



INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

REPLACING MANUAL MATERIAL HANDLING WITH FLEXIBLE SPRING CONVEYOR SYSTEM FOR CONVEYING BULK MATERIAL

PROF. Y.V.DANDEKAR, PROF. A P. EDLABADKAR, PROF. P.P.SARGAONKAR

1. Assistant Professor, Cummins College of Engineering for women, Nagpur.
2. Assistant professor, Yeshwantrao Chavan College of Engineering, Nagpur.
3. Head of Department, Cummins College of Engineering for women, Nagpur.

Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Flexible conveyors,
Spring conveyors,
Powdered material
Conveying

Corresponding Author

Prof. Y.V. Dandekar

Abstract

For any small scale industry engaged in handling of powders or bulk materials, conveying of these bulk materials is key issue when it comes to costs and other aspects like overall performance of the conveyors, adaptability of the system in minimum floor space etc. Industries often choose manual material handling in that case when above mentioned issues play crucial role in selection parameters. In today's era of demand of quality products from customer, precision and accuracy in final output from the material handling is very important. Manual material handling thus has certain limitations and the need of better material handling system arises. Various conventional conveyor systems like belt conveyors, bucket elevators, screw conveyors, pneumatic and vibratory conveyors are extensively used in industries like food, chemical, pharmaceutical, plastics, household products, mineral processing industries or agricultural industries dealing daily with powdered or bulk material handling. In our case, selected industry being run on small scale certainly have limitations to adopt these conventional material handling systems to convey the powders economically and precisely. In this paper the suitability of flexible spring conveyor system is studied critically and compared with other conventional systems to replace the manual material handling.

INTRODUCTION

At VRC Plastomoulds, handling powders or granular materials [1] like PVC; when approached / surveyed to understand exactly the need of proper conveyor system to bulk material handling it is observed that manual handling of materials is having limitations in terms of quality, precision and optimum use of raw material also it is a laborious job of filling the hopper which is at height of around 6 fits every time. Figures shown below are the photographs of existing setup of injection molding machine hopper.



Fig 1. Existing hopper arrangement



Fig 2. Manual feeding at existing arrangement

To study the issue, some relevant data regarding the material need to be conveyed have been collected. It is done so to understand the exact properties of material.[2] Material properties like flowability, lump size and shape[3] etc significantly influence performance of the conveyor system. After the discussion of concept of flexible spring conveyor system with its various advantages over other conventional conveyors and manual handling, the utility and suitability of the new system has been highly appreciated by the industry under consideration. Formats as per Table 1 were used to collect the data.

Table1. Sample: Data collection for known factors

Material: Polyvinyl Chloride powder				
Material form	Powder	Granular	Flakes	Others
Material form	Yes			
Particle Size	≤ 0.5 cm ²			
Bulk Density	25 lbs/cu.ft			
Flowability (Angle of repose)	Very free (30°)	Free (30° to 45°)	Semi Free (45° to 60°)	Non-Free (60° & more)
Misc properties	Flows plastically			
Hazardous	Toxic	Explosive	Flammable	Other
Yes	No	V		

Material properties play an important role while selecting the proper conveyor system. Table 2 and Table 3 shows the key properties of different materials considered before proposing the flexible conveyor system. [8]

Table2. Key properties of bulk solids/powders considered

Material	Properties			
	Bulk density	Particle size/shape	Angle of repose	
Calcium Carbide	80 lbs/cu.ft	0.15 inch ²	40 ^o	
Cashew Nut powder	35 lbs/cu ft	Spherical	60 ^o	
Caustic soda flakes	47 lbs/cu ft	≤ 0.5 inch ²	36 ^o	

Table3. Key properties of bulk solids/powders considered

Material	Properties			
	Bulk density	Particle size/shape	Angle of repose	
Polyvinyl Chloride powder	25 lbs/cu ft	≤ 0.5 cm ²	53 ^o	
Magnesium Chloride	33 lbs/ cu ft	≤ 1 mm ²	40 ^o	
Dry Salt	75 lbs/ cu ft	≤ 0.16 cm ²	25 ^o	
Soybean flour	30 lbs/ cu ft	≤ 0.0059 cm ²	55 ^o	
Rice Polished	30 lbs/ cu ft	≤ 0.5 cm ²	19 ^o	
Alumunium Hydroxide	45 lbs/cu.ft	Less than 0.132cm ²	46 ^o	
China Clay	70 lbs/ cu ft	≤ 0.5 cm ²	38 ^o	

PROPOSED FLEXIBLE SPRING CONVEYOR

The flexible spring conveyor consists of minimum components as compared to

other conventional conveyors systems, namely a spring made up of steel which is enclosed in a tubular casing or a flexible pipe of plastic.

This flexible spring conveyor can outperform other conventional conveyors like rigid screw conveyor, bucket elevators, pneumatic or aeromechanical conveyors etcif it is specifically designed as per the characteristics (e.g. flow properties) of the material being conveyed. It should also be engineered and synchronized properly to the process into which it will be integrated.

The spring is connected and directly driven by an electric motor which is normally located at the discharge end. Depending up on the specific requirement s the motor may be connected to the spring at the feeder end of the plastic tube near hopper.

The end of the tube near the intake is connected to the hopper with a charging adaptor, generally a U- shaped trough. The flexible spring passes through this charging adaptor trough, exposing its end with some free length to the material present in the trough through hopper.

As the spring is rotated, its section exposed to the material feeds material into the tube.

Through this tube then material is agitated into the enclosed portion of flexible spring.

A removable cap for cleaning out purpose is provided at intake of the tube. This enables rapid emptying and flushing of the tube.

Figure 3, 4 and 5 shows the typical CAD model of the system under development.

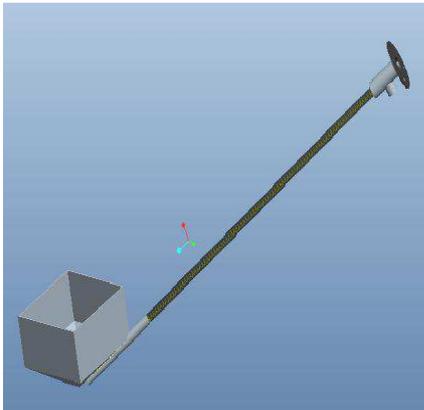


Fig 3 CAD Model Assembly (under development)

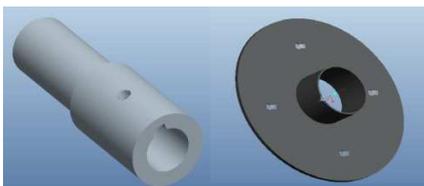


Fig 4. CAD model of Adaptor and Flange

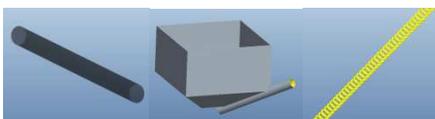


Fig 5. CAD model of Tube, Hopper and Spring

Prototype (under development) of the system will undergo thorough testing for

finding out different performance parameters like throughput at various speeds, different inclinations and elevations. Materials of different bulk density, angle of repose and particle shape and size will be tested for the overall suitability of Flexible Spring conveyor system in particular application.

WORKING OF PROPOSED FLEXIBLE SPRING CONVEYOR

While rotating; the spring automatically self-centers within the tube due to a phenomenon resulting from loose fit of a rotating spring within the tube completely filled by the material to be conveyed. This in turn provides sufficient clearance between spring and the tube wall.

This affords sufficient space for the particles to flow in the tube depending upon the particle size, angle of repose and flowability of material. The one end of the spring is floating freely in the charging adaptor trough and does not require any bearing. As the discharge end is coupled to the motor drive above or beyond the discharge chute the seals or bearings not to come in direct contact with the powders being conveyed. Thus the flexible spring and enclosed tube

are the only parts which come in contact with material directly.

There are two forces acting on the material to be conveyed within the enclosed tube area: an axial force that acts to convey the material along the tube and a radial force that presses the material against the tube. This radial force provides the barrier between the spring and the tube and remains in the centre of the tube. This phenomenon allows the flexible spring to be 'self-centering'.

COMPARISON OF PROPOSED SYSTEM WITH MANUAL AND CONVENTIONAL MATERIAL HANDLING

A. Space requirements

Due to its wide flexibility, Flexible Spring Conveyor will be very useful in workplaces having space constraints. The flexible tube and spring can be easily carried and taken away to any position or place as and when required. Unlike other conveyor systems which are rigid in structure, this particular advantage of this proposed system can give great flexibility to the industries facing limitations to material handling due to their space constraints. [4]

B. Effect on the plant layout if system is adopted newly in the plant

This system can prove great adaptability in existing plant layout of the organization without much alteration in its existing setup. As such no effective changes in the plant layout are required if this system is to be installed newly in the plant.

C. Accuracy and precision in discharge

The output in this conveyor system being controlled by rotational speed of the spring, just by varying rpm of the drive we can achieve great control over the flow of material. In other systems metering has to be done at feeder end, controls are ineffective sometimes at the discharge end. Various new programming techniques can be employed to control the output at discharge end for spring conveyor system. Variations in geometry or design of spring can influence discharge effectively.

D. Less possibility of separation

As the powders are carried due to vortex motion in the enclosed tube, there is less possibility of segregation of powders of different densities in a mixture. In other conveyor systems like screw conveyor or vibratory conveyors, where the carrying

trough is not filled 100%, the high density powders are likely to get settled down in the trough during their travel from feeding end to the discharge end. This is beneficial in industries where the conveyors carry a powder mixture.

E. Costs

This conveyor is cost effective as having minimum number of parts. This also in turn reduces initial setup costs in large scale. The complete absence of bearings and less relatively moving parts leading in high friction are avoided; the maintenance cost is also considerably reduced. When it comes to economy, from technologically suitable conveyors flexible spring conveyor can outperform by offering lower capital and operating costs. [5]

F. Power consumption

It is seen that this conveyor system requires less power as there are no bearings and minimum friction between the parts is achieved. The only friction is between the material to be carried away and tube walls and spring. The throughput, torque & power are significantly influenced by vortex motion of bulk solid being conveyed. [2]

G. Dust control

Dust control is the most common and challenging task in industries like food, chemical, agricultural etc as dust threatens safety of the human being directly exposed in the plant or indirectly involved end users of the product. In conventional conveyors dust control is not only economical but also is a skilled task which needs expensive and precise components to control. As the enclosed tube and spring is used, flexible spring conveyor can have good dust control in much less cost. [6]

H. Working at different angles of elevation

Conventional screw conveyors are restricted to lower angles of inclination. However other systems like bucket elevators are limited to vertical elevations and not effective much in horizontal conveying. The Flexible Spring conveyor can achieve the best between horizontal and vertical distances due to its flexibility. It can literally work at any angle of inclination from horizontal to exactly 90° elevations.[7]

I. Fill ratios

Screw conveyors are restricted to fill ratios and cannot work efficiently at higher fill ratios as to protect the hanger support bearings when long conveying distances are employed. Flexible Spring conveyor is the best solution where higher fill ratios are essential. [3]

PROOF OF CONCEPT

A scaled working model was developed and tested for working of the concept. Materials of different densities and other flow properties were actually tested on the model for feasibility of the system.

It worked to the expectations and showed great results for different densities and angle of repose. Details of materials tested are mentioned in the table5.

Table5. Materials tested in the working model

Material	Properties		
	Bulk density	Particle size/shape	Angle of repose
Mustard	45 lbs/cu.ft	Less than 0.132 m ² /Spherical	25 ⁰
Parting sand	95 lbs/cu.ft	Less than 0.15inch ² /Granular form	39 ⁰
Oats	26 lbs/cu.ft	≤ 0.5 cm ² /Flakes	21 ⁰

Figure 6 and 7 below show the conceptual model of the conveyor system.

Materials of different densities, angle of repose and particle shape and size were conveyed easily when tested in the scaled model.



Fig 6. Conceptual small scale working model developed



Fig7. Conceptual model working

Observations of the testing are:

1. Density, particle size/shape and angle of repose affect the flow properties considerably.

2. Flow is seen decreased at higher elevations of discharge end.
3. Considerable increase in output with increase in speed of the rotating spring.

CONCLUSION

Flexible Spring Conveyor system can be a good substitute to manual material handling in small scale industries care should be taken to keep flow properties of bulk solids like bulk density, angle of repose and particle shape and size in mind.

In economic point of view this system can be greatly useful and concept is highly appreciated by industries as far as its other advantages like accuracy in discharge end, adaptability in existing plant layout, overall cost and easy maintenance over conventional conveyors is considered.

FUTURE SCOPE

The mathematical model as well as a prototype is under development for future purpose to calculate and compare actual and theoretical performance parameters of the spring conveyor system.

REFERENCES

1. Book: "Consolidated Perry's Chemical Engineering Handbook" Chp. 21, Handling of bulk solids and liquids.

2. Alan W. Roberts, "Design considerations & performance evaluation of screw conveyors", The SouthAfrican Institute of material handling/beltcon11/ beltcon1114 /2001

3. Philip J. Owen & Paul W. Cleary, "Screw conveyor performance: comparison of discrete element modeling with laboratory experiments", 7th International conference on CFD in minerals & process industries, CSIRO, 9-11 Dec 2009

4. Robert A. W. (1991), "Bulk Solids Handling: Recent developments and Future directions" Bulk solids handling, 11(1), pp 17-35

5. David Boger, Allen Powel, "Move difficult to handle material with flexible screw conveyor" Journal of Chemical Engineering, Vol 115, No 4, April 2008

6. Dejan MIRAKOVSKI, Zoran DESPODOV, : Fugitive dust control at conveyor transfer points- A solution for puzzle"The International Journal of Transport and Logistics, UDC:622.063.8:622.807.5

7. Da EzzatollahAskariAsli-Ardeh& Ahmad MohsenimaneshTavel, "Determination of

Effective Factors on Power Requirement and Conveying Capacity of a Screw Conveyor under Three Paddy Grain Varieties”, The ScientificWorld Journal Volume 2012, Article ID 136218, 5 pages doi:10.1100/2012/136218vid Boger, Allen Powel, “Move difficult to handle material with flexible screw conveyor” Journal of Chemical Engineering, Vol 115, No 4, April 2008

8..Book: “Bulk solids handling” Chp. 7, Small Scale Bulk HandlingOperation