Review of Cyclone Separator in Trim Handling System in Paper Industry

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Abstract

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.

Keywords: Finishing operation, waste paper, trimmed paper, broke, trim handling, cyclone separators

1. Introduction

In the paper production process, finishing operation plays a major role. Once the big paper roll is manufactured on paper machine, it is cut into small reels by Rewinders. This small reel is cut into sheets with the help of sheeters.

During cutting and sheeting operations, side trims are generated which needs to be recycled back in to process to reduce waste.

The side trim cut from Rewinder and sheeter with the help of Slitter are known as 'BROKE' and recycled back after slashing in water. Side trim generated is blown through air blower and pipe connected to a cyclone which drops trim to a pulper and air escapes from top. Pulper is an equipment wherein trim paper slash with water with an agitator and slashed pulp is pumped to process for reuse.

If The trim production rate is constant then the trim removal process becomes easy.

Removal of trim takes place with the help of trim conveying system and this system is attached to cyclone which is responsible feeding of paper into the pulper. Cyclone system is Widley used for dust and air removal at various industries. The reason for it being its cheap and easy to design. The maintenance required for the operation of cyclone is very low if designed and operated properly

As cyclone plays very important role is the paper collection and its feeding, Lot of factors are to be considered during the design of a cyclone. Factors which are to be considered in design are particle size of trim, input velocity of trim entering the cyclone, Total air flow and pressure in the cyclone and many more.

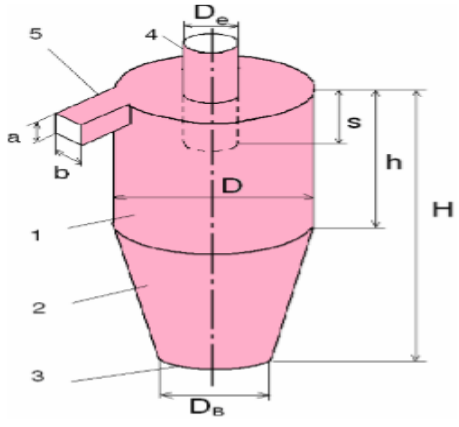
Thus, selection and design of cyclone is an intricate task and lot of training is required while implementing its design.

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

2. Literature Review

M. MARINUC1 F. RUS1(2011) [1]

This paper explains how the size of the particle entering the cyclone and velocity of that particles have an effect on the separation process that takes place inside the cyclone.



Fig; cyclone design with different cross-sectional areas

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As per the research done, it is found that as the cross-sectional area of entry into the cyclone is smaller and there is an increase in the size of the particle, then we get higher efficiency of cyclone.

Further It can be concluded that the separation efficiency of cyclone is directly proportional to the initial input velocity of the cyclone.

This can be shown with the help of table representation given below

Table 1: values of separation at different parts efficiency based on input velocity

v [m/s]	dp [m]	η_1 [%] (S_1 = 0.001575)	η_2 [%] (S_2 = 0.002912)	η_3 [%] (S_3 = 0.004928)	η_4 [%] (S_4 = 0.006608)	η_5 [%] (S_5 = 0.00744)
12	0.00004	75.988	75.78	72.741	67.931	65.896
15	0.00004	78.493	81.935	75.344	70.627	68.614
18	0.00004	80.467	83.772	77.415	72.797	70.812
21	0.00004	82.079	85.256	79.119	74.602	72.647
23	0.00004	83.003	86.1	80.102	75.651	73.717
25	0.00004	83.831	86.852	80.987	76.602	74.689

*Kartik. Vishwanath. Bhadti*1, Devendra S*2, Nitesh Panchal*3(2017) [2]*

This paper reviews different type of dust separation technologies and cyclone separator is review. This paper also takes reference from research paper Mechanical dust collector by Charles A., Gallaier, J. W. Schindeler [3], which states fractional efficiency which vary according to the particle size of the particle for the two parts of the cyclone as shown in the table below:

Table 2: data table for upper part of cyclone

Particle size-microns	Particle size distribution	Fractional efficiency	Percent collected
0-2	10	19	1.9
2-4	8	46	3.6
4-6	8	53	5.05
6-8	7	75.5	5.65
8-10	6	83.5	5.00
10-15	14	91.5	12.80
15-20	10	97.0	9.70
20-25	8	98.9	7.91
25-30	7	99.5	6.96
30+	22	99.75	21.52
	100		80.52

Table 3: data table for lower part of cyclone

Particle size-microns	Particle size distribution	Fractional efficiency	Percent collected
0-2	10	39	3.90
2-4	8	77.5	6.21
4-6	8	91.8	7.34
6-8	7	97	6.78
8-10	6	98.9	5.94
10-15	14	98.9	13.96
15-20	10	99.99	46.95
20-25	8	99.99	
25-30	7	99.99	
30+	22	99.99	
	100		91.08

It can be concluded from the observation that as the particle size goes on increasing, the fractional efficiency value goes on increasing, i.e. particle size is directly proportional to the fractional efficiency of the Cyclone.

Muhammad I. Taiwo. Mohammed A. Namadi. and James, B. Mokwa [4] (2016)

This paper aims to bring out the design parameters that are required for the designing the cyclone and also gives and idea of the effect of pressure drop on the working of the cyclone. As per the research, Cyclone pressure drop estimation by Lapple approach has some problems. Mathematical equation for pressure drop estimation as per this method is given as:

$$\Delta p = \frac{1}{2}\rho g v^2 H_v$$

Where,

$$H_v = K\frac{HW}{D_e{}^2}$$

Where,

Hv = number of inlet velocity heads

H = height of inlet duct (m or ft)

W = width of inlet (m or ft)

K = constant

As per the research "The Lapple pressure drop equation does not consider any vertical dimensions as contributing to pressure drop" as stated by (Leith and Mehta, 1973). With the misleading by Lapple pressure drop model one could conclude that the cyclone should be as long as possible since it would increase cyclone efficiency at no cost in pressure drop (Leith and Mehta, 1973).

The problem of pressure drop and Cyclone design was addressed by Texas cyclone design by Pernell in 1996. Mathematical equation for drop in pressure as per TCD is given as:

$$\Delta p = K * (V_{pi} + V_{p\circ})$$

Where,

K = dimensionless empirical constant

Vpi = Velocity of particle at inlet

Vpo = Velocity of particle at outlet

This process is easy and the results obtained in this process are more accurate than many process for the calculation of pressure drop.

Mahesh R Jadhav [5] (2015)

Experimental research on two cyclones with same dimensions but difference in the input design was

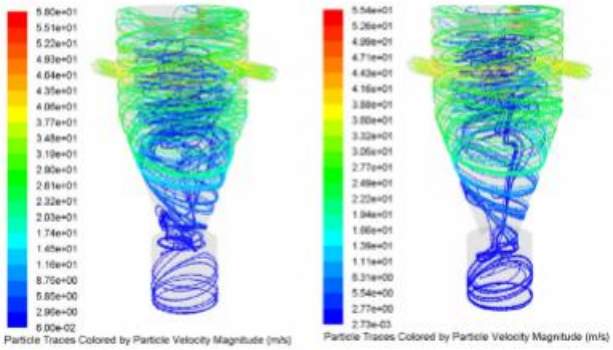
carried out. Single tangential inlet is used for the first design and two symmetrical tangential inlets are used for the second pipe. Both the Cyclones have only one outlet.

CFD analysis was carried out.

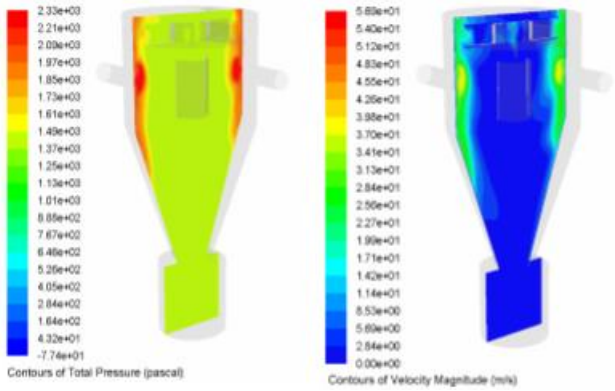
Figure 1: Cyclone model mesh

Figure 2: Top view of cyclone Model

Plots of velocity, contours of velocity magnitude and total pressure were analyzed and the conclusion were studied.



Velocity Plots for 6 and 8 microns particle size



Contours of total pressure and velocity magnitude

It is seen that the drop-in pressure is more in case of single inlet cyclone than the double inlet from which It can be concluded that the pressure drop is changes with the inlet velocity.

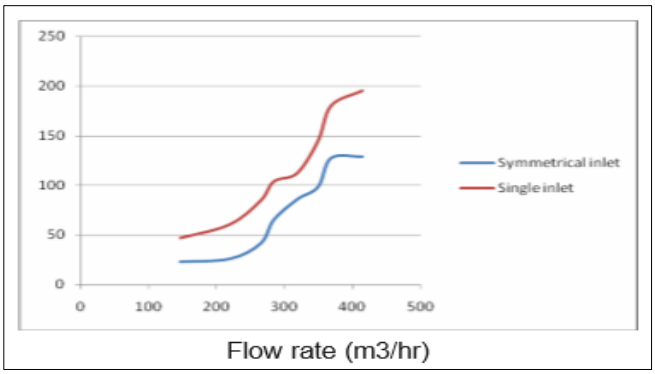


Figure 3: Flow Rate Vs Pressure drop

It can be concluded that the performance factors of symmetrical inlet cyclone are better than the single inlet cyclone. Due to increase in inlet velocity there is an increase in the efficiency of Cyclone.

BILT ltd, Ballarpur

Cyclone in this paper industry Is used in the process of waste paper recycling. Cyclone here is a part of trim handling process and is used for supplying of trim to the pulper.

Figure 4: Cyclone connected to pulper

In this system, vacuum trim handling technology was used. For the proper management of trim and conveying from trim blower to the broke pulper, it was necessary to design economical solution, and the solution that it found was to design a cyclone.

In Total there are four symmetrical inlets to this cyclone and one single outlet cyclone is in-house design and ventilation is given at the top of the cyclone with wire meshing. All the design parameters as stated in this paper were considered during the design and the most optimum solution was then implemented

Conclusions

From the study and review of various papers we can conclude that design of cyclone is an intricate process

which involves studying of various factors such as the velocity, pressure, and size of the particle for the optimum design.

This design process was studied and analyzed in detail by a BIILT, Ballarpur (largest pulp and paper manufacturer in India). The contrivance of the study, analysis and design took place and resulted into one of the most efficient cyclone. This cyclone was used in trim handling system in this paper industry.

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