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Performance Evaluation of Cyclone Separator

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Abstract- In India vast and diverse industrials in future and high demand for cleaning process is increases. Each year, thousands of tons row material or waste material use for recycling or purifier in India. Food, mineral water pure gas or air in mixture of some chemical or dust particle. Food or pharma industry maximum cost spends for cleaning process. Many cleanings process available but this mechanical device very costly therefore to replace the less cost effect and performance of remove dust particle is very efficient. 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. This project have discussed the design parameters required to construct a high performing cyclone through the application of the classical cyclone design, However, the pressure drop in this design does not consider any vertical dimensions as contributing to pressure drop, This is a misleading in that a tall cyclone would have the same pressure drop as a short one as long as cyclone inlets and outlets dimensions and inlet velocities are the same. The cyclone design model was used to obtain an accurate pressure drop and sizing of cyclone, The cyclone approach to design cyclones was to initially determine optimum inlet velocities for different cyclone designs, hence using the inlets velocity a cyclone dimension can be determined.

Keywords- Cyclone Separator, velocity, pressure drop, turbulence intensity, Vorticity, flow of rotation.

I. INTRODUCTION

Cyclone separator is the type of dust separation technology. Where mixture of solid-gas stream to separate the solid particle from carrier gas. The gas cyclones is type of robust cleaning device. Also gas solid cyclone is a stationary mechanical device to that utilizes centrifugal force and gravitational force to separate liquid or solid particles from a gas or air stream. The flow enters near the top of the cyclone through the tangential inlet, which gives rise to an axially descending spiral of gas and a centrifugal force field that causes the incoming particles to concentrate along, and spiral down the inner walls of the cyclone separator and collected the bottom of cyclone separator.

The collected particulates are allowed to exit out a dustbin (underflow pipe) while the gas phase reverses its axial direction of flow and exits out through the vortex finder (overflow pipe and vortex finder). Global warming caused by excessive use of the fossil fuels to mixer many particles in pure air. Purifier the air to mixture of air solid particle with high efficiency of collector. To utilized the waste material with help of the cleaning process. Unhealthy gas or air are directly affected human being food item and medicine there for large scale among people affected.

A cyclone separator is a device that makes mixture flow into the inlet, generates a cyclone, and separates particulates from a gas, air or liquid stream by the use of centrifugal force. Usually, the

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cyclone separator has a simple structure, thus it is easy to manufacture the product. The cyclone separator is widely used in various industries, such as those involved with removing dusts, collecting micro particles, cleaning equipment, biosensors, and air purification systems. The cyclone separator investigated in the present study is a device that removes brine particulates from the mixed brine and steam. This cyclone separator is used as a unit of the geothermal power plant.

Cyclone separator, also called a cyclonic dust collector, is a widely used air pollution control device that cleanses flue gases of particulate matter before such gases exit into the atmosphere. It's a method of collecting up to 99% of airborne waste in an easy-to-empty container beneath the cyclone. These devices are primarily labeled as pre-cleaners, as they are instrumental in removing large and abrasive particles from flue gases, which then go through additional filtration processes to remove fine particulate matter. The relevance of cyclone separators lies in the fact that they facilitate the first step of the flue gas filtration process. The objective of these devices is to minimize air pollution and environmental hazards caused by production plant exhaust.

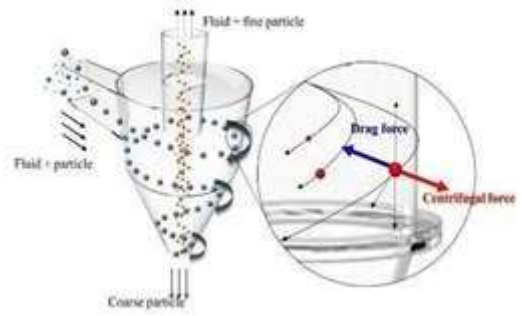

Figure 1. Principle of cyclone separator

II. LITERATURE REVIEW

Ji Zhonhli and zhiyi xiong (2021) [1] In order to evaluate the influence of extremely low particle concentration on separation performance of cyclone separator, the overall collection efficiencies and grade efficiencies of a cyclone separator with particle concentrations of 5–2000 mg/m3 and inlet velocities of 6–30 m/s have been investigated under ambient temperature and atmospheric pressure conditions. Aerosol spectrometer based on measuring particle number is used to measure the particle concentrations and particle size distributions of the inlet and outlet of the cyclone separator. The overall efficiency is equal to the ratio of the particle concentration difference between the inlet and outlet of the cyclone separator to the inlet particle concentration. The grade efficiency is obtained by comparing the particle size distributions of the inlet and outlet of the cyclone separator. The effects of particle concentration on separation performance are predicted by Solid empirical model. Particle agglomeration, which has been found in the inlet and outlet of the cyclone separator, has a very important influence on the collection efficiencies and grade efficiencies of the cyclone separator at the particle concentration of 5–2000 mg/m3.

S. Venkatesh et al. (2021) [2] The square cyclone separators are widely utilized in CFB boilers to isolate tiny specks fromgas flow. In present investigation, three square cyclones are fabricated, after that which is linked in series manner. The average mean particle size of 2.2 µm (magnesium particles) is utilized in experimental analysis. The estimated collectionefficacy of this series arrangement cyclone is 61% at the particle size of
2.2 µm. It is 10.2% higher than the collection efficiency of single square cyclone. The pressure drop is reduced to 14.3% by this series arrangement configuration. The numerical simulation is executed for predicting the pressure drop for different inlet velocities (10 m/s to 28 m/s). The assortment efficacy is appraised for the various size of particles through the CFD analysis. The flow pattern effects are arrived for the particle size of 2.2 µm and 10 µm. The flow pattern result provides better conformity with experimental results.

Omer Sendogan el al.(2020) [4] Cyclone separators have been extensively used both for particle sampling and particle removal from fluids, air or process gases in the field of air pollution control and in industry. In this experimental study, effects of inlet velocity, inlet shape and cyclone length on the cyclone collection efficiency and pressure losses

were investigated. A new cyclone design without conical part and its performance were also presented. Experiments show that optimum inlet size and cyclone length can be found for better collection efficiency at a specified flow rate. Experimental results from the tests on the new cyclone are evaluated and compared with the results in conventional cyclone. Results show that the new cyclone gives better efficiency comparing to the conventional cyclone for the same cyclone diameter and inlet velocity.

Chine Shweta C et al. (2020) [7] the study aimed toward improvement of performance of gas solid separator operating at pressure at 1Mpa and at high flux density in the cyclone body. Here we are going to study various parameter affective the cyclone process and calculating various changes because of it. The receiver consisting of cone shaped converging channel and an externally fined circular pipe is found in the middle of cylindrical cyclone body. A fine and tube flow conditioner is mounted upstream of converging channel inlet. Experimental result show that optimal cyclone design velocity which are for 1D3D cyclone should be determine based on standard air density. It is important toconsider the air density effect on cyclone performance in design of cyclone abatment system. By using this system pressure drop was tested against the measured data at different inlet velocity. This result show cyclone pressure drop varies with inlet velocity but not with diameter. Simulation results are going to be involved in estimation of the main performance characteristics of the separator. Experimental research on a 1;2 separator model allowed estimation of pressure drop.

Shantanu Kashikar et al. (2019) [9] During the finishing operation in paper industry, waste paper is engendered as the result of the trimming operation. This trimmed paper is called broke or trim and needs to be recycled. For the recycling of trim, there is a need of trim handling system and cyclone separator is of paramount importance in trim handling process. In this paper cyclone separators are reviewed and how this technology helps in efficient handling of trim. Industrial Review of cyclone from BILT, Ballarpur (largest pulp and paper manufacturer in India) is also added. This paper aims at reviewing the design and analysis of cyclone and its application in paper trim handling process.

Zhenhua Han et al. (2018) [12] Cyclone separator is a kind of equipment used for gas-solid system or liquid-solid system separation. In view of the problems encountered in the repetitive calculation of the cyclone separator and the drawing of parts.The components encountered in the production of enterprises and factories, that is, the problems of more repetitive work and low work efficiency, it is developed based on VB and AutoCAD software. A set of parameterized design software system for the two-stage cyclone separator is considered. Take the inclination angle of the tapered pipe section, the exhaust pipe insertion depth S and the exhaust pipe diameter D, which have a significant effect on the separation efficiency.For design variables, with separation efficiency and pressure drop as objective functions, the structural parameters of the cyclone separator are optimized. The results show that the separation efficiency of the cyclone separator is increased from 84.3% to 90.4% by the response surface optimization method, and the speed, pressure drop, fractionation efficiency before and after optimization are compared and analyzed, and the optimization efficiencyis found to be obvious.

Zhiquan Zuo et al. (2018) [13] In this study, the computational fluid dynamics (CFD) method was used to optimize the structure of anti-re-entrainment cone in cyclone separator. The Reynolds stress model (RSM) was used to simulate the flow fields inside a cyclone separator with different anti re-entrainment cone structure, and their axial and tangential velocity distribution.

III. EXPERIMENTAL METHODOLOGY

Cyclone separator has been used for micro particle separation in various industries. Its simple design and easy constructability make them very popular. Cyclone separator does not have any moving parts and hence it has very low maintenance costs. Also,

they consume very less energy as separation occurs due to natural forces action and swirl motion of fluid. Hence, cyclone separator, with its simple design, fluid-only type of separation, and low cost, becomes an obvious choice for experimentation.

IV. CYCLONE SEPERATOR

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Figure 2. cyclone separator

Although various large and small cyclone separators have been used successfully in cement, agro, oil and various other industries, there are very less data and research available about its application at micro scale. This research explores possibilities for successful application of micro- cyclone separators for micro particle separation and will provide some guidelines for further exploration. Cyclone separator is a fluid-only type separation device which employs fluid and particle forces to separate particles depending upon their densities. This gives it an upper edge over other techniques as all other techniques require some unique properties like magnetic susceptibility, refractivity, dielectric properties or acoustic and thermal susceptibility.

The fluid enters the cyclone tangentially. The cyclone induces a swirl rotation and hence, imposes radial acceleration on particles. Shows the forces acting on the particle in a cyclone separator.

Most conventional way of designing a cyclone separator is by determining the cut of diameter of particle that needs to be separated. Various designing approach and empirical models passed on them will be discussed in later chapters. The basic principle of separation is that the particles with higher densities have higher inertia and hence they tend to revolve in larger radius. Thus, the heavier particles are revolving nearer to the wall where they slide down and are removed. Lighter ones rotate near the center and are collected out from the center of the cyclone.

V. EXPERIMENTAL SETUP

Acrylic sheet used to prepare the cyclone separator and think of the acrylic sheet is 8mm x 4 mm. initial CAD software uses to design the cyclone separator in different size and then with help of solid work software make 3d model. Cut the different size of cyclone separator using acrylic sheet. After prepare the template tube diameter 304.8mm and cutting heat of acrylic sheet is 50-600oC. Assemble the cyclone separator components.

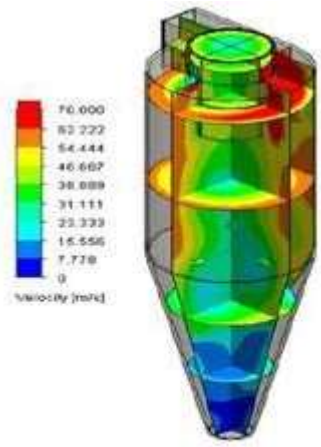
Figure 3. Experimental Setup

All cyclone separators have an associated pressure drop. The pressure drop can be thought of as the amount of energy required to move the gas through the separator, alternatively, it can be thought of as the amount of resistance the cyclone separator adds to the system flow. Another way to increase a separator„s efficiency is to reduce the accept port diameter. This changes the separator body to accept port diameter ratio and has the effect of only allowing finer particles to leave the separator through the accept port

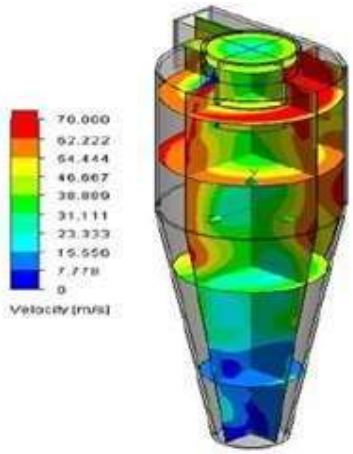
Figure 4. Different size of cyclone separator Setup

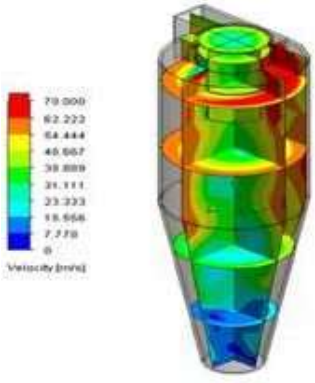
VI. CFD ANALYSIS RESULTS

CFD Analysis of three type of cyclone separator has been done. CFD has been analyzed in Transient mode.



Lapple Cyclone
Inlet velocity – 42.5 m/s
Outlet velocity - 32.346 m/s





Swift Cyclone
Inlet velocity – 42.5 m/s
Outlet velocity – 33.041 m/s

Figure 5.. CFD Analysis of Three Type of Cyclone Separator for Velocity

First, the CFD was analyzed for velocity by giving an inlet velocity of 42.5 m/s. The inlet velocity of cyclone separator is 42.5 m/s. After, inlet velocity is connected to cyclone separator the outlet velocity of the Lapple cyclone separator is 32.346 m/s. And the outlet velocity of the Stairmand cyclone separator is 33.041 m/s. The outlet velocity of the Swift cyclone separator is 33.041 m/s. As per considered case, the velocity should be decreased from inlet velocity when compared with outlet velocity. Here the velocity in the three types of cyclone separator is considered an outlet velocity.

Second, the CFD analyzed for pressure drop by giving an inlet velocity of 42.5 m/s. The inlet velocity of three type of cyclone separator is 42.5 m/s. After the inlet velocity of the three types of the cyclone separator is given the pressure drop is calculated. The lapple cyclone separator pressure drop is 3948 Pa. The Stairmand cyclone separator pressure drop is 4542 Pa. Finally, the swift cyclone separator pressure drop is 4370 Pa. Here the pressure drops in the three-type cyclone separator Is considered as outlet pressure drop.

VII. CONCLUSION

In this paper, optimal cyclone separator from three type cyclone separator is found out through CFD analyzer using seven different types of the particles. From CFD analysis carried from the modelling it is found that the swift cyclone separator is having better velocity, pressure drop, turbulence intensity when compared to the lapple cyclone separator and stairmand cyclone separator with optimal outlet velocity. So, from this analysis and tested result it is well informed that the swift cyclone separator is the optimal technique with higher performance when compared with lapple cyclone separator and stairmand cyclone separator.

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