Experimental Investigation on Cyclone SeparatorPerformance using CFD Simulation

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***Abstract*- Cyclone separator models have been utilized without applicable adjustments for over a century. The greater part of the consideration has been centered around finding new techniques to improve execution parameters. As of late, a few investigations were directed to improve hardware execution by assessing geometric consequences for ventures. In this work, the impact of twister geometry was concentrated through the making of a balanced delta and a volute parchment outlet area in a test cyclone and correlation with a conventional single digressive bay. The study was performed for cyclone separator. The effects of conical angle and particle size on separation efficiency using CFD simulation. The simulation is carried out using computational fluid dynamics (CFD) in ANSYS Fluent for gas-particle flow with cyclone separator. The majority of the consideration is centered around improving the cyclone execution parameters.In this project the geometric effect on cyclone separator is studied with the creation of symmetrical tangential inlet cyclone separator and compared it with the different conical angle.**

Keywords—CATIA, CFD, Cyclone conical angle, collective efficiency

I. INTRODUCTION

Cyclone separators are broadly utilized in numerous mechanical applications to isolate scattered particles from their conveying liquid or for item recuperation. The notoriety is because of their geometrical effortlessness, relative economy in force, and well versatility to incredibly brutal conditions. Numerous investigations have been performed for investigating the stream field qualities, as a principal venture to comprehend pressure drop and molecule division effectiveness. Simultaneously, in light of the accessible trial information, hypothetical models have been created to foresee the stream field and the partition execution, for the most part on semi-observational grounds. Separators are fundamental parts of gas cleaning frameworks and are widely utilized in various ventures. Wide extent of utilization and details added to the advancement of a huge assortment of developments that vary in their proficiency as well as in the sort of powers used for division (latency, gravity, diffusive increasing speed). Enormous scope cyclone winds are utilized in sawmills to expel sawdust from separated air. Cyclone are additionally utilized in petroleum treatment facilities to isolate oils and gases, and in the concrete business as parts of furnace preheaters. Twisters are progressively utilized in the family unit, as the center innovation in bagless sorts of versatile vacuum cleaners and focal vacuum cleaners. Cyclones are likewise utilized in modern and expert kitchen ventilation for isolating the oil from the fumes air in extraction hoods. Littler cycloneis utilized to isolate airborne particles for examination. Some are sufficiently little to be worn cut to apparel, and are utilized to isolate respirable particles for later investigation. A cyclonic partition is a strategy for expelling particulates from an air, gas or fluid stream, without the utilization of channels, through vortex division. While expelling particulate issue from fluid, a hydro cyclone is utilized while from gas, a gas cyclone wind is utilized. Bigger (denser) particles in the turning stream have an excessive amount of idleness to follow the tight bend of the stream, and along these lines strike the outside divider, at that point tumble to the base of the twister where they can be expelled. In a cone shaped framework, as the pivoting stream moves towards the restricted finish of the twister, the rotational span of the stream is diminished, in this manner isolating littler and littler particles. The cyclone geometry, together with volumetric stream rate, characterizes the cut purpose of the cyclone wind. This is the size of molecule that will be expelled from the stream with a half effectiveness.

II. LITERATURE REVIEW

Xun Sun et. al [1] In the current investigation, multi-target streamlining of a gas cyclone wind is performed utilizing a GA. CFD procedures to limit pressure drop and expand its assortment productivity. The second-age non-commanded arranging hereditary calculation is used to enhance the four critical variables of the cyclone wind as indicated by the very much characterized wellness capacities, and 53 non-overwhelmed ideal cyclone configuration focuses are proposed. The presentation and stream field of an agent ideal plan are contrasted and those of the old style Stairmand model and the

reference model. The ideal structure diminishes the weight drop and cut-off size by 7.38% and 9.04%, separately, contrasted with the reference model. It is seen around diminishes of 19.23% and 42.09% are accomplished for the weight drop and cut-off size.

John Dirgoet.al [2]This paper speaks to scarcely any tests led on a Stairmand high-proficiency cyclone wind. The twister was pilot-plant scale with a structure wind stream of 0.139 m^3/s (300 cfm). An oil fog was utilized as a test airborne in light of the fact that it comprised of round drops of uniform thickness improbable to skip or control in the wake of striking the cyclone divider. Test bends were contrasted and partial productivity bends created by a few cyclone proficiency hypotheses. The molecule sizes estimated (1 to 7 pm), the forecasts of an adjusted variant of Barth's hypothesis and the Leith-Licht hypothesis were nearest to trial results. An airborne of fluid beads was utilized to limit the chance of molecule entrainment after assortment in the cyclone wind and to give the circular particles expected by twister proficiency speculations. Hypothetical bends were compliment, crossing the trial bends at a molecule size somewhat bigger than the cut distance across.

Prachi K. Ithape et.al [3], In this paper it presents to maximizecollectionefficiency and limit pressure to minimum level. The geometric parameters that influence its presentation are for the most part cone tallness, chamber stature, plunge tube tallness, delta area and so on. The genuine cyclone wind separator model was first approved by utilizing exploratory outcomes and results acquired from the calculations acted in ANSYS CFX. Assortment effectiveness acquired from the investigation was then utilized as a way to choose the last structure of the twister separator. The efficiency of genuine cyclone wind separator by CFD examination came out to be 53.1 % though the test estimation of it was 52 %.

Muhammad Taiwoet.al [4],This paper has talked about the plan parameters required to build a high performing cyclone wind through the use of the old-style twister structure. The Texas cyclone way to deal with plan twisters was to at first decide ideal channel speeds (structure speeds) for various cyclone wind structures, consequently utilizing the deltas speed a cyclone measurement can be resolved. Cyclone winds have regularly been viewed as low-productivity gatherers, the efficiency differs enormously with molecule size and cyclone plan. It is seen that cyclone makers promote cyclone winds that have efficiencies more prominent than 98% for particles bigger than 5 microns, and others that routinely accomplish efficiencies of 90% for particles bigger than 15 – 20 microns.

Omid Reza Nassaj et.al [5], In this article it presents the cyclone wind separator to configuration causes to shape a solid vortex stream in the twister, which builds the radiating power following up on every molecule independently, expands the assortment effectiveness just as reduction the cut-off distance across. The outcomes speak to a uniform dispersion of static weight designs at twister statures for every speed just as a uniform stream field design in the cyclone. The cut-off measurement decreased by 0.2 μm in examination with the typical cyclone separator. With 20% expanding in the channel speed, the most extreme static weight in all areas increments by around 41%, while the 20% decrease in the bay speed, diminishes the greatest static weight in all segments by 55% to 58%. A 20% expansion in speed contrasted with the underlying speed of 8.809 m/s, diminishing the slice off breadth to around 0.6 μm. A 20% decline in channel speed, the partition proficiency is decreased by and large and expands the slice off measurement to 0.9 μm.

III. PROBLEM STATEMENT

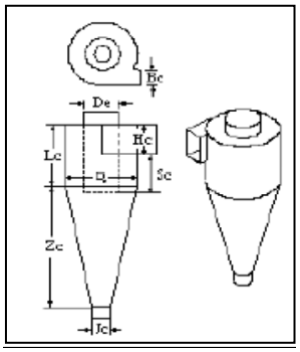
The greater part of the cyclone separators are customarily planned. These structures comprise of tangential input pressure inside the chamber. This has optimum pressure, temperature and speed. Yet at the same time the time required is more for the particular stream and changes for various liquid/gases. Along these lines, we are incorporating cyclone separator a with the distinctive conical angle, which will help in expanding the assortment efficiency and upgrading the outcomes for existing structure.

IV. OBJECTIVES

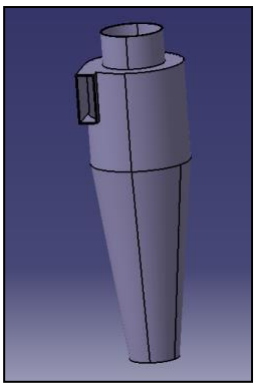
- Design of conical angle geometry of cyclone separator in CATIA software.
- By CFD simulation for maximum collection efficiency as well as decrease in pressure drop to calculate using ANSYS fluent software.
- Manufacturing of cyclone separator from CFD simulation for experimentation.
- Experimental analysis of cyclone separator by using air velocity and measurement by anemometer.
- Validation of CFD results by experimentation and CFD simulation.

V. METHODOLOGY

Step 1:-Initially research paper are studied to find out research gap for project then necessary parameters are studied in detail. After going through these papers, we learnt about improving the efficiency of cyclone separator.
Step2:-Research gap is studied to understand new objectives for project.
Step 3:- After deciding the components, the 3D Model and drafting will be done with the help of CATIA software.
Step 4:- The CFD simulation of the components will be done with the help of ANSYS Fluent.
Step 5:- The Experimental Testing will be carried out with the optimized cyclone separator.
Step 6:-Validation of experimental and simulation results.



Diameter Dc = 150 mm for 1D2D type of Cyclone Separator,
Bc = Dc/4 = 150/4 = 37.5 mm
De = Dc/1.6 = 150/1.6 = 93.75 mm
Hc = Dc/2 = 150/2 = 75 mm
Jc = Dc/2 = 150/2 = 75 mm
Sc = 5Dc/8 = 5x150/8 = 93.75 mm
Lc = 1*Dc = 1*150 = 150 mm
Zc = 2*Dc = 2*150 = 300 mm



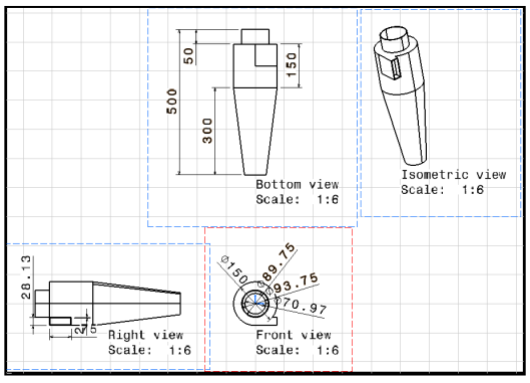


Fig.1.CATIA and drafting of conical angle cyclone separator

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to analyze and solve problems that involve fluid flows. CFD is now recognized to be a part of the computer-aided engineering (CAE) spectrum of tools used extensively today in all industries, and its approach to modelling fluid flow phenomena allows equipment designers and technical analysts to have the power of a virtual wind tunnel on their desktop computer.

CFD PROCEDURE

- Fine meshing is performed for CFD simulation.
- Named selection is performed in CFD to define air inlet, outlet and surface.
- In general box model gravity is defined in perpendicular direction and energy is kept on to perform conservation of mass, momentum and energy equation to solve.
- In viscous model k epsilon, realizable and standard wall function is selected to maintain turbulence flow.
- Selection of k epsilon model with wall scalable function along with material as air as fluid and base material for model are selected.
- Inlet velocity of 8 m/s is defined with initial temperature and for solution initialization hybrid is selected.
- Ash particle size of 1 micron with discharge at 1 e^{-6} kg/s have been provided.
- Number of iterations of approx. 100 is provided and calculation is performed.
- Calculation of pressure and particle time plot has been plotted.

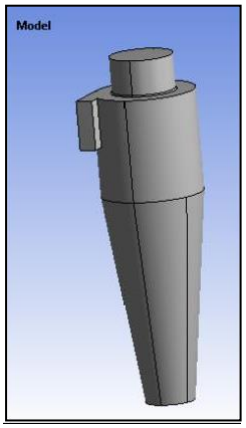
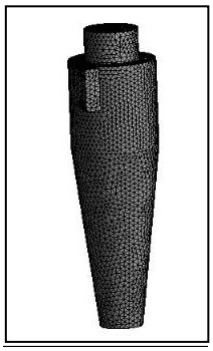


Fig. 2.Geometry imported in ANSYS for CFD simulation

Mesh

In ANSYS meshing is performed as similar to discretization process in FEA procedure in which it breaks whole components in small elements and nodes. So, in analysis boundary condition equation are solved at this elements and nodes.ANSYS Meshing may be a all-purpose, intelligent, automated high-performance product. It produces the foremost acceptable mesh for correct, economical metaphysics solutions. A mesh well matched for a selected analysis may be generated with one click for all elements in a very model.



Statistics	
Nodes	19014
Elements	97231

Fig.:3. Details of meshing of different cyclone separator model

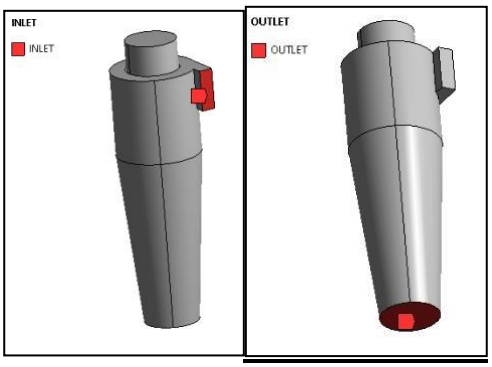


Fig.4. Named selection for CFD simulation

14 DEGREE CONICAL ANGLE

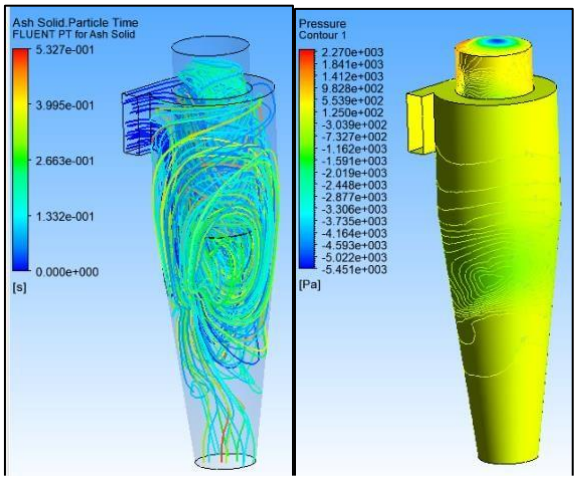


Fig.5. Solid particle time and pressure contour

From the above plot it is observed that maximum pressure of 2341 Pa and ash particle time required is 0.53 second to reach bottom.

EXPERIMENTAL WORK

- Initially design is designed in CATIA software and fixture is assemble to hold the component.
- Pipe of specified dimensions are selected as per standard design along with GI sheet is wrapped to form conical shape with standard shape dimension.
- Rivet joint are preferred over welding to joint components along with M seal to provide leak prof joint.
- For experiment initial velocity as per CFD simulation is considered and outlet velocity is measured by anemometer for validation of CFD results.

Fig.6. Experimental setup

Fig. 7. Experimental testing results

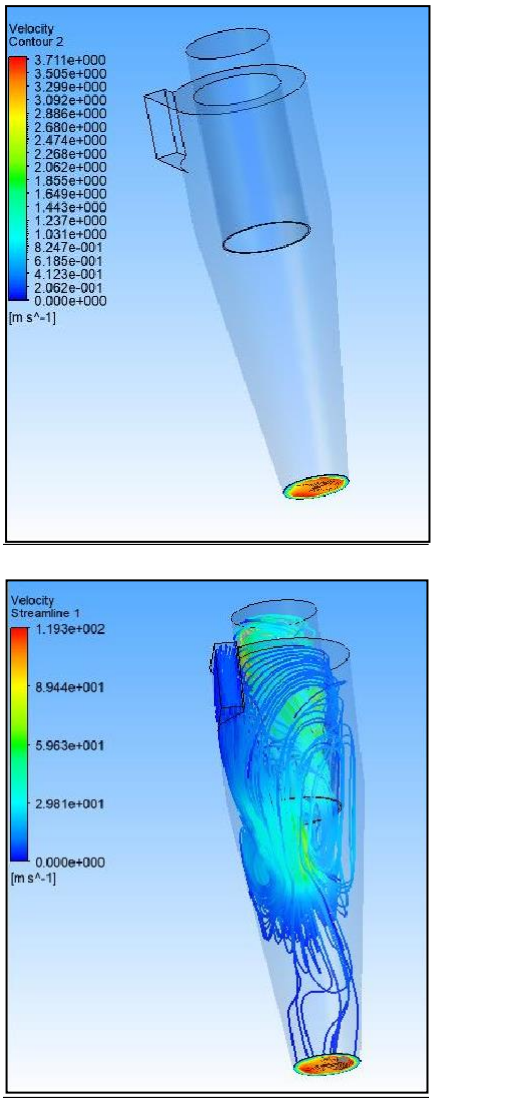


Fig. 8. CFD simulation result

It is observed that for 8 m/s for both experimental and CFD simulation outlet velocity is around 3.9 and 3.55 m/s respectively.

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VI. CONCLUSION

In present study design of cyclone separator have been performed with CFD simulation for a preliminary boundary condition to determine pressure contour and time taken by particle to reach outlet at bottom.
It is observed that conical angle with 14 is optimum as solid particle take less time to reach at bottom and also maximum pressure drop compared to other geometries.
Experimental and CFD simulation results are in similar range for validation and successfully validated.
It is observed that for 8 m/s for both experimental and CFD simulation outlet velocity is around 3.9 and 3.55 m/s respectively.

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