Enhancement Of Cyclone Dust Conveying System Using QC Tools

Shashank G C¹ & Santosh Diwatar²
¹UG Students, Mechanical department, BITM, Ballari
²Assistant professor, Mechanical department, BITM, Ballari

Abstract: Conveying hard and the abrasive materials has been one of the major operational problems in industrial situations. The erosion of pipe bends by abrasive solid particles of a fluid stream makes pressure drop and the puncture at the bends in the pipelines. Modification in the pipeline - bend geometry by means of long-radius bend can improve the performance and decrease the pressure drop and puncture in the pipelines. In this paper we are identifying the problems in the Gas Cleaning Plant using the TQM tools and obtaining the solutions for the root causes. The implementation of the solution can increase the performance, no. of cycles and the capacity of the dust conveyed in tons/day.

Keywords — Histogram, Cause and Effect Diagram, Cyclone Separator.

1. INTRODUCTION
A dust collection system is an air quality improvement system used in industrial, commercial, and home production shops to improve breathable air quality and safety by removing particulate matter from the air and environment. Dust collection systems work on the basic formula of capture, convey and collect. The dust is collected with devices such as capture hoods to catch dust at its source of origin. Many times, the machine producing the dust will have a port to which a duct can be directly attached. The collected dust is conveyed in a ducting system and a pneumatic conveying system, properly sized and manifolded to maintain a consistent minimum air velocity required to keep the dust in suspension for conveyance to the collection device. A duct of the wrong size can lead to material settling in the duct system and clogging it.

2. LITERATURE SURVEY
The first pneumatic conveying equipment was used to unload grain from ships before the 19th Century. Later, this new continuous conveying method spread to small and middle size systems, as well as to other bulk products. Pneumatic tubes used for transporting physical objects have a long history. The basic principles of pneumatics were stated by the Greek Heron of Alexandria before 100 BC [2]. On the other hand, the concept of conveying materials in pipeline systems also goes back to pre-historical age with some evidence of that the Romans used lead pipes for water supply and sewage disposal and the Chinese used bamboo to convey natural gas [3]. Although there had been various applications of pneumatic conveying earlier in many civilizations, the first documented pipeline conveying of solid particles was recorded in 1847 [4]. In Peugeot plant in France, the pneumatic conveying principle was used for the exhaust of dust from number of grindstones with the help of an exhaust fan. The first published pneumatic conveying system [4]. In 1864, an experimental pneumatic railway was built at Crystal palace with the intention of using the principle of vacuum applied to a railway tunnel to move a carriage, which had been fitted with a sealing diaphragm [5]. Another application of vacuum pneumatic transport was reported in ship unloading plant in London in 1890 [5]. A number of applications of operational principles of pneumatic transport could be seen in last decade of the 19th century at some places in Europe [4, 6] and especially, in the grain transport and handling field [5].

3. PROBLEM IDENTIFICATION
The QC tools such as Histogram and Pareto chart are used to identify the problem occurred in the conveying of the dust in a pneumatic conveying system. The problem analysis is based on the problems occurred at the Blast Furnace-IV, JSW Vijaynagar Steels.

3.1 Histogram
A histogram is a graphical representation of the distribution of numerical data. It is an estimate of the probability distribution of a continuous variable (quantitative variable) and was first introduced by Karl Pearson. It is a kind of bar graph. To construct a histogram, the first step is to "bin" the range of values—that is, divide the entire range of values into a series of intervals—and then count how many values fall into each interval. The bins are usually specified as consecutive, non-overlapping.
intervals of a variable. The bins (intervals) must be adjacent, and are often (but are not required to be) of equal size. Converting this data into the frequency for both no. of cycles/day and Dust Shifter in Tanker Tons/day based on the range of the data collected. The Histogram is plotted for the collected data which gives mean no. of cycles/day operated.

<table>
<thead>
<tr>
<th>No of cycles/day</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

From the above graphs we can infer that the average no. of cycles/day is 6. While desired no. of cycle/day was 17 cycles.

Hence the modification in the plant was necessary for the environment as well as the production. The common problems faced by the engineers in the plant are low dust conveying. The cause and effect diagram for the low dust conveying is as shown below.

3.2 Cause and effect diagram

When utilizing a team approach to problem solving, there are often many opinions as to the problem's root cause. One way to capture these different ideas and stimulate the team's brainstorming on root causes is the cause and effect diagram. Also known as "Fish-bone Diagram" for its fish bone kind of construction or Ishikawa Diagram. It was invented by Prof. Kaoru Ishikawa in the year 1943. He first used it to explain at Kawasaki Steel Works. The root causes in these 4Ms are obtained through a brainstorming session. The fish bone diagram for the primary and secondary root causes is drawn as shown below.

The main root causes which are responsible for the low conveying of the dust are
1. Small Radius Bend failure
2. Conveying pipeline Jams

We are focusing on the small radius bend failure in this paper.

4. Problem Analysis and solution

Bends are installed in a pneumatic conveying system wherever a change in direction is required along the conveying route. They can be broadly classified into three major categories:

- Common-radius bends (including elbows, short-radius, long-radius and long-sweep bends)
- Common fittings (including tee bends, mitered bends and elbows)
- Specialized bends and innovative designs (such as the wearback designs, and lined bends)

The pressure decreases along the flow constantly, where the effect of pipe bend on flow is absent. However, as the flow reaches near pipe bend, the decrease in pressure is not constant and it decreases rapidly in comparison to the horizontal pipeline. The pressure gradient across the bend increases as the solid concentration or flow velocity...
increases. This increase in pressure gradient may be attributed to the increased interaction between particles at higher concentrations and flow velocities.

However, among all the components of a pneumatic conveying system, in spite of their apparent simplicity bends are probably the least understood and most problematic component for process operators. Findings from various research studies are often not consistent, and often the field experience does not match the theoretical data. If not properly selected and designed they can contribute significantly to overall pressure drop, product degradation and erosion wear.

Historically, a basic long-radius bend (Shown in fig) has been the bend of choice for designers of pneumatic conveying systems, for a variety of reasons:

- Long-radius bends provide the most gradual change in direction for solids, and hence are most similar to a straight section of piping.
- The angle of impact on the pipe wall is relatively small, which helps to minimize the risk of attrition or erosion.

Years of field experience and a variety of studies conducted to troubleshoot common problems such as line jamming, excessive product degradation, unacceptably high bend wear and higher pressure drop clearly indicate that the flow through bends in pneumatic piping is very complex.

There are different methods to evaluate the performance of a bend. One of the methods used in this paper is pressure drop related to the bends method.

### 4.1 Pressure drop related to the bends method

As the name indicates the method is related to the pressure drop at the bends due to various parameters. Single-phase flow of a fluid through any component causing directional change will result in additional pressure drop. This behavior is well understood in the field. The pressure drop in a bend depends on the ratio of bend radius to pipe diameter (RB/D) and the internal roughness (k) of the pipe. Below fig shows the relation between these

![Fig 3 Flow in short radius bends](image)

![Fig 5 Effect of bend geometry and internal pipe roughness on bend pressure drop](image)
The Solution was implemented by changing the radius of the bends and changing the orientation of the conveying line by 180° for acceleration of the dust particles. This was obtained by discussing the solution with the engineers and the management of the Blast Furnace IV at JSW Steels Vijayanagar. The efficiency of the conveying system was improved and the problem of clogging of the dust and the pressure drop was minimized.
The difference before modification and after modification of the bend radius is shown below.

<table>
<thead>
<tr>
<th>SL NO.</th>
<th>Before Modification</th>
<th>After Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The jamming of the dust at the bends was more</td>
<td>The jamming of the dust at the bends was minimized</td>
</tr>
<tr>
<td>2</td>
<td>The pressure drop use to occur due to the clogging of the dust</td>
<td>The pressure drop was reduced</td>
</tr>
<tr>
<td>3</td>
<td>Reacceleration was less at the end of bend zone.</td>
<td>Reacceleration was more at the end of bend zone</td>
</tr>
<tr>
<td>4</td>
<td>The time for taken to complete a cycle was 20-30 min.</td>
<td>The time taken to complete a cycle was 10-13 min.</td>
</tr>
</tbody>
</table>

5. Conclusion

Capacity of the conveying system was increased from 5.5TPH to 12TPH. The dry dust generated in cyclone is being conveyed to storage silo, without dumping into the atmosphere. The time for each cycle to complete was reduced from 20-30min to 10-13min. The no of cycles conveyed per day was increased from average of 10 cycles to 17 cycles.

6. Future Modification

- Increasing the bore diameter of the conveying pipeline to reduce the conveying pipelines jams.
- Changing the booster joint to the nozzle type booster.
- Both Feed hopper and Storage Silo vent filter capacity to be increased to Avoid puffing due to vessel pressure.
- Provision of Auto flow control valve at leg 3 for Smooth running of the System by eliminating manual valve.
- Conveying Pipe Line to be replaced with Cast Basalt or ceramic coated line.

7. References

[1]. A Comprehensive Scaling Up Technique for Pneumatic Transport Systems By ChandanaRatnayake, Department of Technology, Telemark University College(HiT-TF), Kjolnes Ring, N-3914 Porsgrunn , Norway


[8]. B. K. Datta and C. Ratnayake, A Possible Scaling Up Technique for Dense