DESIGN OF CYCLONE DUST COLLECTOR

A project report submitted in partial fulfilment of the requirement for

the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

BY

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CERTIFICATE

This is to certify that the Project Report entitled **"DESIGN OF CYCLONE DUST COLLECTOR"** being submitted by PAPPALA DHARAN KUMAR (318126520L54), KARRI MANOJ KUMAR (317126520204), KAKINADA SAI DHEERAJ (317126520198), YEDDU PRASANTH (318126520L38), PANTALA UGANDHAR ANIL (317126520212) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING, ANITS**. It is the work of bona-fide, carried out under the guidance and supervision of **MR. K.GOWRI SHANKAR**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

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ABSTRACT

To design a cyclone abatement system for particulate control, it is necessary to accurately estimate cyclone performance. In this cyclone study, new theoretical methods for computing travel distance, numbers of turns and cyclone pressure drop have been developed. The flow pattern and cyclone dimensions determine the travel distance in a cyclone. The number of turns was calculated based on this travel distance. The new theoretical analysis of cyclone pressure drop was tested against measured data at different inlet velocities and gave excellent agreement. The results show that cyclone pressure drop varies with the inlet velocity, but not with cyclone diameter. Cyclone cut-points for different dusts were traced from measured cyclone overall collection efficiencies and the theoretical model for calculating cyclone overall efficiency. The cut-point correction models 2D2D cyclones were developed through regression fit from traced and theoretical cut-points Diameter.

Experimental results indicate that optimal cyclone design velocities, which are for 2D2D cyclones, should be determined based on standard air density. It is important to consider the air density effect on cyclone performance in the design of cyclone abatement systems. The tangential inlet generates the swirling motion of the gas stream, which forces particles toward the outer wall where they spiral in the downward direction. Eventually the particles are collected in the dustbin located at the bottom of the conical section of the cyclone body. The cleaned gas leaves through the exit pipe at the top.

In Pakistan it has been installed in many industries its Main modes of operation is similar to collect the particles but the collection of particles and method of collection are Distinguish. Cement Sector is one of advance sector application for Cyclone Separator. DG cement in one of those Cement Manufacturing Plant where Cyclone working Efficiently .

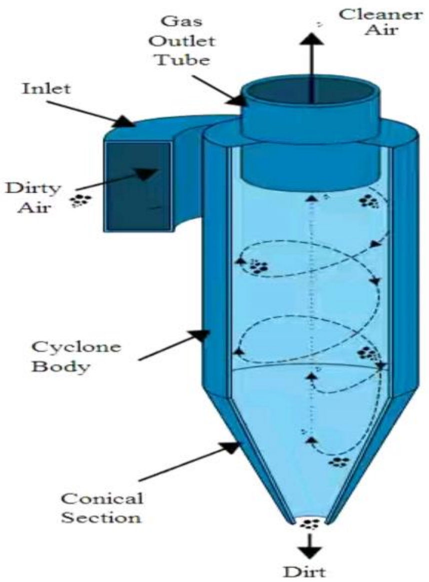
INTRODUCTION

Floor cleaning is achieved by different technique which might be of different kinds. Different types of floor need different type of treatment. The floor should be totally dry after the cleaning process. Otherwise it may result in hazard. On some floors sawdust is used to absorb all kinds of liquids. This ensures that there will no need of preventing them from spill of. The sawdust has to be swept and replaced every day. This process is still used in butchers but it was common in bars in the past. In some places tea leaves are also used to collect dirt from carpets and also for odour removing purposes. Different types of floor cleaning machines are available today such as floor buffers, automatic floor scrubbers and extractors that can clean almost all types of hard floors or carpeted flooring surfaces in very less time than it would have taken using traditional cleaning methods. Again the cleaning would be different for different floorings.

1. CYCLONE DUST COLLECTOR

1.1 WORKING PRINCIPLE

Materials flow two locations. This phenomenon is the basic working principle of an ideal vacuum from one location to another when a pressure difference is created between cleaner. When a centrifugal fan rotates it makes the air to flow by adding it external kinetic energy. Air is sucked from behind and pushed forward with pressure and so negative pressure is creates behind the fan. Ideal vacuum cleaners have such centrifugal fan in it connected to a motor. This unit has suction and discharge connections, on the suction side filter bag is fitted before the hose connection. The discharge has another air purifier filter and opened to atmosphere. When the electric power is given the motor rotates and so that the centrifugal fan. Air from the suction side is sucked into the unit along with the air all air born particles, cat allergen, mist, dirt, and small solid particles are carried to the auction filter. They are trapped in the filter and dirt free air is pushed out from the discharge opening.



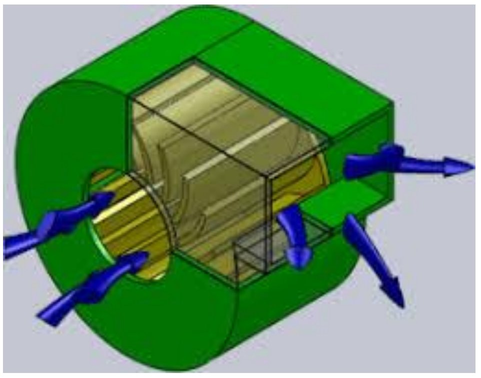
2. LITERARTURE

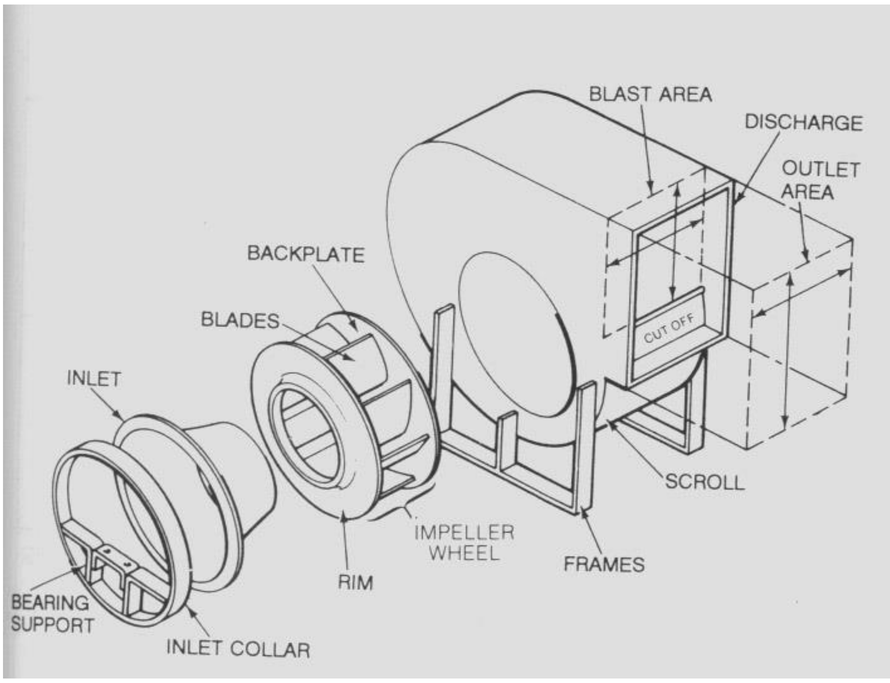
2.1 BLOWER

Blowers are mechanical or electro-mechanical devices used to induce gas flow through ducting, electronics chassis, process stacks, etc.--wherever flow is needed for exhausting, aspirating, cooling, ventilating, conveying, and so on. See also Fans. Key specifications include intended application, blower type, port design, as well as the parameters of flow capacity, electrical ratings, and dimensions. Blowers cool electronic enclosures, induce drafts in boilers, increase airflow on engines, and are configured in a variety of designs such as centrifugal flow or rotary lobe styles. Motors usually drive blowers, though they can be powered by other means such as engines. Often used interchangeably with “Fans,” blowers are defined by the ASME as having a ratio of discharge pressure over suction pressure between 1.11 and 1.2, while fans are defined as anything below this ratio and compressors are defined as anything above it. Some makers of portable fans refer to their units as blowers even if they do not necessarily conform to the ASME distinction, which applies to permanently installed industrial process equipment. Another kind of blower is the mobile or hand held device used for moving fallen leaves.

Centrifugal Blowers

The centrifugal blower use high speed impellers or blades to impart velocity to air or other gases. They can be single or multi-stage units. Like fans, centrifugal blowers offer a number of blade orientations, including backward curved, forward curved, and radial. Blowers can be multi- or variable speed units. They are usually driven by electric motors, often through a belt and sheave arrangement, but some centrifugal blowers are directly coupled to drive motors. Fan speed can be changed to vary flow rates by resizing sheaves, using variable speed drives, etc., but dampers are even more common as a means of adjusting flow. Fan affinity laws dictate that a percent reduction in speed will produce a like reduction in flow.





Main terms

Blades:

Backward inclined and forward curved refer to centrifugal blowers and relate to the blades also relate to centrifugal units, representing simple paddle type construction with no backward or forward inclinations. They can be self-orientation of the blades. Forward curving blades move larger quantities of air than backward inclined blades do, albeit at lower pressures. Backward inclined blades tend toward higher efficiencies. Radial cleaning, an important consideration for blowers handling dirty media. Airfoil blades also apply to centrifugal blowers.

Flow Capacity:

This attribute is important when selecting a blower. Blower capacity is generally rated in cubic feet per minute.

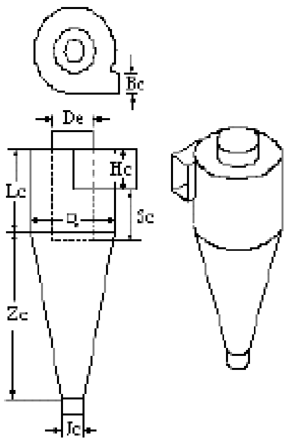
Maximum Operating Pressure:

Along with flow capacity, this is another important attribute in blower selection. Manufactures generally rate this item in inches of water column.

2.2 CYCLONE SEPARATOR

Cyclone separators provide a method of removing particulate matter from air or other gas streams at low cost and low maintenance. Cyclones are somewhat more complicated in design than simple gravity settling systems, and their removal efficiency is much better than that of settling chamber. Cyclones are basically centrifugal separators, consists of an upper cylindrical part referred to as the barrel and a lower conical part referred to as cone. They simply transform the inertia force of gas particle flows to a centrifugal force by means of a vortex generated in the cyclone body. The particle laden air stream enters tangentially at the top of the barrel and travels downward into the cone forming an outer vortex. The increasing air velocity in the outer vortex results in a centrifugal force on the particles separating them from the air stream. When the air reaches the bottom of the cone, it begins to flow radially inwards and out the top as clean air/gas while the particulates fall into the dust collection chamber attached to the bottom of the cyclone.

DIFFERENT CYCLONE MODELS:



1D2D

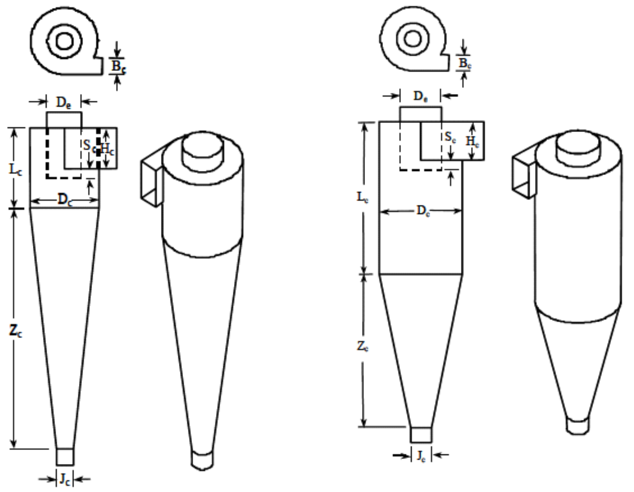
$B_c = D_c/4$ $J_c = D_c/2$

$D_e = D_c/1.6$ $S_c = 5D_c/8$

$H_c = D_c/2$ $L_c = 1 \times D_c$

$Z_c = 2 \times D_c$

Figure 3. 1D2D cyclone configuration.



1D3D

$B_c = D_c/4$ $J_c = D_c/4$

$D_e = D_c/2$ $S_c = D_c/8$

$H_c = D_c/2$ $L_c = 1 \times D_c$

$Z_c = 3 \times D_c$

2D2D

$B_c = D_c/4$ $J_c = D_c/4$

$D_e = D_c/2$ $S_c = D_c/8$

$H_c = D_c/2$ $L_c = 2 \times D_c$

$Z_c = 2 \times D_c$

Figure 2. 1D3D and 2D2D cyclone configurations.

2.3 WATER SPRINKLER

A sprinkler system is integrated system of piping, connected to a water supply, with listed sprinklers that automatically initiate water discharge over a area where required. As water sprays from a sprinkler it breaks up into small drops between 0.5 and 4.0 mm in size. The small drops fall close to the sprinkler whereas the larger ones fall close to the edge of the wetted circle. Drop size is also controlled by pressure and nozzle size. When the pressure is low, drops tend to be much larger as the water jet does not break up easily. So to avoid more wetting of soil use small diameter nozzles operating at or above the normal recommended operating pressure.

2.3 FRAME

1. Materials required: G.I square pipe of 1 inch side of 40 feet, castor wheels, AC/DC arc welding equipment with accessories.
2. We took the beams measured and marked up to the points
   Length:65 cm
   Breadth:50 cm
   Height :90 cm
3. Now, cut the pieces at marked points with help of a circular saw.
4. Fix all the pieces as shown in the figure below.
5. Weld them permanently which will now form the basic structure.
6. Now, take the M.S Flats measure and mark them as required for the base.
7. Cut the pieces at marked points.
8. Arrange the M.S Flats in checked formation to form a strong base.
9. Weld the base to the frame.
10. Take the castor wheels and fix them at bottom of frame with help of an arc welding.
11. We have made the basic structure on which the all the components are to be mounted.

2.4 CASTOR WHEELS

A caster is a wheeled device typically mounted to a larger object that enables relatively easy rolling movement of the object. Casters are essentially special housings that include a wheel, facilitating the installation of wheels on objects. Casters are found virtually everywhere, from office desk chairs to shipyards, from hospital beds to automotive factories. They range in size from the very small furniture casters to massive industrial casters, and individual load capacities span 100 pounds (45 kg) or less to 100,000 pounds (45 t). Wheel materials include cast iron, plastic, rubber, polyurethane, forged

Applications:

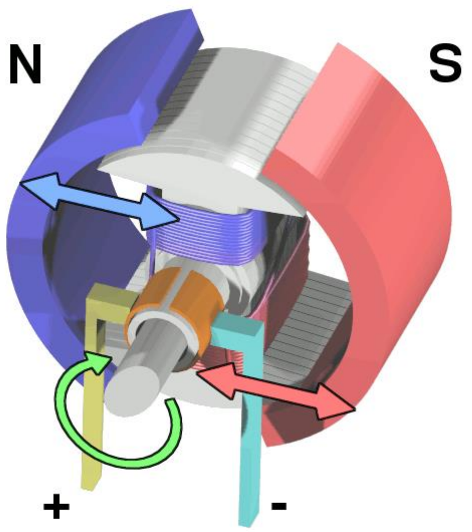
Casters are available in a large selection of various rigs and yokes, wheel materials, swivel offsets, and wheel configurations. In many cases, it can become extremely difficult to choose the right caster for the application. In order to help the user to determine the right caster to use, it's important to take a couple of factors into consideration, which include:

- Load capacity (the total load applied on the casters)
- The number of casters to be used on the equipment (usually four or six casters)
- Floor type (concrete, steel, linoleum, carpet, etc.)
- Floor condition (are there cracks, bumps, unlevel floors?)
- Environment (is the equipment operating in high temperatures, wet or humid conditions, etc.)
- Floor cleanliness (are the floors clean or contain debris such as metal chips, grease, gravel, etc.)Steel, stainless steel, aluminium, and more.

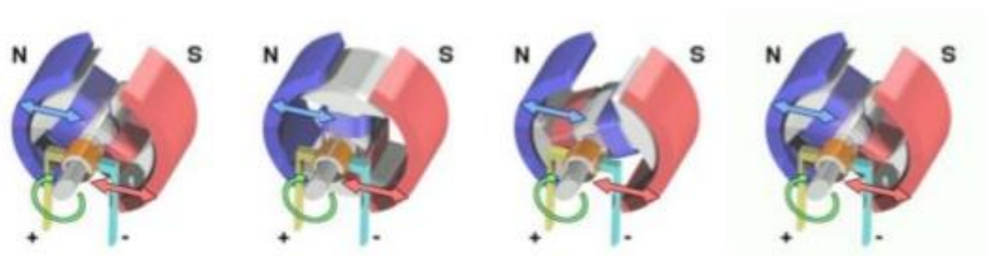
2.5 DC MOTOR

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.



OPERATION OF DC MOTOR:



1. When the coil is powered a magnet field is produced around the armature

the left side of the armature is pushed away from the left magnet and drawn towards right, causing rotation.

2. The armature continues to rotate.
3. When the armature becomes horizontally aligned, the commutator reverses the direction of Current through the coil, reversing the magnetic field.
4. The process then repeats.

- Magnetic force acts perpendicular to both wire and magnetic field.
  F=ILB
  I=Electric current
  F=Magnetic force
  B=Magnetic field
  L=Length of wire

ADVANTAGES:

- Provide excellent speed control for acceleration and deceleration.
- Easy to understand design.
- Simple, cheap drive design.

DISADVANTAGES OF DC MOTOR:

Brush wear: Since they need brushes to connect the rotor winding. Brush wear occurs, and it increases dramatically in low pressure environment. So they cannot be used in artificial hearts. If used on air crafts, the brushes would need replacement after one hour of operation. Sparks from the brushes may cause explosion if the environment contains explosive materials. RF noise from the brushes may interfere with nearby t.v. sets, or electronic devices etc..,

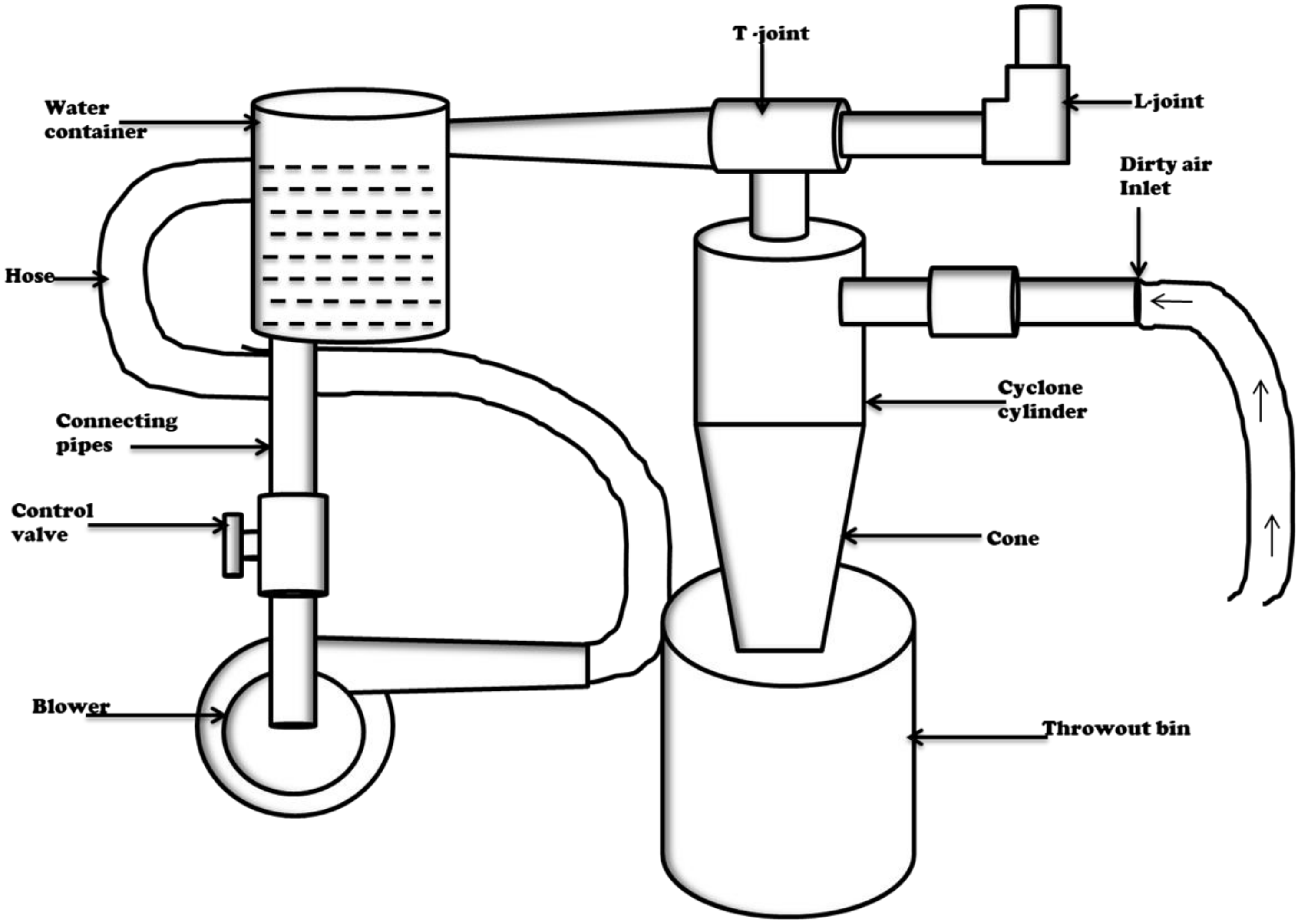
2.6 DC ADAPTORS

An AC adapter, AC/DC adapter, or AC/DC converter [1] is a type of external power supply, often enclosed in a case similar to an AC plug. Other common names include plug pack, plug-in adapter, adapter block, domestic mains adapter, line power adapter, wall wart, power brick, and power adapter. Adapters for battery-powered equipment may be described as chargers or rechargers (see also battery charger). AC adapters are used with electrical devices that require power but do not contain internal components to derive the required voltage and power from mains power. The internal circuitry of an external power supply is very similar to the design that would be used for a built-in or internal supply.

External power supplies are used both with equipment with no other source of power and with battery-powered equipment, where the supply, when plugged in, can sometimes charge the battery in addition to powering the equipment.

Use of an external power supply allows portability of equipment powered either by mains or battery without the added bulk of internal power components, and makes it unnecessary to produce equipment for use only with a specified power source; the same device can be powered from 120 VAC or 230 VAC mains, vehicle or aircraft battery by using a different adapter. Another advantage of these designs can be increased safety; as the hazardous 120 or 240 volt mains power is transformed to a lower safer voltage at the wall outlet, and the appliance which is handled by the user is powered by this lower voltage.

3.CIRCUIT DIAGRAM OF CYCLONE DUST COLLECTOR



BLOWER: Blowers use high speed impellers or blades to impart velocity to air or other gases. They can be single or multi-stage units. Like fans, centrifugal blowers offer a number of blade orientations, including backward curved, forward curved, and radial. Blowers can be multi- or variable speed units. They are usually driven by electric motors, often through a belt and sheave arrangement, but some centrifugal blowers are directly coupled to drive motors.

BLOWER OUTLET: The blower outlet let all the dust particles into the throw out bin with which we can collect all the dust in a bin and make the required work done.

CYCLONE CYLINDER: It is one kind of a passage of the system which helps in flow of dust particles into the cone and then to the throw out bin.

DIRTY AIR INLET: It is the passage through which the waste which is being collected is entering the system.

CONE: The conical shaped container where the cone shape creates a cyclone with higher centrifugal air speed and helps in collecting all the dust particles into the throw out bin.

THROWOUT BIN: It is the bin which collects all the dust particles in it and can be opened when required for emptying the bin.

MOTOR: It converts electrical energy into hydraulic energy.

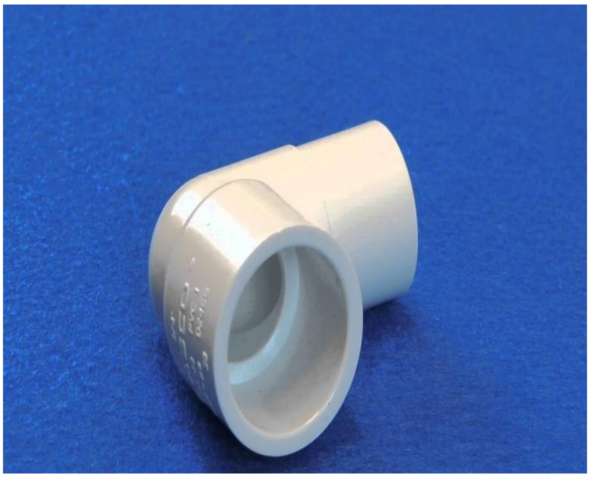
CONTROL VALVE: The control valve helps in the controlled passage for the air/water and the required amount can be passed through the passage.

WATER CONTAINER: The water container is for the storage of the water for sprinkling the water on the cleaned surface.

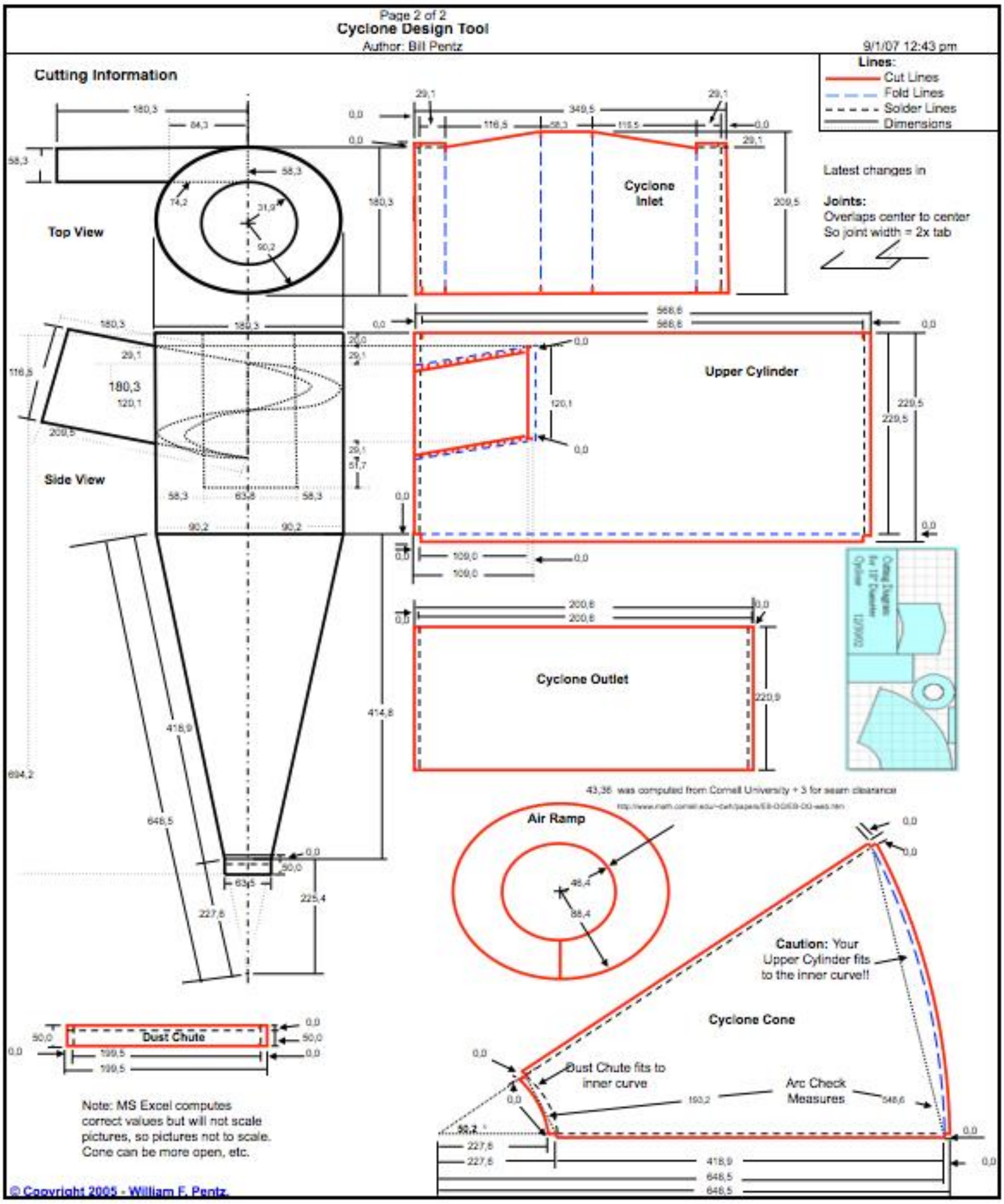
HOSE: The hose pipe is for carrying the collected air for the inlet to the outlet and it acts as the passage for the dust collection.

T-JOINT: The t-joints are used for connecting purpose, in which two pipes can be connected and make a passage for collecting the dust.

L-JOINT: The L-joint is also known as angle joint it is of 90° angle and used for connecting pipes in the L shape and make the passage for collecting the dust particles.



4. DESIGN



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Cyclone Design Tool
Author: Bill Pentz
9/1/07 12:43 pm
Lines:
Cut Lines
Fold Lines
Solder Lines
Dimensions
Cutting Information
Top View
Side View
Cyclone Inlet
Latest changes in
Joints:
Overlaps center to center
So joint width = 2x tab
Upper Cylinder
Cyclone Outlet
Air Ramp
Caution: Your Upper Cylinder fits to the inner curve!!
Cyclone Cone
Dust Chute fits to inner curve
Arc Check Measures
Dust Chute
Note: MS Excel computes correct values but will not scale pictures, so pictures not to scale. Cone can be more open, etc.
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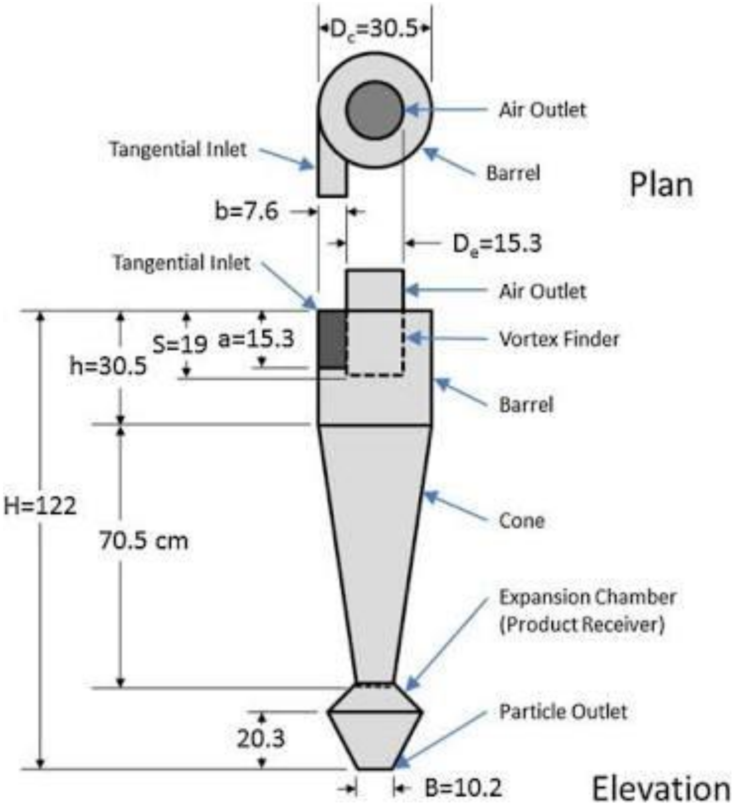


SPECIFICATIONS OF MOTOR:

Voltage: 12 V
Speed: 200 rpm
Current: 0.5- 1 A

DESIGN OF BLOWER:

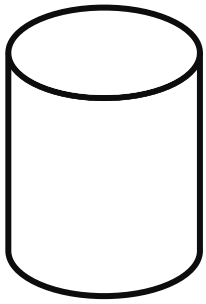
Flow Discharge Q = 0.5 m3/s
Static Suction Pressure = -196.4 N/m2
Static Delivery Pressure = 784.8 N/m2
Static Pressure Gradient ΔPs = 981.2 Pa
Speed of impeller rotation N = 2800 rpm
Air Density = 1.165 kg/m3
Optimized number of blades z = 16 [135]
Outlet Blade Angle β2 = 90°
Suction Temperature Ts = 30 °C = 303 K
Atmospheric Pressure Patm = 1.01325 x 105 Pa
Atmospheric Temperature Tatm = 30° C = 303° K
These parameters are kept identical for each design methodology prescribed here in.

DESIGN OF PIPE:

Diameter of pipe (d) =1 inch =2.54cm
Length of pipe (l) = 205cm

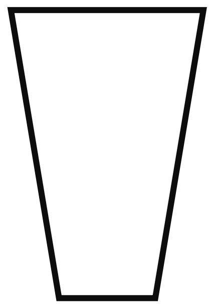
$$V = \frac{\pi d^2}{4} \times l = 1039\text{cm}^3$$

DESIGN OF CYLINDER:



Length (L) = 36cm
Diameter (d) =15cm
Radius(R) = $d/2$ =7.5cm
Area (A) = πr^2=176.78cm^2

DESIGN OF FRUSTUM OF CONE:



Volume of a frustum of cone:
V = $\pi h(R^2+r^2+R*r)/3$ =101.35*10^{2}cm^3
Slant height of frustum of a cone:
s = $\sqrt{((R_1-R_2)+h^2)}$ =42.074cm
Lateral surface area of a frustum cone:
L = $\pi(r+R)\sqrt{((R-r)^2+h^2)}$ =986cm^2
Base surface area of a frustum cone (a circle):
B = $\pi D^2/4$ =176.71cm^2
Total surface area of a cone:
A = L + B =986+176.71=1162.71cm^2

TOTAL VOLUME

Total Volume= Volume of cylinder +volume of frustum of cone
= 6364.8+1162.71=7527.51cm^3

DESIGN PARAMETERS OF CYCLONE SEPERATOR:

Length of cylinder(L_1) = $2D_2$
Length of cone (L_2) = $2D_2$
Diameter of exit (D_e) = $0.5D_2$
Height of entrance (H) = $0.5D_2$
Width of entrance (B) = $0.25D_2$
Diameter of dust exit (D_d) =$0.25D_2$
Length of exit duct (L_3) = $0.125D_2$

Applications:

cyclone separator is widely used in industries to separate dust from gas or for product recovery because of its geometrical simplicity, relative economy in power and flexibility.

Major applications include:

- oil refineries to separate oils and gases
- cement industry
- ginning mills

CHEMICAL AND PETROCHEMICAL PROCESSES

Dust collector for dryer and cooler processes hot gas cleaning and product recovery separation in spray dryers cyclone dust collector for dust recovery of 5 microns [and below] recovery of particulate in maleic anhydride process reactors ultra fine gas cleaning of fluid catalytic cracking (FCCU) regenerator gases

INDUSTRIAL, METALLURGICAL AND POWER GENERATION

Cyclone dust collector for metallurgical process mills, smelters and kilns fine particulate recovery cyclone in fluidised bed combustors hot gas cleaning in coal gasifier and activated carbon plants particulate recovery in abrasive and hot gas Streams cyclone separator for npk & lan fertilizer dust in coolers & dryers dust collector cyclone for reducing emissions in fluidised bed boilers zinc dust recovery and extraction in galvanizing plants.

FOOD & PHARMACEUTICAL

Powder recovery cyclone filter in pharmaceutical sterile processes cyclone separator for product recovery in milk powder, coffee and cereal plants

Cement Industry

In cement manufacturing industries, large-sized cyclone separators are used as main process equipments in significant numbers for handling high volumetric flow rates of dust-laden gases. The cyclone is a simple mechanical device commonly used in the grinding circuits to remove relatively large particles from gas streams. Cyclones are often used as pre-cleaners to remove more than 80% of the particles greater than 20μm in diameter. Smaller particles that escape the cyclones can then be collected by more efficient control equipment like bag filters and electro precipitators Cyclones are relatively inexpensive since they have no moving parts and they are easy to operate The most common type of cyclone is known as reverse flow cyclone separator

Others: Cyclones are used in sawmills to remove sawdust from extracted air

5. CONCLUSION

A prominent problem in calculating the efficiency of cyclone is the effect of flow characters in cyclone. In big cyclones the flow is turbulent and friction factors assumed give good results. This is not true for small cyclones. The flow in small cyclones can be laminar or even transitional. In such case the operational conditions, like velocity, temperature, pressure, viscosity and cyclone diameter, may be of significant importance and their effect changes from cyclone to cyclone. In laminar flow, operating parameters influence cyclone efficiency more than turbulent case. This makes the prediction of efficiency and pressure drop very difficult especially in small cyclone. Most of the models depend on empirical or semi-empirical equations.

The models calculate efficiency and predict the cutoff size which corresponds to 50% efficiency. According to Wang et al. cyclone performance is function of geometry and operating parameters of cyclone, as well as particle size distribution of the entrained particulate matter. Several models have been proposed to predict the efficiency of cyclone. It is widely agreed amongst the scientists that cyclone performance is definitely affected by operating parameters and hence they should be included in the modeling. Many theories account for density, gas velocity, viscosity and particle diameter. As far as effect of geometry is considered there is difference in approach for various scientists. Some consider all the geometric parameters where as some consider only few important parameters like inlet and outlet diameter and height in their models.

As mentioned, most of the theories consider cut size "d50", which corresponds to diameter of particle where 50% of particles smaller and 50% of particles greater that that size will be collected. Two most common approaches for calculating efficiency are Force Balance Theory [Lapple] which assumes that terminal velocity is achieved when drag fore and centrifugal force equal each other and the Static Particle Approach [Barth] which considers simple force balance where forces acting on particle are balanced. Various other complicated theories have been proposed but the essentially have their base in one of the two theories.

6. FUTURE SCOPE

In the future, state implementation plans and local environmental regulations will need to consider the energy consumption of control devices and not just stack total emissions, as producing electricity to operate control devices results in pollution where that electricity is generated .Future cyclone research will continue to focus on collection effectiveness, especially for finer particulates, but will also focus on minimizing energy costs. As computing resources become less expensive and CFD modeling becomes more sophisticated, increasingly complex models will continue to contribute to our still imperfect understanding. Yet numerical simulation will always require validation trials that test cyclones under conditions and loads as near to the real world application as feasible. As methods for quantification of particulate emission particle size distributions become more affordable, the quality of the data collected in these future trials should further improve.