic precipitator, a multistage bag house, or a chemically treated wet scrubber or stripping tower. A motorized dust extractor works on a high mass air flow/low velocity principle, which means they are much better at drawing large volumes of waste material at a lower rate. A motorized dust extractor uses a motor to spin a centrifugal impeller that - through its clever blade design, sucks air in through the centre of the fan and pushes it out toward the sides of the fan. Dust extractors are designed so that the inbound waste follows this air path, through the impeller and into a collection chamber. The change in air direction once we get to this chamber (and gravity helps here), causes the heavier waste to fall down, and the lighter dust particles to rise up. These are caught in a filter on the top. This filter can be either a cloth, felt bag or a more elaborated pleated filter cartridge. A high speed rotating (air) flow is established within a cylindrical or conical container called a cyclone. Air flows in a helical pattern, beginning at the top (wide end) of the cyclone and ending at the bottom (narrow) end before exiting the cyclone in a straight stream through the center of the cyclone and out the top. Larger (denser) particles in the rotating stream have too much inertia to follow the tight curve of the stream, and strike the outside wall, then fall to the bottom of the cyclone where they can be removed. In a conical system, as the rotating flow moves towards the narrow end of the cyclone, the rotational radius of the stream is reduced, thus separating smaller and smaller particles. The cyclone geometry, together with flow rate, defines the *cut point* of the cyclone. This is the size of particle that will be removed from the stream with 50% efficiency. Particles larger than the cut point will be removed with a greater efficiency and smaller particles with a lower efficiency. Moving particles normally have the tendency to travel in a straight line, but for a cyclonic dust separator; particles following a circular path inside a cyclone are therefore being acted upon by an external force. This centripetal force is actually drag caused by the surrounding fluid (air) flowing radially towards the center of the cyclone. Drag force is governed by Stokes' Law:

$F=3\pi\mu dvr$ ………….. (1)

Where (μ), is the dynamic viscosity, (d) is the particle diameter and (vr) is the velocity of the particle relative to the surrounding fluid (Cooper and Alley, 1994). In this relationship the only variable influenced by ambient air conditions is the dynamic viscosity. The impact of pressure is negligible and dynamic viscosity is primarily a function of temperature (Maxwell, 1866). Over a temperature range of from 0 to 200°C the dynamic viscosity of air varies from 1.72 x $10^{'5}$ to 2.57 x $10^{''5}$ (Ns/m^2), a difference of only 50% (Roberson and Crowe, 1980). Particle inertia results in an apparent force (sometimes called centrifugal force), described by Newton's second law, which in the case of uniform circular motion is:

$F=mvt^2/r$ ……………… (2)

Where (m) is the particle's mass, (vt) is its tangential velocity, and (r) is the radius of its circular path. In this relationship the only variable influenced by ambient air conditions is particle velocity. The initial tangential velocity of a particle is approximately equal to the entrance velocity of the air carrying it. Particles escape being collected when drag force (1) is greater than inertia (2) and air carries the particle out of the cyclone. A particle is collected when drag force is too weak to maintain a circular orbit and the particle contacts the cyclone wall during the time it is in the cyclone volume.

2. Research methodology

2.1 Design calculation / considerations

For this design, consideration was given to cyclone body diameter, particle size, and capacity of fan and motor. The collection efficiency of a cyclone is dependent on the body diameter, which all dimensions of the cyclone are related to. Centrifugal fan is inefficient in moving large volume of air; hence, an axial flow fan was incorporated, for large volume of air at low static pressure, which determines the capacity of the motor. Mild steel plate of 1.5mm thickness was used for the construction of all parts of the dust extractor except for the frame which involves the use of angle bar.

2.2 Dimensioning of the Cyclonic Dust Extractor

According to Shepherd and Lapple, the standard dimensions in (*m}* of the classes of cyclones (high efficiency, conventional and high throughput cyclones) is shown in Table 1

Table 1: Standard Dimensions for Cyclones

Description	Cyclone Type: High Efficiency Conventional High Throughput					
	1	2	3	4	5	6
Body Diameter (D)	1.0	1.0	1.0	1.0	1.0	1.0
Height of Inlet (H)	0.5	0.44	0.5	0.5	0.75	0.8
Width of Inlet (W)	0.2	0.21	0.25	0.25	0.375	0.35
Diameter of Air Exit (D_e)	0.5	0.4	0.5	0.5	0.75	0.75
Length of Vortex Finder (S)	0.5	04	0.625	0.6	0.875	0.85
Length of Body (L_b)	1.5	1.4	2.0	1.75	1.5	1.7
Length of Cone (L_c)	2.5	2.5	2.0	2.0	2.5	2.0
Diameter of Dust Outlet (Dd)	0.375	0.4	0.25	0.4	0.375	0.4

Source: Stairmand, (1951); Swift, (1969); Lapple, (1951).

Dave (1999) gave the following dimensional guidelines of the typical cyclone and this was used for dimensioning of the dust extractor.

- $H<S$
- $W< (D-D_e)/2$
- $L_b + L_c > 3D$
- Cone angle = between 7° and 8°
- $D_e/D = 0.5$
- $(L_b + L_c)/D_e = 8$, $S/D_e = 1$

2.3 Diameter of Cyclone Body

All dimensions are related to the body diameter of a cyclone. It is possible to find a multitude of experimental data for cyclones with body diameter in the range of 100 to 200cm. The experimental data used in this work, however, is related to small diameter cyclones with body diameter in the range of 20 to 50cm. These data were obtained from Kim and Lee (1990), and Griffiths and Boysan (1992). Low body diameter increases centrifugal forces, collection efficiency, velocity, and pressure drop (Halasz and Massarani, 2000). For this design, a body diameter (D) of 30cm (0.3m) was used.

2.4 Inlet Height

Inlet height (H) = (1/2) D
= 0.5 x 0.3 = 0.15m

2.5 Inlet Width

Inlet Width (W) = (1/5) D
= 0.2 x 0.3 = 0.06m

2.6 Diameter of Air Exit

Diameter of Air Exit (D_e) = (1/2) D
= 0.5 x 0.3 = 0.15m

2.7 Length of Vortex Finder

Length of Vortex Finder (S) = (1/2) D
0.5 x 0.3 = 0.15m

2.8 Length of Body

Length of Body (L_b) = (5/3) D
=1.7 x 0.3 = 0.5m

2.9 Length of Cone

Length of Cone (L_c) = (5/2) D
=2.5 x 0.3-0.75m

2.10 Diameter of Dust Outlet

Diameter of Dust Outlet (D_d) = (2/5) D
= 0.4 x 0.3 = 0.12m

2.11 Determination of Volumetric Air Flow Rate

According to Kaan (2006), volumetric air flow rate can be calculated from the following relation:

$$D = 0.015 \left[\frac{Q\rho_a^2(1 - K_b}{\mu_a \rho_p (K_b)^{2.2}}\right]^{0.454} \qquad \dots\dots(3)$$

$$Q = \left[\frac{\mu_a \rho_p K_a (K_b)^{2.2}}{\rho_a^2(1 - K_b} \left(\frac{D}{0.015}\right)\right]^{\frac{1}{0.454}} \qquad \dots(4)$$

Where D is the cyclone body diameter (m), Q is the air flow rate (m /s), p_a is the air density (kg/m^3), p_p is the particle density (kg/m^3), μ_a is the air viscosity (kg/m-s), and K_a and K_b are design parameters.
D = 0.03m, p_a= 1.29kg/m^3, p_p= 1600kg/m^3, μ_a = 1.18xlO $^{-5}$kg/m-s, K_a =0.5, and K_b=0.2.

$$Q = \left[\frac{0.0000118x1600x0.5(0.2)^{2.2}}{1.29(1 - 0.2)} \left(\frac{0.3}{0.015}\right)\right]^{\frac{1}{0.454}}$$

= 0.15m^3/s
Similarly, capacity flow rate (Q_c) = 0.15x3600 = 539m^3/h

2.12 Calculation for Air Spinning Revolutions in the Outer Vortex

Air spins through a number TV of revolutions in the outer vortex. The value of TV can be calculated as the sum of revolutions inside the body and inside the cone.

$$\mathbf{N} = \frac{\mathbf{1}}{\mathbf{H}}\left[\mathbf{L_b} + \frac{\mathbf{L_c}}{\mathbf{2}}\right] \quad \ldots\ldots\ldots(5)$$

H = 0.15m, L_b = 0.5m, and L_c = 0.75m

$$\mathbf{N} = \frac{\mathbf{1}}{\mathbf{0.15}}\left[\mathbf{0.5} + \frac{\mathbf{0.75}}{\mathbf{2}}\right] = 6$$

2.13 Determination of Inlet Flow Velocity

Inlet flow velocity $(\mathrm{U}_i) = \frac{\mathbf{Q}}{\mathbf{WH}} \quad \ldots\ldots\ldots\ldots\ldots(6)$

Q = 0.15m^3/s, H= 0.15m, and W = 0.06m

$$(\mathrm{U}_i) = \frac{\mathbf{0.15}}{\mathbf{0.06\ x\ 0.15}} = 16.7\mathrm{m/s}$$

2.14 Determination of Air Residence Time in the Outer Vortex

For particles to be collected, they must strike the wall within the amount of time that the air travels in the outer vortex. Air residence time, i.e. time spent by air during spiraling descent (At) is calculated as follows:

$$\Delta\mathrm{t} = \frac{\text{Path length } (\mathrm{P_L})}{\text{Speed } (\mathrm{U_i})}, \text{where } \mathrm{P_L} = \pi\mathrm{DN}$$

$$\Delta\mathrm{t} = \frac{\pi\mathrm{DN}}{\mathrm{U_i}} \quad \ldots\ldots\ldots\ldots (7)$$

Where, all the parameters have their usual meaning.
D =0.30m, N = 6, and U_i = 16.7m/s

$$\Delta\mathrm{t} = \frac{3.142\ \mathrm{x}\ 0.30\ \mathrm{x}\ 6}{16.7} = 0.34\mathrm{s}$$

2.15 Determination of Particle Drift Velocity in the Radial Direction

The maximum radial distance, traveled by any particle is the width of the inlet duct W. The centrifugal force quickly accelerates the particle to its terminal velocity in the outward (radial) direction, with the opposing drag force (F_d) equaling the centrifugal force (F_c). The terminal velocity (U_t) that will just allow a particle initially at distance *W* away from the wall to be collected in time is given as:

$$\mathrm{U_t} = \frac{\mathrm{W}}{\Delta\mathrm{t}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where W = 0.06m, and At = 0.34s

$$\mathrm{U_t} = \frac{0.06}{0.34} = 0.18m/s$$

2.16 Determination of Particle Size

The particle drift velocity is a function of particle size. Assuming Stokes regime flow,
Drag force $F_d = 3\pi\mu d_p U_t$ ……… (9)
Spherical particle subjected to a centrifugal force is given as:

$$\mathrm{F_c} = \frac{\mathrm{mu^2}}{\mathrm{r}}$$

Where, m is the mass of particle in excess of mass of air displaced, u = inlet flow and r is the radius of cyclone body.

m = p x V_p, p = (Pp - p_a), Vp = $\frac{4}{3}\pi r_p^3$
Assuming a spherical particle,
$V_p = \frac{4}{3}\pi\frac{r_p^3}{8,}\ where\ r_p\frac{d_p}{2}$
Taking $r\frac{D}{2}\ ,then$
But $F_d = F_c$

$$3\pi\mu\mathrm{d_\rho U_t} = \frac{\left[\pi\mathrm{D_P^3U_i^2}(\rho_\mathrm{p} - \rho_\mathrm{a})\right]}{3\mathrm{D}} \quad \ldots\ldots\ldots\ldots\ldots\ldots.(10)$$

Recall.

$$\Delta\mathrm{t} = \frac{\pi\mathrm{DN}}{\mathrm{U_i}}, \text{and } \mathrm{U_t} = \frac{\mathrm{W}}{\Delta\mathrm{t}}$$

Then,

$$\mathrm{U_t} = \frac{\mathrm{WU_i}}{\pi\mathrm{DN}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Equating (10) and (11) and solving for d_p gives,

$$\mathrm{d_p} = \left[\frac{9\mu_\mathrm{a}\mathrm{W}}{\pi\mathrm{NU_i}(\rho_\mathrm{p}-\rho_\mathrm{a})}\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where, Uf = terminal drift transverse velocity = 0. 18m/s; d_p= diameter of the particle =?
p_p = density of the particle = 1600kg/m; p_a = air density = 1.29kg/m;
μ_a= air viscosity = 1.18x10 $^{-5}$kg/m.s; N = 6; U_i = 24.4m/s, and W = 0.06m.
Therefore =

$$\mathrm{d_p} = \left[\frac{9\ \mathrm{x}\ 0.0000118\ \mathrm{x}\ 0.06}{3.142\ \mathrm{x}\ 6\ \mathrm{x}\ 16.7(1600 - 1.29)}\right]^{\frac{1}{2}}$$

=4 x 10^{-6}m = 4 μm.

It is worth noting that, dp is the size of the smallest particle that will be collected if it starts at the inside edge of the inlet duct. Thus, in theory, all particles of size dp or larger will be collected with 100% efficiency. Lapple (1951) developed a semi-empirical relationship to calculate a 50% cut diameter, d_{pct} which is the diameter of particles collected with 50% efficiency. The expression is given as:

$$\mathrm{d_{pc}} = \left[\frac{9\mu\mathrm{W}}{2\pi\mathrm{NU_i}(\rho_\mathrm{p}-\rho_\mathrm{a})}\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots (13)$$

$$= \left[\frac{9\ \mathrm{x}\ 0.0000118\ \mathrm{x}\ 0.06}{2\ \mathrm{x}\ 3.142\ \mathrm{x}\ 6\ \mathrm{x}\ 16.7(1600 - 1.29)}\right]^{\frac{1}{2}} = 2.5\ \mathrm{x}\ 10^{-6}\mathrm{m}$$

$$= 3\mu\mathrm{m}$$

2.17 Determination of Static Pressure Drop

The static pressure drop is an essential parameter in the design of cyclone systems that allows evaluating the blower specifications.

$$\text{Pressure drop } \Delta\mathrm{P} = \mathrm{N_H}\left(\frac{\rho_\mathrm{a}\mathrm{U_i^2}}{2}\right)$$

Where N_H is the pressure drop in heads, a dimensionless parameter and depends on the cyclone proportions.

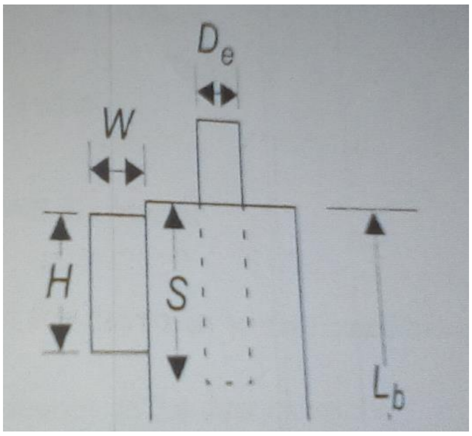

Figure 1: Inlet Velocity Head

$$N_H = \frac{16WH}{D_e^2}$$

H = 0.15m, W = 0.06m, D_e = 0.15m, p_a = 1.29kg/m^3, and U_t = 16.7m/s

Therefore,

$$N_H = \frac{16 \text{ x } 0.06 \text{ x } 0.15}{0.15^2} = 6$$

2.18 Determination of Power Required for Blowing Air

Fluid power requirements (P_{ollt}) can be calculated as:

$$P_{out} = \Delta p \text{ x } Q \qquad \text{……………} \; (14)$$

Where Δp is the pressure drop and *Q* is equal to volumetric flow rate.

ΔP= 1l00Pa, and Q = 0.15m^3/s .

P_{out}= 1100x0.15 = 165W **3.5**

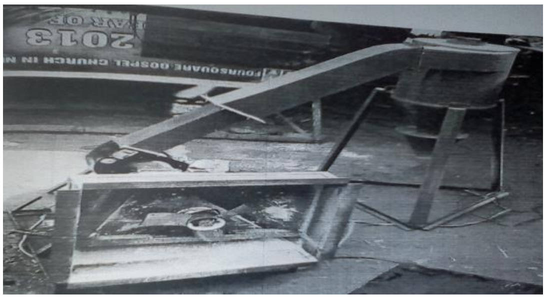

Figure 2: Final Designed Dust Extractor

3. Result and discussion

3.1 Test Result

The dust extractor was tested to determine its level of performance and the overall functionality of the system. The dust extractor was tested by sprinkling l0g of baking powder on the dust capture hood of the device. The device was switched on and a fixed flow rate was maintained. The dust on the capture hood was sucked into the cyclone by the axial and centrifugal flow fans, and the particles, having acted upon by frictional and centrifugal forces in the cyclone separator, dropped through the dust collector vortex breaker (serving as dumper to control the air) and were deposited in the dust collection unit for later disposer, while the clean air escaped through the vortex finder. This process was repeated four more times using l0g of the dust in each process. The weight of dust collected at inlet and dust collection unit per minute were measured and recorded. The results obtained are presented in Table 2.

Table 2: Result of the Machine Test

S/N	Dust at Inlet (g)	Dust Collected at Inlet (g)	Amount of Dust Filtered (kg)	Dust Weight at Air Outlet (g)	Duration (min)
1	10	9.75	9.52	0.23	1
2	10	9.77	9.56	0.21	1
3	10	9.86	9.62	0.24	1
4	10	9.75	9.56	0.19	1
5	10	9.90.	9.67	0.23	1

Average weight of dust collected at inlet= $\frac{9.75+9.77+9.86+9.75+9.9}{5} = 9.81\text{g}$

Average weight of dust at air outlet = $\frac{0.23+0.21+0.24+0.19+0.23}{5} = 0.22\text{g}$

Average weight of dust filtered = $\frac{9.52+9.56+9.62+9.56+9.67}{5} = 9.586\text{g}$

3.2 Performance Evaluation

The performance of the dust extractor was evaluated on the basis of its capacity and efficiency of dust separation.

3.3 Machine Capacity

Machine capacity, $C_m = \frac{\text{Average weight of dust filtered (kg)}}{\text{Time taken to filter the dust (hr)}}$

Average weight of dust filtered = 9.586g, time taken = 1min

Therefore, C_m = 9.586g/min = 0.58kg/hr

The constructed machine was tested and found capable of extracting 0.58kg of dust particle in one hour. The machine can be used specifically for industrial purposes, though domestic use is also applicable.

3.4 Machine Efficiency

Efficiency (e) of the dust extractor is calculated as:

$$\frac{\text{Average weight of dust filtered (kg)}}{\text{Time taken to filter the dust (hr)}} \text{ x } 100$$

$$= \frac{9.586}{9.81} \text{ x } 100 = 97.72\%$$

4. Conclusion

A cyclonic dust extractor for dust control was designed, fabricated and tested. The newly designed machine has a mass flow rate capacity of 0.58'kg/hr and collection efficiency of 97.72%. This dust extractor is acceptable for collection of dust particle size greater than 2m. With optimum capacity flow rate of $539m^3$/hr, this machine meets the requirements for industrial application. This machine can be used for domestic and industrial applications.

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