Design and Analysis for Flour Mill Cyclone

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***Abstract*— Cyclone is most commonly used device to separate dust particles from gas and dust flow. The project presents design development of flour mill cyclone and its analysis by CFD along with experimental trials. In this 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. Cyclone is designed with two symmetrical tangential inlets and a single tangential outlet at the barrel top area where impeller is mounted. The study was performed on both cyclones for gas-solid flow, based on an experimental study available in the literature, where a conventional cyclone model was used. The collection efficiency of single inlet cyclone is compare with double symmetrical inlet cyclone and the result indicate that the double inlet cyclone provide higher collection efficiency than that of the single inlet cyclone. Simulation of flow will be done with the help of CFD software and verification will be done with the help of experimental work. This new design can improve the cyclone performance parameters significantly and very interesting details were found on cyclone fluid dynamics properties.**

Keywords— Cyclone, Pressure drop, Double symmetrical inlet, Tangential outlet, Collection efficiency

I. INTRODUCTION

Cyclone separators are widely used in the field of gas-solid separation for both engineering and process operation. Their relative simplification in fabrication, low cost in operation and well adaptability to extremely harsh condition make them important equipment, especially used in application involving milling technologies for coal fuelled boilers in power plant. These technology demands high efficiency Cyclone to provide satisfactory and economical performance, ensure regularity compliance, project expensive downstream components. This cyclone separator provides a method of removing particulate matter from air streams at low cost and low maintenance. In general, a cyclone consists of an upper cylindrical part referred to as the barrel and a lower conical part referred to as cone (see figure 1). The air stream enters tangentially at the top of the barrel and travels downward into the cone forming an outer vortex. The solid particles entering the cyclone immediately bifurcate into two layers of dust due to the eddy current based on the secondary flow on the upper cover surface in the coaxial space between cyclone body and exit pipe. One of them goes around the coaxial space on the upper cover surface and rotates around the exit pipe with the gas flow. The other rotates and descends along the surface of the cyclone body. Then, on the surface of the cone, the dust layer, which is pressed onto the cone surface by the centrifugal force, descends aided by gravitational force and descending airflow in [1].

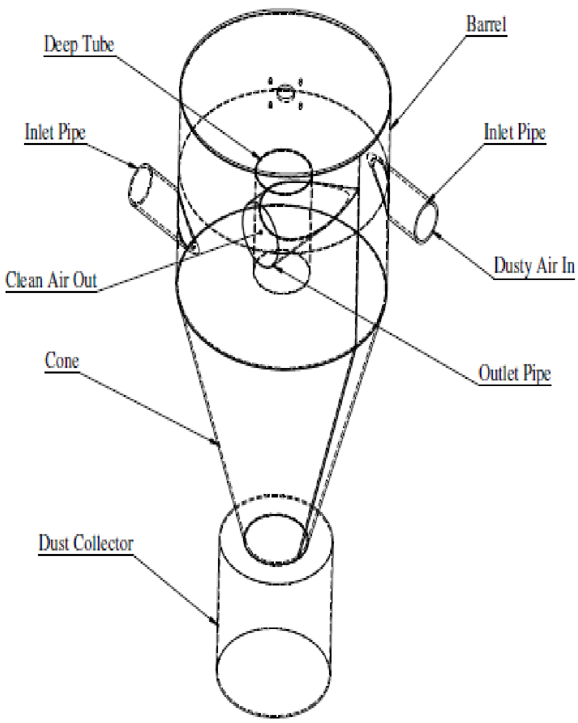

Fig.1 Cyclone Geometry

Most of the attention has been focused on finding new methods to improve performance parameters. Some studies were conducted to improve equipment performance by evaluating geometric effects on projects. Cyclone dust collectors have been used in many industrial facilities to collect solid particles from gas-solid flows and to reduce air pollution originating in chimney smoke from chemical plant drier equipment. However in this situation to control the air pollution is very important and cyclone is used for pollution control in flour mill. Currently, with new engineering applications of cyclones as dryers, reactors and particularly in the removal of high-cost catalysts from gases in petroleum refineries, industries require a greater understanding of turbulent gas flows, which could lead to rigorous procedures capable of accurately predicting efficiency, velocity and pressure fields [2]. Also the pollution due flour mill is cannot be neglected, small flour particles in large quantity are coming out through the mill and get mixed in atmospheric air. The operator who is continuously working on this mill is suffering through this pollution and there will be chances of lung deceases. So the aim of study is to design a cyclone for flour mill application and to optimize its performance parameters by doing some geometrical changes.

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 [4].

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.

II. EXPERIMENTAL WORK

Therefore in this study flour mill cyclone is designed and 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. For experimental setup the fabricated cyclone, impeller, dust collector, electric motor, top flange, gaskets etc. Parts area assembled together. For measurement of inlet and outlet velocity an anemometer is selected, Anemometer gives reading of velocity in m/s. For measurement of pressure at various points the connectors are provided at both inlet and an outlet port.

The experimental work is carried on both cyclone, they are tested for various flow rates i.e. for various inlet velocity. The variation in flow rate is obtained by changing the rotational speed of impeller (motor) by using VFD.

Fig.2 Cyclone experimental setup

TABLE I

cyclone geometric configurations

Reading. The velocity reading sheet is given as follow:

Sr. no.	Geometric data	Dimension(mm)
1	Barrel Diameter	380
2	Barrel Height	180
3	Cone bottom Diameter	115
4	Cone height	385
5	Inlet pipe dia. For symmetrical inlet	47
6	Inlet pipe dia. For single inlet	86.8
7	Exit pipe dia.	86.8
8	Deep tube dia.	100
9	Deep tube length	150
10	Inlet of cyclone from top of impeller	165
11	Exit of cyclone from top of impeller	50

Measurement of Velocity:

Velocity is measured for different 8 cases, and noted as a

TABLE II

Velocity Measurement readings

Flow Rate (m3/hr)	Velocity (m/s) Symmetrical inlet			Velocity (m/s) Single inlet	
	Inlet1	Inlet2	Outlet	Inlet	Outlet
420	28	30.2	19.1	19.4	17.6
380	25.8	26.5	17	16.8	15.4
340	24.2	23	16.1	15.8	13.9
300	21.8	21.6	14.7	14.3	11.7
260	17.5	16.75	13.1	12.9	10.8
265	18.6	17.3	12.2	12.1	10.5
220	13.2	14,8	10.1	10.3	8.55
150	10.5	9.25	6.75	6.9	5.7

Measurement of pressure:

The pressure is measured by using manometer, as shown below

TABLE III

Pressure Measurement readings

Flow Rate (m3/hr)	Symmetrical inlet	Single inlet
420	128.8	220.14
380	127.5	180.21
340	98.2	144.26
300	85.76	112.32
260	65.0	103.46
265	41.0	84.36
220	25.5	60.40
150	22.5	24.46

		case 1		
		inlet1	inlet2	outlet
Diameter	d	0.05	0.05	0.0875
Area	m2	0.001964	0.001964	0.006014
Density	kg/m3	1.142	1.142	1.142
volumetric flow rate	m3/hr	190	190	380
	m3/s	0.0528	0.0528	0.1056
Mass flow rate	kg/s	0.0603	0.0603	0.1205
Velocity	m/s	27.08	27.07	21.73
Static pressure	pa	1019.69	1024.68	-3.11
Total pressure	Pa	1438.57	1443.46	432.89
Δp	Pa	1005.68	1010.57	

NUMERICAL MODELLING BY CFD

TABLE IV

Boundary conditions for simulation

Properties		Value	Unit
Gas phase	Material	Air	-
	Viscosity of gas	0.0000185	kg/ms
	Density of gas	1.142	kg/m3
Solid phase	Material	Wheat Flour	-
	particle size	0.01	mm
	Particle density	561	kg/m3
	Viscosity of particle	1.983x10-5	pa.sec

		case 2		
		inlet1	inlet2	outlet
Diameter	d	0.05	0.05	0.0875
Area	m2	0.001964	0.001964	0.006014
Density	kg/m3	1.142	1.142	1.142
volumetric flow rate	m3/hr	140	140	280
	m3/s	0.0389	0.0389	0.0778
Mass flow rate	kg/s	0.0444	0.0444	0.0888
Velocity	m/s	19.94	19.94	15.97
Static pressure	pa	546.39	550.25	-1.64
Total pressure	Pa	773.49	777.3	232.91
Δp	Pa	540.58	544.39	

III. BOUNDARY CONDITIONS AND COMPUTATIONAL GRIDS:

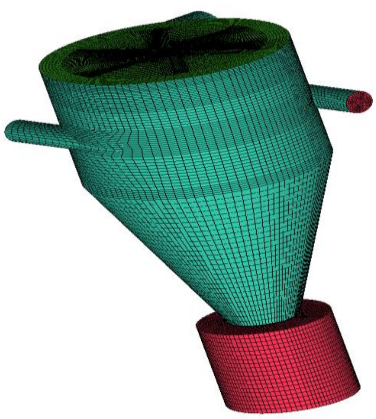

Fig3. Mesh model of cyclone

		case 3		
		inlet1	inlet2	outlet
Diameter	d	0.05	0.05	0.0875
Area	m2	0.001964	0.001964	0.006014
Density	kg/m3	1.142	1.142	1.142
volumetric flow rate	m3/hr	90	90	180
	m3/s	0.0250	0.0250	0.0500
Mass flow rate	kg/s	0.0286	0.0286	0.0571
Velocity	m/s	12.85	12.84	10.27
Static pressure	pa	222.61	224.47	-0.67
Total pressure	Pa	316.84	318.68	95.32
Δp	Pa	221.52	223.36	

Fig4. Mesh model of cyclone top

IV. RESULT & CONCLUSIONS

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. The different readings of velocity, pressure is given in table no.2, 3 respectively. Below are different graph for comparison of results of single and symmetrical inlet cyclone.

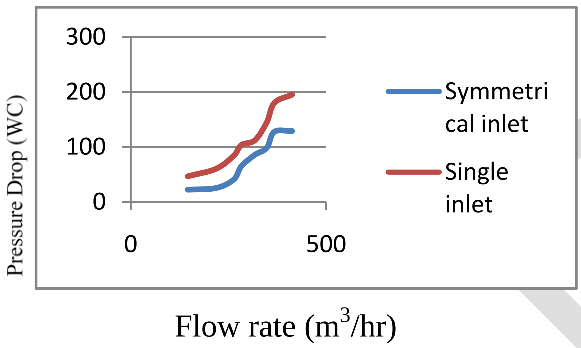

Fig.7 Flow rate Vs Pressure drop.

From above fig.7 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.

By doing changes at inlet geometry of cyclone i.e. two symmetrical inlets the flow gets divided in to two parts. The performance parameters of symmetrical inlet cyclone are optimum than single inlet cyclone. It also proved that as inlet velocity increase the cyclone efficiency also increases for same model.

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