Design & Development of Non-Continuous Type Pneumatic Conveying Systems for Ginning Industries

Mr. Hitesh M. Tupkari
M. Tech Student
Department of Mechanical Engineering
KDK College of Engineering Nagpur, Maharashta, India

Dr. A. V. Vanalkar
Professor
Department of Mechanical Engineering
KDK College of Engineering Nagpur, Maharashta, India

Abstract

This concept of conveying lint from intermittent ducting from various source of point has lot of present problems in ginning Industries, such as jamming of lint collection box/hopper, power consumption is more due to high CMH requirement. The main advantage of pneumatic conveying system is that material is transferred in close loop, thereby preventing the environmental effect on the material and vice versa. No standard procedure is available for the design of pneumatic lint conveying system. As the configuration of the system changes, variable involved also changes, and one has to change the design considerations based on the applications. So there is wide scope for experimentation in the field of pneumatic conveying system.
Keywords: CMH requirement, Belt type of lint conveying system, Pneumatic lint conveying system

I. INTRODUCTION TO THE TECHNOLOGY

Cotton was used for textile products several centuries before recorded History. Indian Cotton Ginning Industry is the second largest in the world. Cotton ginning plays very important role of separation of fibers from cottonseed and converts field crop into a saleable commodity i.e. lint. Ginning acts as a bridge between cotton farmer and textile industry. In India, cotton is ginned on double roller gins manufactured domestically. In ginning industries where bulk material is to be conveyed from multiple source of point to a single point, material handling systems are required. Various types of conveying systems are available in the market like belt conveyors, screw conveyors, vibrating conveyors etc. having their own characteristic features. This conveying system resulted in significant improvements in conveying methods with reduce operating cost and improved equipment reliability. The main advantage of pneumatic conveying system is that material is transferred in close loop, thereby preventing the environmental effect on the material and vice versa.

It has been observed that most of the ginning industries utilizing Pneumatic Conveying Systems for lint conveying the conveying conditions continuous type pneumatic system is used with more HP Accordingly This require significant investment in terms of capital, time and past experience of the system designer. Through this project we seek to theoretically design a Dilute Phase Pneumatic Conveying System for lint conveying with non-continuous type. This would result in less HP and running cost of the plant with more accurate prediction of the important parameters associated with this form of material conveying, thus resulting into reduced expenditure of resources & Focuses on elucidating on the various key aspects of pneumatically conveying materials.

A. Objectives

As per current scenario the ginners wants to reduce the production cost as well as running per bale produce in their plant. The main objective is

- To design the non-continuous lint suction system from DR Gin machine
- To minimize the running cost of the system
- To minimize HP power consumption for the present conveying system.
- To eliminate Jamming of lint collection box/hopper & poor suction of last machine
- Minimum inventory control

B. Lint Conveying In Ginning Industries

Lint obtained after ginning needs to be transported to press house for packaging into bales. Careful handling of the lint is necessary to avoid contamination and to preserve fibre quality. In modernized ginneries lint is conveyed from gin house to press house in one, two or three stages. In the first stage lint is conveyed from individual DR gins to the lint cleaner. In the second stage cleaned lint obtained from the lint cleaner is conveyed to the pala house for conditioning. In the third stage, the conditioned lint from pala house is conveyed to the press house for formation of bale. Sometimes the first two stages are combined together

by mounting the lint cleaner over the pala house. In integrated ginning and pressing plants, lint is directly conveyed from gin house to the press house through lint cleaner. In India following lint conveying systems are used:

- Belt type of lint conveying system.
- Pneumatic lint conveying system.

These two systems are used either in combination or independently.

1) Belt Type of Lint Conveying System

This system is not widely used and has several limitations. Belt conveyors are used in cotton ginnery to convey lint under the DR gins from gin house to the end of gin house where it is deposited into lint cleaner. Belt conveyor system is a continuous type of lint conveying system. Belt conveyor can be located either at the centre of the gin house between the two rows of DR gins or separate belt conveyors are provided for each row of DR gin.

Fig. 1: Belt type lint conveying system Working Principle

The basic components of this system are the metal trough, endless belt, metal slopper and mechanical drives. The endless belt is mounted on the head and tail pulley and supported by the idlers throughout the length. The belt conveyor is driven by geared motor with the help of belt and pulley arrangement. The width of belt, depth of metal trough and speed of the belt are decided based on the production capacity of the ginning plant. The endless rubber belts of 3 to 4 mm thick are located in the trench in the metal trough. The metal sloppers are fitted under each DR gin in an inclined fashion to deliver the lint received from the DR to the main belt conveyor. The belt conveyor moves in a metal trough at a constant forward speed of about 1 -1.5 m/sec. The main belt conveyor delivers the lint to the cross belt conveyor provided towards the far end of gin house. The cross belt conveyor discharges lint into the lint cleaner.

This system has following disadvantages

1) Because of exposure of lint during conveying to the atmosphere, contamination will be very serious.
2) Chances of trapping of lint under the edges of belt and in the idler roller are more.
3) Lint spill over will be more and add to contamination and losses.

2) Pneumatic Lint Conveying System

Pnuematic lint conveying system consist of a suction fan, lint collection box, ducting line, air separator and a cyclone.The selection of suction fan depends on the capacity of lint production and resisitance pressure of the system. Centrifugal fans are widely used in these systems. There is a slight varaition in the design of fan housing used in seed cotton conveying. The ducting, air separator and cyclones are selected based on the plant capacity. The air saparators used in lint conveying systems use 3 mm mesh screen and other parameters remains the same as that of air saparator in seed cotton suction system. The most important part of the punematic lint conveying system is the lint collection box and ducting line. The hopper of lint collection box needs to be properly designed to prevent dropping of lint outside and also should allow free fall of lint in to the ducting.

Fig. 2: Pnuematic lint conveying system

Two hoppers are fitted underneath the ginning rollers and rested on tie rods of DR gin. These two hoppers are connected to a flexible pipe via a double mouth chute cum elbow. The flexible pipe is connected to the main ducting line with the angular 'T' connector pipe. The lint collection boxes are fitted under each DR gin and connected to main ducting line. The main ducting line is conical in shape with small pipe diameter at far end gin and bigger daimeter at near gin form the suction fan. "T" connector pipes are connected at an angle to the main line just below and near the centre of each DR gin. The main ducting line is placed in an undergroud trench. The flexible pipe connects the main line to the lint collection box.

C. Working Principle

Centrifuagal fan creates the air suction and in the main line in each collection box. The lint falling from the DR gin is sucked into the collection box and passed on to main line through the flexible pipe.Thus the lint from all the gins is collected and conveyed to the lint cleaner. Each row of DR gin has one main ducting line. Both the ducting lines are connected together at the end of gin hall and lint is conveyed to the linr cleaner.

Both the air loss and pressure loss could be more if the pipe joints at "T" connector and at collection box are not properly sealed. Manual feeding as well as feeding of lint in lumps should not be allowed otherwise chocking will occur. The designed air flow and air velocity need to be maintained constantly to ensure the smooth operation of the system. The air velocity needed for lint conveying is about 8-12 m/sec.

D. Design Calculation for 24 Dr (Jumbo) Plants

1) Total Air Required

Quantity of lint produces by DR GIN Machine= 2600 kg
Air required per kg of lint to covey it
= 1.4 m3/kg of lint
Therefore total air required
=2600*1.4= 3640 CMH
Considering leakages as 20%
= 4368 says 4500 CMH (Total)

2) Duct Pipe Size Required

Calculation considering air required quantity as 3640 CMH neglecting leakages in the system.
For ducting pipe calculation
We know Q = A x V
i.e Discharge = Area X velocity
3640 = (3.14/4) X d^2 X 3600 x 16.5(Pickup/Discharge velocity)
d^2 = 0.0780
d = 0.2793m
= 279.39 mm i.e 11" duct
The duct diameter selected (d) = 11 inch

3) Cyclone Size Calculation

To calculate the cyclone size considering the CMH as 4500 & 1D-3DCyclone dia for 1D-3D = $D_c = \sqrt{8\,Q/vi}$

Vi = 3200 ft/min
Q = 4500 CMH
There for Diameter Of Cyclone $D_c = \sqrt{8\ x4500x/1.7\ x3200}$
D_c = 2.57 feet
= 784.09 mm approx 800mm
Taking D_c = 815 mm which is available

4) Power Required Calculation

Considering
Length of pipe = 180 ft
The loss 11" pipe per feet = 1.5 inch/ 100ft of pipe (Standard Chart)
TotaL loss = 180* 1.5/100 = 2.7 inch (Say 3 inch)
Number of bends (5 nos) = 5 *12.5' = 62.5' = 1 inch
Air seperator loss (1nos) = 4 inch (Standard Data)
Blower loss (1 nos) = 2 inch (Standard Data)
Cyclone loss (1nos) = 3 inch (Standard Data) – (815 - 1D/3D)
Total loss = 3+1+4+2+3
= 13 inch
= 330.2 mm
Considering Extra loss = 10%
= 1.1 x 13
= 14.3 inch
= 363.2 mm ie mm of Wgp
Thus power required = (CMH x Wgp x 0.491 x 1.25)/(4449.5 x 25.4) HP
= (4500 x 363 x 0.491 x 1.25)/(4449.5 x25.4)
= 8.87 HP
= 10 HP (Standard)
Final Specification of blower: 10 HP/4P, 4500 CMH @ 363 mm Wgp

E. Volume and Cycle Time Calculation for 24 DR Intermittent Lint Suction System

1) Twin Hopper Arrangement

- Quantity discharged from 1 gin machine = 1.81 kg/min
- Volume of reservoir = 0.37 m^3
- Density of lint = 10 kg/m^3
- Filling Factor = 0.6
- Weight of lint collected in reservoir = Density x volume x packing factor
  = 10 x 0.37x 0.6
  = 2.36 kg
- Cycle time = weight of lint collected in hopper/ time
  = 2.36/1.8
  = 1.31 min
  = 79 sec
- Operating time of flap valve For 24 machines
  = 79/24
  = 3.29 sec (approx)

But for safer side 1 sec window period is to be taken for 24DR setup which is less than the above theoretical value obtained via calculations.

II. RESULTS

Table 1:
Comparison Table with previous & current design

Sr No	Required	Previous	Current	% Of Change
1	Cmh	15000	4500	30
2	Power In Hp	30	10	33.33
3	Cyclone In Mm	1676	815	48.62
4	Ducting Size In mm	664.4	279.4	42.05

Fig. 3: Non-Continuous Type Pneumatic Conveying Systems

The detail results of the experimentation conducted during this work provides an exposure to new development. The analytical and graphical representations are as shown. The theoretical calculation and the actual reading are comparable and various head losses reading are taken accordingly which helps to find out the losses in ducting & affecting parameter for the system

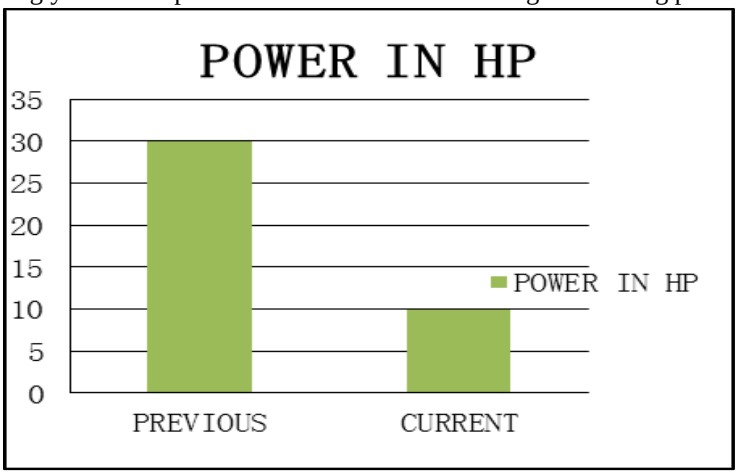

Fig. 4:

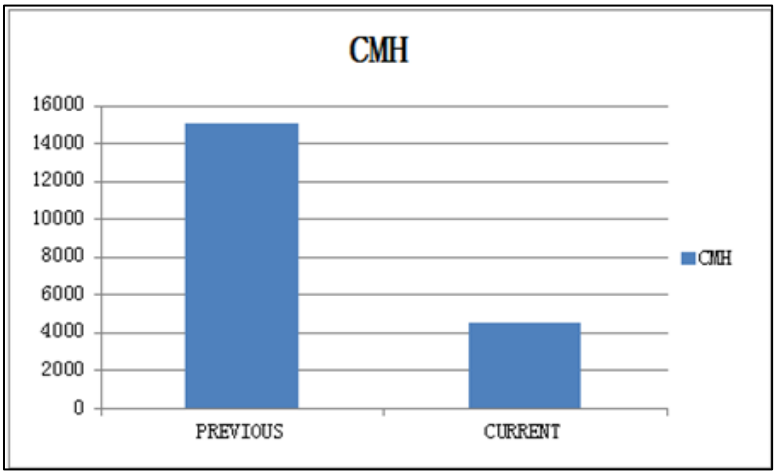

Fig. 5:

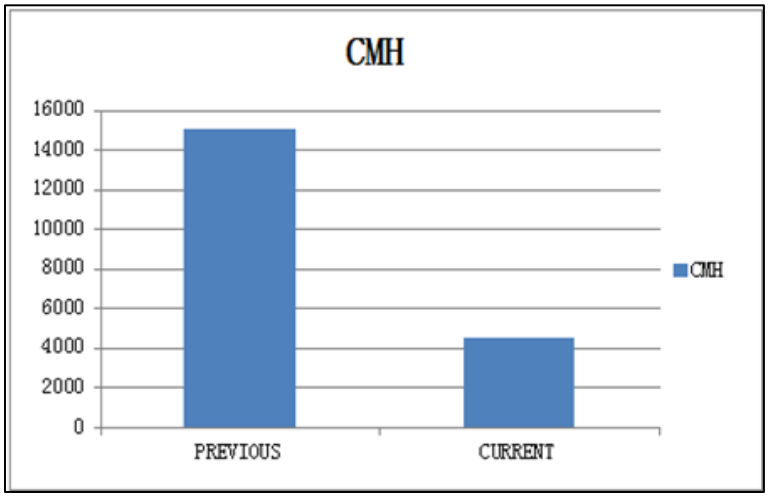

Fig. 6:

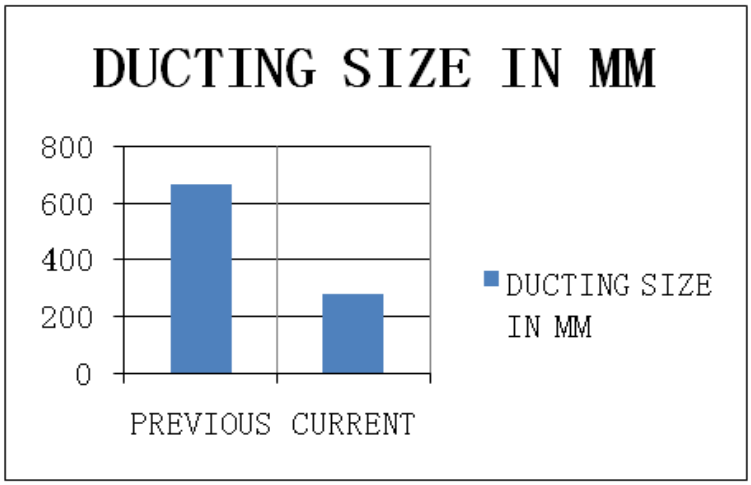

Fig. 7:

From this comparison graph it is shows that the CMH in the previous system is 15000 and the new system is 4500 that is CMH reduces up to 30%.power required to the previous system is 30hp and the new system is 10 hp which reduce up to 33.33% of the power to this new proposed system. Also cyclone and the ducting size of the system also reduce up to 48% and 42% respectively. This reduce in the percentage of the values are shows in the graph as follows. Graph shows the previous and the new system CMH in this the percentage of the CMH reduce is up to 30%.

III. CONCLUSION

After implementing the design of non-continuous (Intermittent) system the main conclusion is that this developed system really provides a great solution for reducing the running power consumption with low CMH & eliminates the jamming of lint in the hopper & hose pipe. This project is implemented & running successfully in ginning industry. Also the future scope we can do CFD analysis of this design, also it can be identified as a new development.

Even this system not only has application in ginning industries but also has wide important in various field because of its following benefits

1) Completely dust free operation
2) Flexibility in routing
3) Careful and gentle handling of product
4) Low maintenance and low manpower cost
5) Minimum floor space.
6) Ease of automation and control.
7) One pipeline can be used for variety of products.
8) High operational reliability due to few moving machine parts.

REFERENCES

[1] Design Considerations for Pneumatic Conveying System: A Review LP Dhole, LB Bhuyar and GK AwariVSRD International Journal of Mechanical, Auto. & Prod. Engg. Vol. 1 (1), 2011
[2] "Pneumatic conveying systems"- A. Bhatia.
[3] Dust Cyclone Technology – A Literature Review" - Paul A. Funk* and Kevin D. Baker. The Journal of Cotton Science 17:40–51 (2013) 40http://journal.cotton.org, © The Cotton Foundation 2013
[4] "PNEUMATIC CONVEYING SYSTEM" Shubhangi Gondane1*, M.S.Giripunje2. International Journal of Production and Mechanical Engineering Volume I Issue I January – March 2014
[5] "Theory and Design of Dilute Phase Pneumatic Conveying Systems" A.T. Agarwal Vol. 17 • No. 1 • January/February 2005
[6] "Design And Development Of Pneumatic Conveying System For Chilli Handling And Experimentation" J. M. Mahure, P. G. Mehar, S. R. Ikhar And A. V. Vanalkar Science Park Research JournalVol-1, Issue-10, 26 Sept 2013
[7] Recent Advances in Cotton Ginning Technology in India. Dr. P.G. Patil1& Er. V. G. Arude
[8] "NEW DEVELOPMENT IN COTTON GINING"by M.K. Sharma. , Nov 20,2008 ICAC , Ouagadougou, Burina Faso
[9] Pneumatic Conveying Design Guide 1990 which was written by Dr David Mills under contract with the Department of Trade and Industry.
[10] "Cotton Ginners Handbook" Anthony, W.S., and William D. Mayfield, eds. 1994. Cotton Ginners Handbook, rev. U.S. Department of Agriculture, Agricultural Handbook 503, 348.