A Review on Gas Solid Cyclone Separator Parametric Analysis

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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 cleaning process available but this mechanical device very costly therefore to replace the less cost effect and performance of remove dust particle is very efficient. This paper summarizes the research literature referred relative to the cyclone separator design aspects, flow in cyclone separator and efficiency of cyclone separator.

Key words: Cyclone Separator, CFD, Collection efficiency

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

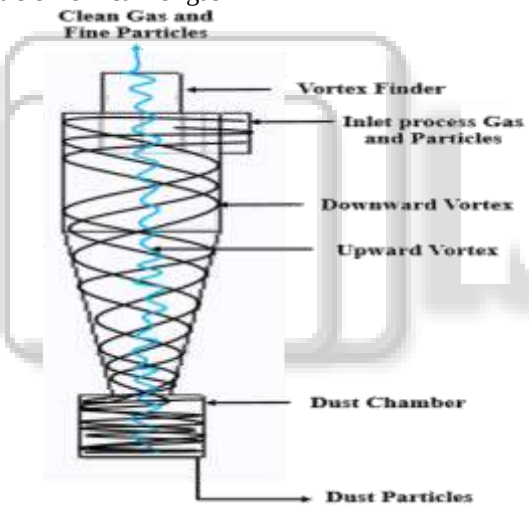

Fig. 1: Principle of cyclone separator

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 particle 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.

II. LITERATURE REVIEW

This section summarizes the research literature referred relative to the parameters that are affecting to the cyclone separator.

A. W. P. Martignoni,S. Bernardo and C. L.Quintani.(2007) [1]:

In this research paper study on different type of cyclone design. Symmetrical inlet and volute scroll outlet section in an experimental cyclone and comparison to basic cyclone separator. They are used solid material silica and carrier air stream. From table I observe LES turbulent model results nearest compare to RSM model and overall collection efficiency also nearest the experimental results. Figure 2 Illustrate the overall cyclone collection efficiency increase and pressure drop increase certain simulated time.

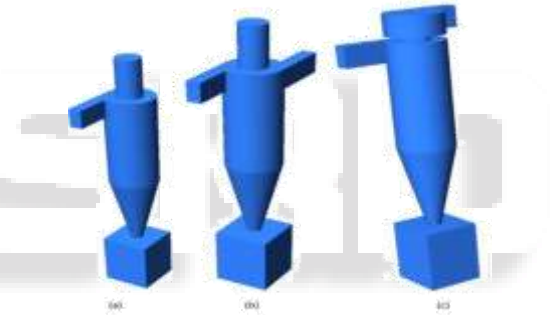

Fig. 2: (a) Conventional (b) Symmetrical inlet (c) scroll inlet and out let section three different type of cyclone model. [1]

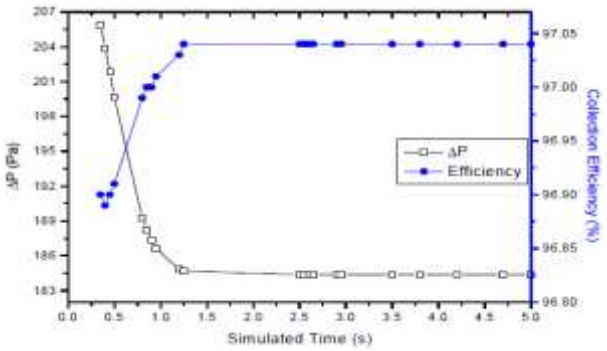

Fig. 3: Performance parameters profile cyclone with symmetrical inlet section using the LES model. [1]

	Total Pressure Drop (pa)		Overall Collection Efficiency (%)	
	RSM	LES	RSM	LES
Conventional Cyclone	440	490	90.96	91.18
Symmetrical Inlet	182	184	97.04	97.03
Volute Inlet and Outlet	431	432	97.37	96.55
Experimental	579		92.00	

(Patterson and Manz,1989)		

Table I. Performance parameter of the cyclone separator design purposed. [1]

B. Giulio Solero, Aldo Coghe (2002)[2]:

This paper discusses the detailed description experimental investigated measure the collection efficiency and pressure drop for the laboratory scale model of a gas cyclone at open/closed loop test facility built up to study the flow field of both the gas and solid phase. They have also measured the mean and fluctuation in velocity component for gas solid cyclones with geometric swirl number by mean of the laser Doppler anemometry analysis. In experimental the feeding material is aluminum titanate powder. Operating condition of experiments performed three test condition open loop, closed loop and open loop air with solid particle. In all case the volumetric flow rate 0.063 m^3/s.

C. Sujeet Kumar Shukla, Prashant Shukla, Pradyumna Ghosh (2013) [3]:

This study aims to present all had velocity distribution graphs are compared with the experimental results with Hoekstra, and simulation of collection efficiency result are validate with the experimental results of Zhow. Outcome experimental model injected material used are talcum powder. Air velocity was taken as 16.1 m/s and particle velocity was 20.18 m/s. The concluded that when particle size will increase so collection efficiency increases and they also investigated when node size increase in CFD simulation results near the experimental results. They concluded that turbulence large eddy simulation (LES) has good compare to RSTM model mean flow field and fluctuation flow field. Figure 5 Illustrate particle size increase then grade efficiency increase.

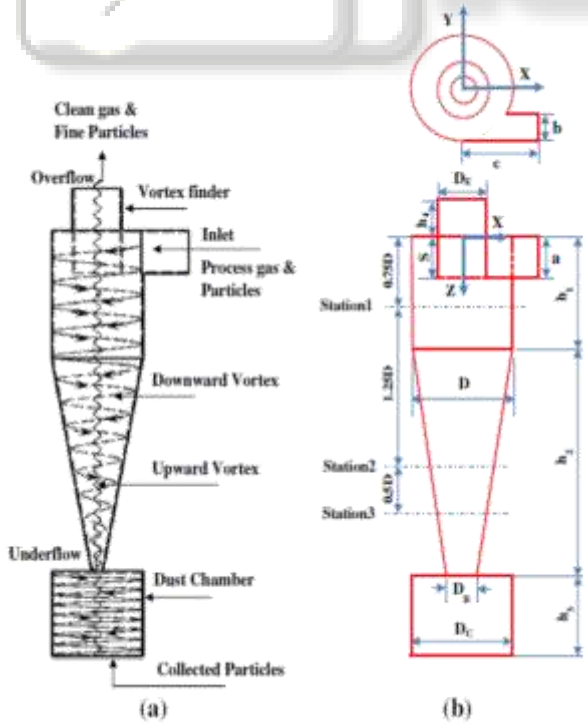

Fig. 4: Diagram of high efficiency stairmand cyclone geometry (a) working principle (b) Coordinate system for cyclone geometry. [3]

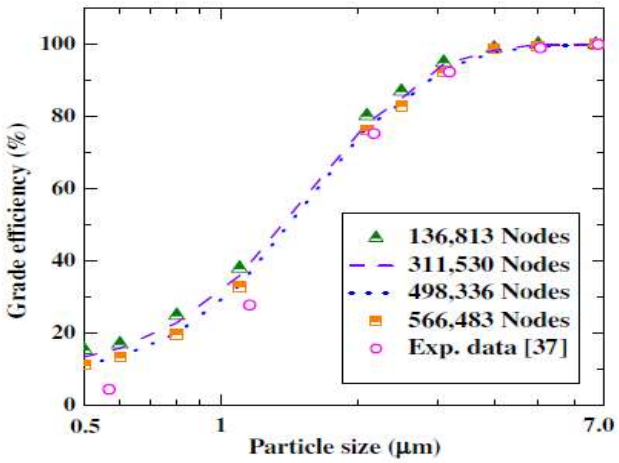

Fig. 5: Simulated grade efficiency profiles for the Stairmand cyclone of 0.3 m barrel diameter with different mesh density using RSTM technique. [3]

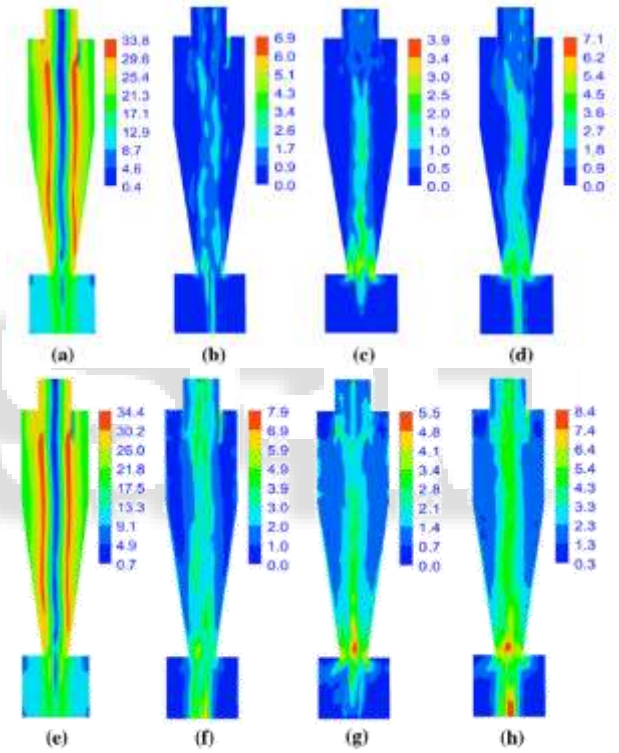

Fig. 6: Comparisons of RSTM and LES model from top to bottom and from left to right: mean velocity magnitude m/s, RSM tangential velocity m/s, RSM axial velocity m/s, and RSM velocity magnitude m/s. [3]

D. Mi-Soo Shin, Hey-Suk Kim a, Dong-Soon Jang (2005) [4]:

In this research paper experimental study develop for the high efficiency cyclone separator application for high environment condition of much higher pressure and temperature respectively 6 bar and 400 ° c. They have two experimental investing carried out the calculation results prediction well its magnitude of the experimental measurement pressure drop with the conditions of increase pressure and temperature as an obtained in term of flow rate (velocity).During the experimental condition applied increase of pressure and temperature they effect on collection efficiency. Experiment analysis particle size below 10μm temperature and pressure more effect. They

outcomes when we increase pressure increases separation efficiency, Negative effect on separation efficiency when increase temperature they results limit of flow rate. The experiment analysis indicated the large effect of the geometric swirl number on mean flow velocity; in particular with depend on size of vortex finder and tangential velocity magnitude maximum. Forced vortex area of the flow is determining the process vortex finder.

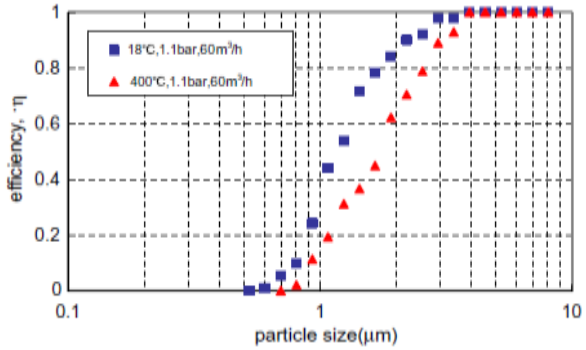

Fig. 7: The effect of temperature on the measured fraction collection efficiencies for 18 ° c and 400 ° c temperature. [4]

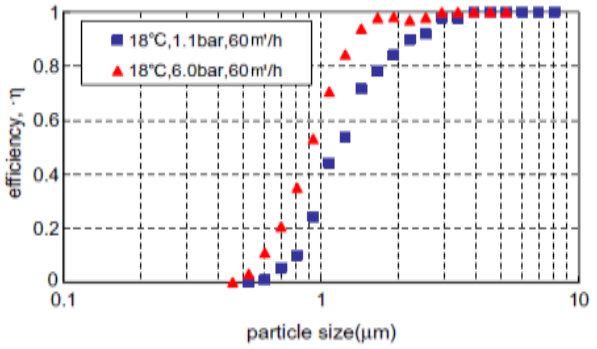

Fig. 8: The effect of temperature on the measured fraction collection efficiencies for 18 ° c and pressure drop1bar and 6bar. [4]

The program is developed using Patankar's SIMPLE method for the application of 2-D axis symmetric flow field. The two-equation turbulence k–e model is employed for the resolution of Reynolds stresses. Further the particle trajectory calculation is made by the incorporation of drag, centrifugal and Coriolis force in a Lagrangian frame.

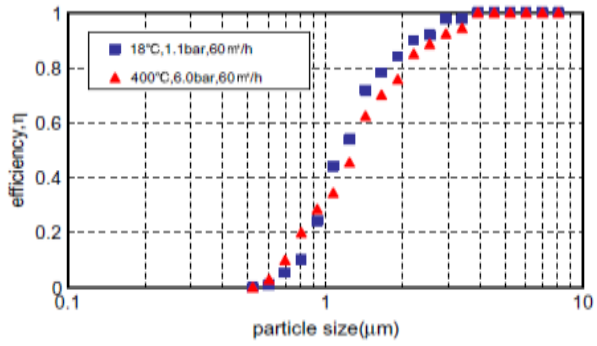

Fig. 9: The effect of temperature on the measured fraction collection efficiencies for 18 ° c and pressure drop1bar and 6bar. [4]

E. David Leith, Dilip Mehta (2005) [5] :

In this research paper collection efficiency increase various reason

1) Increasing particle size and density.
2) Increasing speed of rotation in the cyclone separator.
3) Decreasing cyclone diameter.
4) Increasing cyclone length.

A cyclone grade efficiency curve relates size of particles going to the cyclone to the cyclone efficiency on particles of that size. The grade efficiency curve for Stairmand's high efficiency cyclone is high compare to other cyclone design.

They also observation in cyclone separator pressure drop analysis SHEPHERD and LAPPLE (1939) as. In cyclone separator pressure drop measured between tangential inlet and vortex finder.

1) Reduced due to expansion of the gas when it enter the cyclone body.
2) Reduced of kinetic energy of circulation in the cyclone body.
3) Reduction due to wall friction in the cyclone separator body.

F. Cristobal Corteis, Antonia Gil (2007) [6] :

Author carried out Antonia gill computationally investigated several standard cyclone design. Results of measure data are further use for CFD simulation for Collection efficiency and pressure drop. The CFD modeling is providing an understanding of how to separate in cyclone and tangential flow. Overall CFD method is inexpensive and reliable method of analysis the number of effect when changes in design the. CFD approach for geometry optimization method compare experimental method.

G. Bingtao Zhao (2005) [7] :

In this paper to developed new theoretical method for calculation collection efficiency is developed based on analysis of flow pattern. And particle size and boundary condition theory developed. Comparison of the calculated grade efficiency with experimental data and theoretical data.

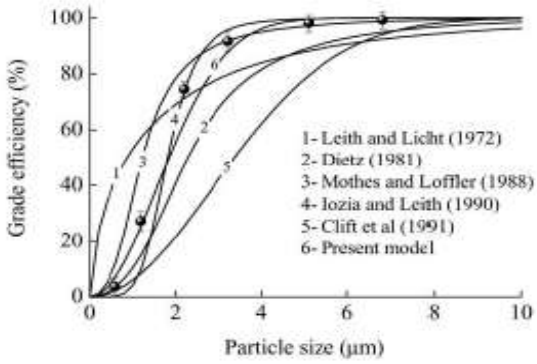

Fig. 10: Comparison of theoretical and experimental results. [7]

H. Khairy Elsayed, Chris Lacor (2011) *[8]*:

Author carried out Convention cyclone design was changing in tangential inlet height and width. They are analyzes changing inlet height and width effect on pressure drop and collection efficiency. In this research paper five different type of cyclone separator used. Figure 11 Illustrate the increase the inlet height A1, A2, A3 then grade efficiency decrease and increase inlet width also decrease the grade efficiency. Also obtained inlet width/height ratio 0.5 to 0.7.

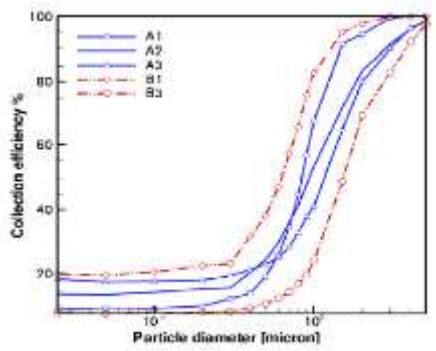

Fig. 11: The Grade efficiency curves for the five cyclones. [8]

H. Khairy Elsayed, Chris Lacor (2013) [9]:

They are analyzes the convention cyclone design to changing in vortex finder length and diameter. They nine different type design of cyclone separator analysis in CFD simulation. They are using LES model in CFD simulation. They following conclusion obtained.

1) Reduction the vortex finder diameter by 40% the result 175% increase in the dimensionless pressure drop and 50% decrease in the Stokes number.
2) The values of the performance of parameters of depends on barrel height.

I. J. K.W. Chu, B. Wang, D.L. Xu, Y.X. Chen, A.B. Yu (2011) [10]:

In this research paper analysed gas-solid cyclone separator used of CFD-DEM simulation method. They are investigation both experimental and simulation. Validation the experimental result and simulation results. When solid loading ratio increase the pressure drop was decreasing in show figure 12. And gas velocity increase the pressure drop increase in cyclone separator show figure 13. They also analysis the magnitude of particle-fluid forced are much larger compare to particle-particle and particle-wall forced.

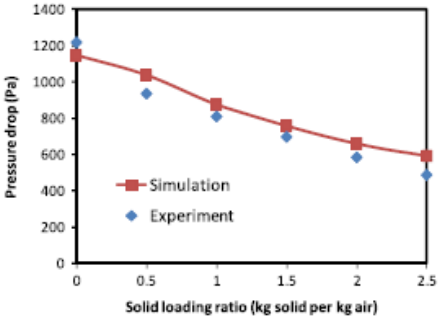

Fig. 12: Comparison of simulated and measured pressure drops at different solid loading ratios. [10]

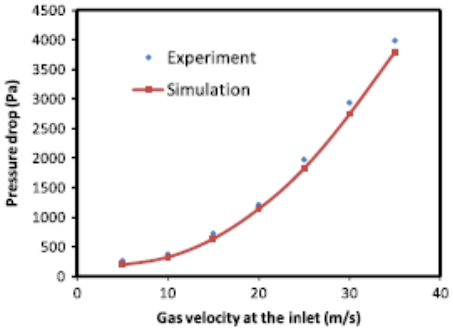

Fig. 13: Comparison of the simulated and measured pressure drops at different inlet gas velocities. [10]

J. K. B. Wang, D.L .Xu, G.X. Xiao, K.W. Chu, A.B. Yu (2003) [11]

In this research paper to study on numerical analysis on gas solid cyclone separator. They are gas-powder flow in Lapple cyclone design used for analysis gas-powder flow. Author concluded that when inlet gas velocity increase the separation efficiency increase in Lapple cyclone.

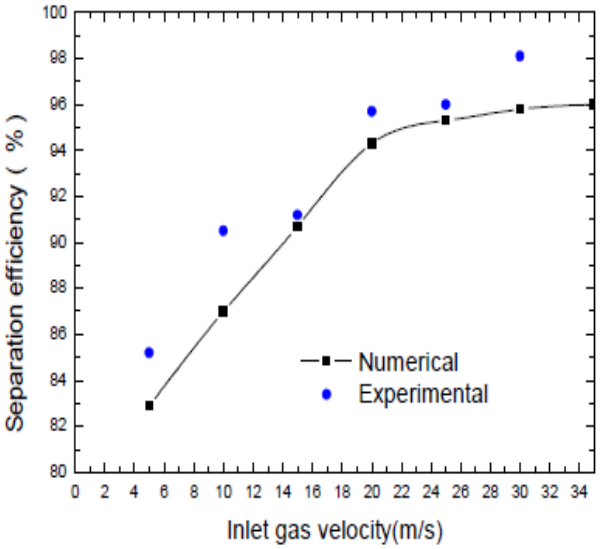

Fig. 13: Experimental results of separation efficiency compared with calculation results. [11]

III. Conclusion

This review has discussed new technology inventing in mechanical (centrifugal) separation. A recent reverse flow investigation has been directed toward the effect of high solids loading on cyclone separation performance. CFD have also been applied to cyclone separation technology with the aims of understanding fundamental flow field phenomena inside the cyclone separation.

Cyclone separation efficiency 86% to 95% this is very high separation efficiency compare to other separation technology. Cyclone separation efficiency and pressure drop effect on various parameter.

Cyclone geometry parameter like cyclone inlet height and width, cyclone vortex finder height and diameter, cyclone height are affected the cyclone separator. Solid loading ratio, gas inlet velocity flow field parameter effect on pressure drop and separation efficiency.

When solid loading ration increased the pressure drop of cyclone separator decrease. When gas velocity increase also pressure drop increase.

When gas velocity increase the separation efficiency also increase.

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