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A literature review on investigation of design parameter of cyclone separator

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Abstract – *Separators are essential components of gas cleaning systems and are extensively used in different industries. Wide scope of application and specifications contributed to the development of a large variety of constructions that differ not only in their efficiency but also in the type of forces utilized for separation (inertia, gravity, centrifugal acceleration). This review paper provide a wide perspective of various designed of cyclone separator for collection of particle .A review of literature related to optimum design and computational fluid dynamic approach for the study of various parameters affecting the cyclone process and calculating the various changes due to it and also related to the improvement of efficiency of a gas-liquid separator operating at the pressure of high flux density in the cyclone body.*

Key Words: **Cyclone Separator, CFD, Collection of particle, Efficiency, Pressure Drop, Particle Flow**

1. INTRODUCTION

Cyclones are widely used for removing industrial dust from air or process gases. They are the Most frequently encountered type of gas-solid and gas liquid separator in industry. The primary advantages of cyclones are economy, simplicity in construction and ability to operate at high temperature and pressures. A cyclone separator provide a method of particulate matter from air at low cost and low maintenance. In general a cyclone consists of cylindrical part referred to as the barrel and lower conical part which show in fig. 1. A cyclone separator working principle is based on particle settling by centrifugal force. High gas velocity inside the cyclone separators provides high absolute value of centrifugal force, which promotes settling of particles with the diameter >5μm and hence the efficiency of cyclone separators reaches 98–99.5%. However, the reduction in overall dimensions or increase in flux density degrades the cyclone separator performance substantially. Nevertheless, high efficiency of cyclone separators accompanied by relatively low flow resistance made them a class of choice for the majority of industrial engineering systems. A cyclonic separation is a method of removing particulates from an air, gas or liquid stream, without the use of filters, through vortex separation. When removing particulate matter from liquid, a hydro cyclone is used while while from gas, a gas cyclone is used. Rotational effect and gravity are used to separate mixtures of solids and fluids. The method can also be used to separate fine droplets of liquid from a gaseous stream.

There are many types of cyclones for the purpose of solid particle separation. However, the following are the most typical: returned flow or reversed flow, axial flow and rotary flow with tangential injection of the second gas flow into the cyclone body. The historical transition of cyclones development can be found in Crawford, Storch and Ogawa, where many old and interesting types of cyclones are discussed. The most standard construction of the returned flow type is composed of a cylindrical body with a fixed diameter and a conical part. Physical models or families of cyclones are established when a set of dimensions is fixed in relation to the diameter (Crawford M, 1976). Since its conception over a century ago, many researchers have contributed to the large volume of work on improving the efficiency of cyclones by introducing new design and operation variables. However, in most cases, the improvement in efficiency is marginal and in some cases it is associated with complex structure and additional operating costs. [2]

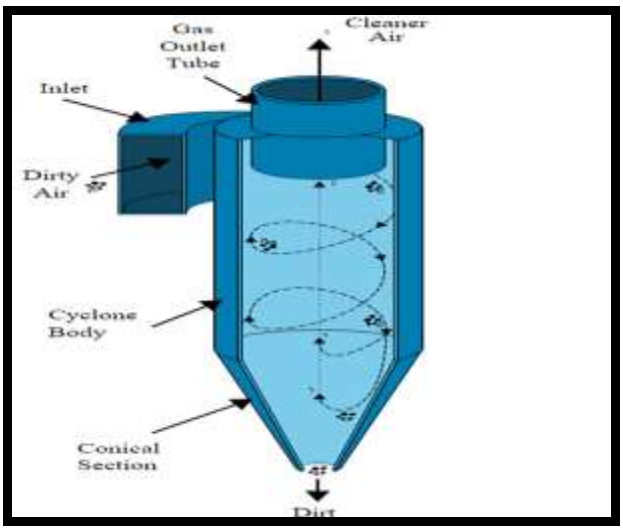

Fig.-1: Basic Principal of cyclone Separator

2. LITERATURE SURVEY

"CFD Analysis of Symmetrical Tangential Inlet Cyclone Separator "In this paper Abhejit Gayakwad and Dr. Shivarudraiah studies CFD analysis of symmetrical tangential inlet cyclone separator. In this paper simulation is carried out using computational fluid dynamics (CFD) for gas-particle flow with cyclone separator in one of the approaches. Most of the attention is focused on improving the cyclone performance parameters. In this paper the geometric effect on cyclone separator is studied with the

creation of symmetrical tangential inlet cyclone separator The Computation Fluid Dynamics (CFD) analysis is carried out for both single inlet cyclone and symmetrical inlet cyclone separator under the same condition of inlet velocity, flow rate and particle diameter and compared it with the classical cyclone separator. The results showed that the new geometric modification to the cyclone improves the performance. In this modification Dc=0.30 meter, which is comparatively safe as it is close to standard size diameter of 0.203 meter Thus, the dimension of the design cyclone is as under Stairmand's design. The result showed that the pressure distribution is uniform on the symmetrical inlet cyclone, the tangential velocity which relates to the pressure drop, will be increased which accounts for the better cyclone efficiency. The collection efficiency for the modified cyclone geometry is more than the standard cyclone design. The results of pressure contour show uniform distribution of pressure throughout the cyclone body as compared to the standard design. The results of tangential velocity vector show an increase in the tangential velocity in the cyclone body. Maximum tangential velocity for the single cyclone design is 18 m/s and for symmetrical cyclone design is 23 m/s. This shows an increase in the tangential velocity. [1]

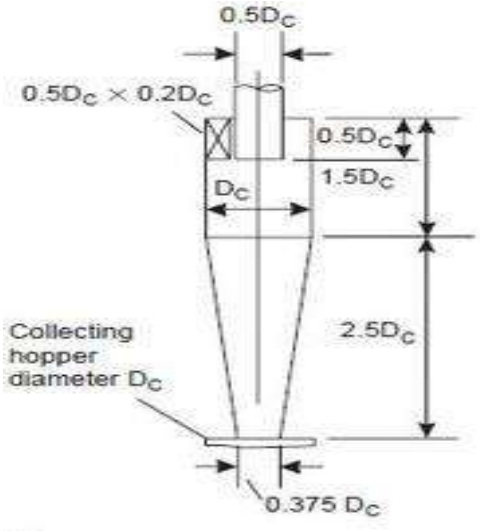

Fig- 2: Modifide Cyclone separator

" Design Analysis of Cyclone seperator" In this paper Reddy Deere and G. Mahesh Babu studies design and analysis of cyclone separator. In this paper they given stair and optimized design also they give energy equation and continuity equation they have also done CFD analysis of cyclones in detail. Temperature analysis this analysis involves various flow studies at various temperatures. The stairmands design is used for the simulation in fluent. The same setup is used for the temperature analysis as the stairmands design analysis.

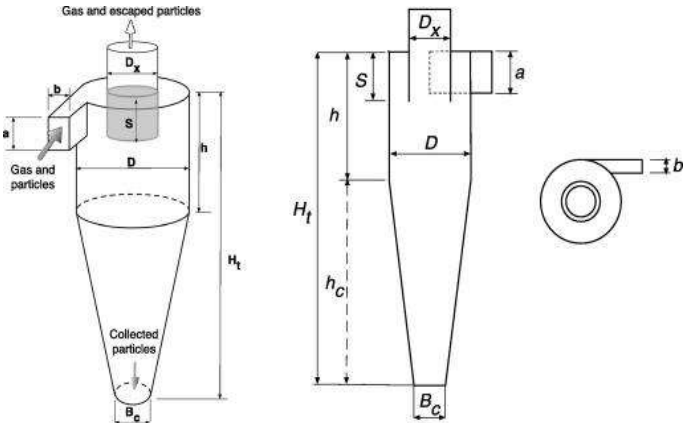

Fig- 3 Cyclone geometry in solid work

Table -1: Sample Table format

Geometry	a/D	b/D	Dx/D	S/D	h/D	H/D	B/D
Stairmand's Height Effeciency	0.5	0.2	0.5	0.5	1.5	4	0.375

The same setup is used for the temperature analysis as the stairmands design analysis Additional to the energy equation is activated so start the temperature analysis. In the velocity inlet boundary conditions the temperature of inlet flow is added. This study involves in the simulation of the cyclone at 4 different temperatures. The variation in the pressure and velocity are noted and compared. The effect of the temperature is justified. [3]

"Design of Cyclone and Study of Performance parameter" in this paper Mahesh R. Jadhav studies Design of cyclone and study of performance parameter. This paper present the development of cyclone based on CFD along with experimental trials. This study is based on the performance of flour mill cyclone for different flow rates. In the present investigation the characteristics of flour mill cyclone are studied for various flow rates (inlet velocities) and its effect on performance parameters like pressure drop and efficiency are Studied Therefore in this paper two cyclones are evaluated with same dimensions only difference in their inlet geometry. One cyclone model is having single tangential inlet with same size inlet and outlet pipe and another is having two symmetrical tangential inlets and one outlet. Simulation of flow will be done with the help of CFD software and verification will be done with the help of experimental work. Results showed that these new designs can improve the cyclone performance parameters significantly and very interesting details were found on cyclone fluid dynamics properties. Experimental trial is completed successfully also CFD simulation is also done. A small scale cyclone designed for flour mill is evaluated and following results are obtained.
The test was performed on both cyclones at different velocities. Graph shows the comparison of results of single and symmetrical inlet cyclone.

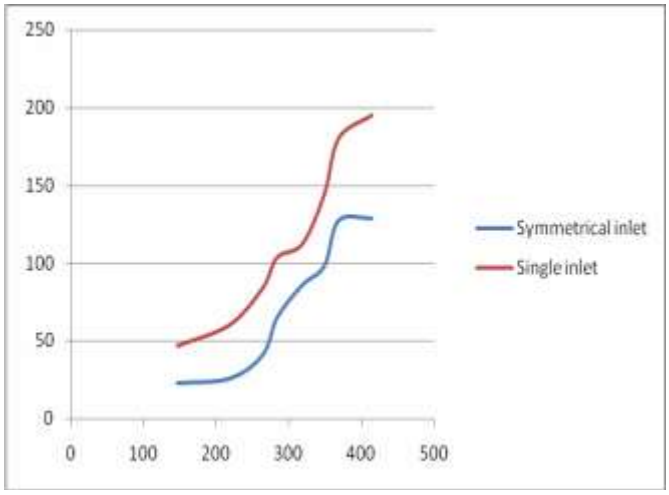

Fig -3: Flow rate Vs. pressure Drop (flow rate in m3/hr.)

From above Fig 3 it is been observed that the pressure drop is more for single inlet cyclone than symmetrical inlet cyclone. Means the pressure drop is depending on the inlet velocity for the same model. It is observed that the pressure drop is increases as the inlet velocity increases for same model. [3]

"Cyclone Separator for Gas-Liquid Mixture with High flux Density". In this paper Nikolay Mikheev, Ilya Saushin studies the Cyclone separator for gas-liquid mixture with high flux density. The study is aimed at improvement of efficiency of a gas-liquid separator operating at the pressure of 2.5 MPa and high flux density in the cyclone body. The construction of the separator provides the reduced dynamic head of gas in the zones with increased liquid phase concentration and prevents the entrainment of separated liquid to the outlet receiver. The receiver consisting of a conical converging channel and an externally finned circular pipe is located in the middle of cylindrical cyclone body. A fin-and-tube flow conditioner is mounted upstream of the converging channel inlet. Detailed flow structure in the separator has been obtained from numerical study based on Reynolds-averaged Navier–Stokes equations with anisotropic Reynolds stress turbulence model. Result show that the construction of a gas-liquid high-pressure cyclone separator provides high separation efficiency at the K-value that was at least one order higher than the limitations recommended in literature. The effect is achieved due to very effective damping of the high-velocity head in outlet duct of separator. It is established from numerical simulation of flow in the separator that there are no conditions for drop entrainment from the liquid film surface at the maximum flow rate of the mixture, and the near-wall dynamic head of upward flows does not exceed 30 Pa. Such values of the dynamic head prevent conditions that trigger upward film flows from the lower bottom. Cyclone separation efficiency was confirmed by experimental studies on the scale cyclone model without sacrificing of all criteria for dimensionality and similarity of separation processes. The separation efficiency >98% obtained from numerical simulation and experimental research corresponds to separators designed for operation in conditions close to atmospheric pressure, but yet the high values of K-value indicate the realized possibility of a significant increase in separator specific capacity in the proposed scheme with respect to separators of other known schemes. In this case, the proposed separator has a low resistance coefficient, which is several times smaller than the value used for such cyclone separators. Thus, the proposed schematic construction of the separator allows reducing the influence of most negative effects related to increasing the operating pressure in the cyclone on the separation efficiency.

3. CONCLUSION

From the study and analysis of different papers, it observed that the efficiency of cyclone increases with the decrease in dimensions of cyclone body diameter, and initial condition like temperature and cyclone pressure. The pressure drop increases with the increase in inlet velocity; but pressure drop decreases significantly with the rise in temperature. It is observed that, the pressure drop and cyclone efficiency varies with inlet velocity. Comparison of performance, between symmetrical inlet cyclone and single inlet cyclone shows that, symmetrical inlet cyclone is optimum than the conventional cyclone with single inlet. [4]

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