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A Review Paper on Design, Development and Experimental Analysis of Perticuler Matter Separator

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Abstract— Dust collection is an online process for collecting any process-generated dust from the source point on a continuous basis**.** They are often used as an air pollution control device to maintain or improve air quality. Conventional mist collectors or wet scrubber available and used in the industry are extremely costly , high running cost and high maintenance cost hence there is a need of a modified cyclone separator that primarily can separate the particulate matter by mere action of cyclone in the dry condition there by reducing the initial investment, running cost and maintenance cost. Project work will include Mathematical model of cyclone system for optimal precipitation of dust capacity. Development of mathematical model of system of mss flow rate of air , derivation and resolution of pressure drop across various sections of the separator , determination of forces and utilizing system of forces to determine the precipitation of dust and particulate material. 3-D modeling of set-up will be done using Unigraphix Nx-8.0 and CAE of critical component and meshing using Ansys. The experimental validation part of the system be validated using test-rig.

Index Terms— Cyclone Separator, Collection Efficiency, Inlet Velocity, Optimization, Particulate Matter, Pressure Drop, Tangential Inlet.

1 INTRODUCTION

DUST collectors are used in many processes to either recover valuable granular solid or powder from process streams, or to remove granular solid pollutants from exhaust gases prior to venting to the atmosphere. Dust collection is an online process for collecting any process-generated dust from the source point on a continuous basis. Dust collectors may be of single unit construction, or a collection of devices used to separate particulate matter from the process air. They are often used as an air pollution control device to maintain or improve air quality.

Mist collectors remove particulate matter in the form of fine liquid droplets from the air. They are often used for the collection of metal working fluids, and coolant or oil mists. Mist collectors are often used to improve or maintain the quality of air in the workplace environment.

Fume and smoke collectors are used to remove sub micrometre size particulate from the air. They effectively reduce or eliminate particulate matter and gas streams from many industrial processes such as welding, rubber and plastic processing, high speed machining with coolants, tempering, and quenching.

Construction and Working

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 (figure). 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.

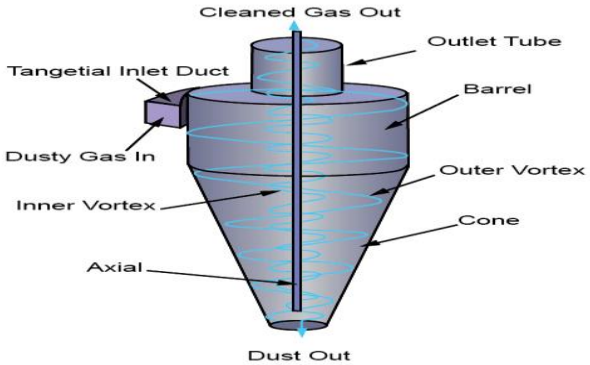

Fig 1.Cyclone Separator

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2 LITURATURE SURVEY

Mahesh R Jadhav [1] carried out the studies on design development and CFD analysis of cyclone. They also did experimental trials on cyclone. They carried out experimentation on the performance of flour mill cyclone for different flow rates and study of parameters like velocity and pressure drop. They designed two cyclones one cyclone with two symmetrical tangential inlets and a single tangential outlet at the barrel top area where impeller is mounted and another with single tangential inlet. They use anemometer for measurement of inlet and outlet velocity. Anemometer gives reading of velocity in m/s. For measurement of pressure the connector is attached at inlets and outlet port. Their results indicated that these new designs can improve the cyclone performance parameters significantly. They also observed that pressure drop is more in single inlet cyclone than symmetrical inlet cyclone means pressure drop depends on inlet velocity. As inlet velocity increases pressure drop increases for same model. Taiwo etal. [3] Discussed the design parameters required to construct a high performing cyclone through the application of the classical cyclone design. Texas cyclone design model was used to obtain an accurate pressure drop and sizing of cyclone, The Texas cyclone approach to design cyclones was to initially determine optimum inlet velocities (design velocities) for different cyclone designs, hence using the inlets velocity a cyclone dimension can be determined. 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.

Prof. Nerkar and Padole [4] gives a theoretical approach for Study the Effects of various Parameters on Performance of Cyclone Separator. cyclone separator is a device used to collect dust, dirt & particulate matter. These are the devices that employ centrifugal force generated by spinning the gas stream to separate the foreign material from the carrier gas. They did review study to find out the innovation, development in the technology of the cyclone separator until now. Finally they revealed that For the optimization of the cyclone separator Computational Fluid Dynamics (CFD) modeling play a vital role. There are many software to optimize the performance of cyclone as the computational cost decreases with increase in optimization rate of cyclone. Faulkner and Shaw [5] study the efficiency and pressure drop of cyclone across a range of inlet velocities. The Texas A&M Cyclone Design (TCD) method is a simple method for designing cyclones based on an inlet design velocity. They conduct experiments on two type of cyclone that is 1D3D and 2D2D cyclones and gives result on the collection efficiency and pressure drop associated with 1D3D and 2D2D cyclones across a range of inlet velocities. Finally they conclude that with increases in the inlet velocity the collection efficiency and the pressure drop of cyclone is also increases.

Sakura and Leung [6] did the experimental study on Particle Collection efficiency of Cylindrical Inlet Type Cyclone Separator. In this they reported the performance of collection efficiency of cylindrical inlet-type cyclone separator for relatively low solid loading rate conditions. Grade efficiencies and overall collection efficiencies have been investigated from 0.008g/m3 to 0.2g/m3 solid loading rates at 5m/s and 10m/s inlet velocity conditions. . Experimental data were compared with two theoretical predictions based on empirical and mechanistic relationships, developed by Smolik and Muschelknautz. Finally from both experimental and theoretical observations they conclude that with the increase of solid loading rate and inlet velocity, the particle collection efficiency of cyclone separator increases.

Verma et.al [7] study out investigation on design of cyclone separator under collection efficiency and air density effect. Cyclonic separation is a method of removing particulates from on air, gas or liquid stream, without the use of filters; through vortex separation they used rotational effects and gravity to separate mixtures of solids and fluids. According to them, the cyclone is probably the most widely used dust collector in industry because of its simplicity and low operating cost. They characterized cyclone performance as affected by design and operational parameters. With increasing particle mean diameter and density, increasing gas tangential velocity, decreasing cyclone diameter, increasing cyclone length collection efficiency increased.

Gopani and Bhargava [8] carried out studies on cyclone separator aimed at designing of high efficiency cyclone by using stairmand method for a tiny cement plant.According to them cyclone separator was reasonable option as it is cheaper and has low operating cost. They designed cyclone separator for 90 percent efficiency.

Ramachandran and Sivakumar [9] carried out study on design And Development of Cyclone Separater Interconnected CFBC. This work aims at optimizing the vortex finder configuration to reduce the pressure drop and denudation rate, for a given collection efficiency of the cyclone separator. Literature findings suggest the dependence of pressure drop on the dimensions of the vortex finder. Our model suggests the introduction of REPDS in the vortex finder, as a means of reducing pressure drop. Six existing cyclone separator designs were chosen and the more efficient Coker model was used to find pressure drop in each case. Four different models, with 25%, 50%, 75% and 100% RPDS length were developed for each design and CFD analysis of the existing designs with and without the RPDS were done. A mass flow rate of 500 m 3/hr, an inlet flow velocity of 15 m/s and the k-ε turbulence model were chosen for flow simulation. By fixing constraints for pressure drop, denudation rate and collection efficiency, an optimum model was developed by the dynamic programming method of optimization. The 50% RPDS length model was found to be best suited for any CFBC cyclone separator. Vekteris etal.[9] presented a novel concept of cyclone separator, where sound waves are used to agglomerate fine particles.They presented results of numerical simulation of air flows inside conventional and acoustic cyclone separators. During investigation they observed that the average separation efficiency of conventional cyclone separator reaches 87.2% only, while separation efficiency of acoustic cyclone separator is approximately 97.5%.They proved that air flow inside cyclone separator can be investigated numerically.

3 METHODOLOGY

a) Mathematical model of cyclone system for optimal precipitation of dust capacity. Development of mathematical model of system of mss flow rate of air.
b) Development of mathematical model of system of mss flow rate of air , derivation and resolution of pressure drop across various sections of the separator , determination of forces and utilizing system of forces to determine the precipitation of dust and particulate material.
c) Mechanical design of above components using theoretical theories of failure after selection of appropriate materials

- 3-D modeling of set-up using Unigraphix Nx-8.0
- Meshing using ANSYS.
- Validation of strength calculations of critical components using ANSYS.

d) Creation of Prototype: The selected mechanism and machine along with the damper will be designed using following machines:

- Centre lathe
- Milling machine
- DRO – Jig Boring machine
- Electrical Arc Welding

e) Experimental validation

4 CONCLUSION

From the review of various papers on cyclone separators, following conclusions can be highlighted – The cyclone separator is probably the most widely used dust collector in industry because of its simplicity and low operating cost .Tangential inlet velocity plays an important role in the gas movement of the cyclone separator. With increasing particle mean diameter and density, increasing gas tangential velocity, decreasing cyclone diameter, increasing cyclone length collection efficiency increased. Pressure drop and separation efficiency are affected by factors like solid loading ratio, gas inlet velocity flow field parameter.

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