

Ask Joe! Column

Design of Metering Screw Feeder

Guest article by Mike Page of Rospen Industries

Introduction

The following points provide a detailed consideration relating to the design of metering feeders used in controlling the flow of powders into a process at a prescribed rate. This perspective is based on the 25 plus years of experience with metering and loss in weight feeders.

Whatever means are employed to actually control the powder, certain basic fundamentals need to be assessed and understood before a solution can be arrived at. Firstly, the terminology used to describe aspects of the equipment is universal and can be summarized as follows:

- **Diameter of Screw** – This is the nominal outside diameter of the screw not the diameter of the tube in which it runs, nominal, because a 40 mm screw is in fact 38 mm diameter.; a 20 mm screw is 19 mm diameter etc. These differences only occur because the nearest available stainless steel tube schedule requires selection of these dimensions to give a proper running clearance.
- **Pitch of Screw** – The dimension from leading face to the next leading face of the screw. In metering screw feeder terms the pitch dimension relates to the nominal screw diameter, applicable on screws up to 100 mm diameter. Above this size, the pitch will be smaller than the diameter but is still referred to as full pitch.
- **Box Loading** – This refers to the level of material in the screw tube/casing and is usually quoted in % terms i.e. 50% etc. When box loading is related to the screw pitch then fractional terminology i.e. 1/2, 1/3 is invariably used. For reference, we apply 100% loading. However, for long feed applications the screw may require an expanding pitch to reduce the box loading in the tube.
- **Volumetric Feeding** – Strictly based on a screw of a known diameter and pitch, metering powder at a specified speed. It must be noted that any variation of material bulk density will have a direct effect on the ultimate feed rate.
- **Gravimetric or Loss-in-Weight** – A feeder usually identical in design to the volumetric feeder but mounted to a weigh platform to measure the weight lost from the feeder at intervals of time. (A separate design paper is available, which covers the design principles)



Principles Of Metering Screw Feeding

The principles of metering screw feeding can be summed up as follows:

Correct filling of the screw

Otherwise known as entrainment. This process is enabled by the knowledge of the powder and critically, its handling characteristics, correct design of the storage hopper, and both the impact and necessity of flow aids.

Each powder has an ideal speed range through which it will not adversely react to the process of changing direction and filling the pitches of the screw. Invariably this is determined by trials and typically the conclusion is, that the higher the screw feed the greater the potential for capacity and linear accuracy tail off problems.

A typical hopper design usually incorporates the standard taper shape assisted by two or four blade agitators with intermittent or continuous running. For more difficult materials the tapered sided hopper is replaced with vertical walls to ensure a consistency of material flow to the screw. In extreme cases vibrator motors can be used.

With larger hoppers, above 150 liters and up to 0.5 m³ capacity it may be necessary to promote product flow by creating an unstable material bridge in the hopper by use of a vibrating discharge cone along with air evassers arranged asymmetrically in the hopper walls.

In the case of assisted flow by either the above or larger vibrating cone bin activators, care should be taken not to mis-match the output from the discharger and the screw by too great a factor. This can result in compaction, causing material, which cannot get away to compact in the feeder causing it to bore or tunnel a hole without conveying smoothly. The solution to this process is to scale down the problem by batching from large hopper or silos into the feeder hopper using high and low level probes to control the refills from the silo.

Screw Geometry and Metering Zone

Once the screw size and pitch have been determined it is important to realize that to be effective the pitch of the screw selected must enter the metering zone, namely the discharge tube for the first 3 full pitches of the screw. On extended length screws the pitch is opened out to reduce the box loading. This has two effects, it lowers the stress on the on the drive shaft of the screw and also the consumed power taken to drive it.

Screw Design

Feeders are supplied in single and twin, screw configurations with variations on the screw design such as solid and wire screws



Single Screw and Twin Screw

The majority of applications use single screw with variations on pitch and diameter, this is generally found to be satisfactory due to the unique feeder trough profile and method of agitation on the our style of feeder.

Twin, screw feeders are generally used where extreme flushing of powders can occur or the complete opposite with cohesive powders like pigments or those with a high resin content, which require a large entrainment area to enhance flow. The one main advantage of twin screws is the fact the faces run together and not edge to edge such that a self cleaning effect is the result. Also the pulsing effect is reduced at the outlet, particularly important with sluggish powders.

Solid Screw

Solid screws take the form of a continuous Archimedean spiral with a shaft running throughout the screw. The vast majority of applications use this design principle. Even with the flavor powders usually associated with the snack industry solid screws are used, the only additional feature given to the screw are breaker bars set on to the screw in the trough area to break up any dead area that may form in the trough.

Wire Screw

On occasions wire screws can be used, which take the form of a helix spring manufactured from square section material. This type can only be employed for very difficult fibrous materials, which need a larger entrainment area in the screw, i.e. minimum blade width and no centre shaft. It should be noted that wire screws have minimum surface area, which does not support serious build up of cohesive powders.



Extended Length Screw, in the event the standard length of feed tube is insufficient and a further extension is required work on the following dimensions as a general rule for the maximum permitted tube length.

- 25 mm diameter – 1000 mm
- 40 mm diameter – 1500 mm
- 50 mm diameter – 2500 mm
- 75 and 100 mm diameter – 3500 mm

Note: The above table is for guidance only and selection will depend on product characteristics and specific applications. There may also be a requirement to increase the motor power to provide additional torque.

When considering long screws it may be advisable to reduce the box loading in the tube by sizing the screw diameter with a reduced pitch at the metering point, i.e. in the trough. Even a 90% pitch at this point, which will give a 10% reduction in the tube can have marked advantages on the consumed power.

Oversize Product

If the powder to be handled has a large particle size up to say 5 mm, then problems will occur in either these particles jamming between the edge of screw and the tube, or if not jamming causing extreme increase in torque requirements preventing successful feeding. In such a case fit an oversize tube and/or reduce the metering pitch to ease the box loading.

Cohesive Powders

The use of an oversize tube will assist in cohesive powders which, when compacted in the normal screw/tube clearance cause extreme increases in power requirement. The increased clearance allows material to run on material in an un-compacted state.

Consistent Bulk Density

A necessity for volumetric feeding is a consistent product bulk density but it can be overlooked if it is assumed the same chemical from different suppliers will have the same characteristics. Note! when obtaining density figures be aware that the specific gravity approach relates to solid powder with no air gaps between the particles of powder. Therefore, if in doubt take a sample and pour loosely into a measured container and weigh it.

Feed Rate Calculations

There are no feed rate tables accompanying this paper for the reason that they can be open to mis-interpretation and it is advisable to approach the manufacturers or competent agents with any project details or specific sizing problem. For reference purposes, tabular information can be found on the our web site <http://www.rospen.com/feeder-sizing.html>.

Conclusion

The use of Metering Screw Feeders can provide accuracies of 1% to 2% depending on material characteristics and consistency of properties as highlighted throughout the above article.

For more information contact:

Mr. Mike Page
Senior Sales Engineer
Rospen Industries
Oldends Lane Industrial Estate
Stonehouse, Gloucestershire
United Kingdom, GL10 3RQ
Email: mikepage@rospen.com
Web site: <http://www.rospen.com/>

+++++

Welcome to Ask Joe!, a monthly column by our resident materials handling guru, Joe Marinelli of Solids Handling Technologies. Joe addresses the issues that bug you the most. And Joe knows!! Formerly with Jenike & Johanson, Solids Flow and Peabody TecTank, Joe is an expert on materials handling.

For past articles, **Ask Joe!** Archived Articles.

Guest articles for the **Ask Joe!** Column are always welcome, for more information please contact Joe Marinelli directly at his email address: joe@solidshandlingtech.com.