Biomass handling

Richard Farnish, Consulting Engineer, The Wolfson Centre for Bulk Solids Handling Technology, University of Greenwich, UK

Introduction

An increasing range of industrial processes are incorporating waste of biomass materials into their operations. However, in many cases, issues of poor handling or storage characteristics can create considerable problems when these types of materials are handled in loose bulk form. This article will consider the issues that can arise when handling some types of biomass or waste materials (typified by extreme particle shapes – flaky, stringy, or elastic behaviour), and potential techniques for addressing these issues.

Figure 1. Stable, self supporting masses of flaky products in a conical vessel.

Typical handling issues

Most bulk handling facilities are well suited to dealing with a diverse range of conventional materials (such as ore concentrates, grain, etc.). However, when these systems are required to handle biomass type material problems can often arise.

Within bunkers or silos, materials that by visual inspection exhibit free-flowing behaviour when handled in loose form can be capable of forming substantial cliffs of self supporting particles or arching over outlets or feeders. In this respect, the bulk particulates resemble the static storage behaviour of cohesive materials.

The standard approach for the design of storage equipment to achieve reliable discharge consists of the use of measurements of wall friction, bulk density and internal strength measurements obtained from a representative sample of bulk particulate. However, the combination of irregular, large or flaky particle shapes for some types of biomass materials renders existing design approaches of limited value due to the problems of accommodating a statistically significant number of particles within test equipment designed for use with granular or powder forms of particulates.

Figure 2. Dust generation during transfer operations.

Hygiene issues

Biomass, by its very nature, consists of degradable or fermentable materials. It also represents a bulk material that presents a media through which moisture can migrate or be absorbed. Thus, where large volumes of these materials are stored, considerable care must be taken to reduce exposure to the environment (wind erosion and moisture uptake) and to ensure that stock rotation of stores is undertaken.

Mobilisation and migration of moisture through stored bio mass materials is not an unusual phenomenon and is one that can be exacerbated if the storage bunker/silo is located on site where a significant differential between day and night ambient temperatures can occur. In such circumstances moisture liberated by evaporation can condense within the headspace of the storage structure and generate 'rain' onto the top surface of the stored material. Depending upon the levels of moisture mobility and location within the inventory, the material can also have the potential to ferment – generating heat in the process and providing an additional mechanism by which moisture can be driven from the bio mass. This mechanism is capable of driving the development of significantly sized concretions that may pose sufficient strength to completely block the outlets of equipment – sometimes requiring manual entry and extraction of the inventory from the top downwards in order to reclaim lost 'live' storage capacity. A good example of this type of problem would relate to the storage of pelletised citrus material (or other extruded waste products), which can expand considerably or (in some instances) disintegrate back to its original form depending upon the severity of moisture uptake from the environment.

Most materials that are received and handled in bulk form tend to be at very low moisture content. While this approach minimises the potential for bioactivity through subsequent storage schemes, it also endows the bulk material with a propensity to readily generate fugitive particles when handled. Although the issue of fugitive particles in the form of dust clouds represents an immediate hazard (in terms of not only inhalation by operatives, but also as a potential for dust explosion) it can also generate a longer term health hazard through mould growth/spore generation amongst the spilt and settled particles. The deposition of these fugitive fines can often be dispersed over considerable distances from the original source. Thus, the removal of these deposits can tend to be quite an extensive undertaking if carried out diligently around the site.

Minimising the problems

Improvements on site can be obtained in several areas of handling operations if the biomass material is particularly fibrous or exhibits high fines content (and is therefore prone to generating significant fugitive particles).

Considering the issue of bulk storage, irrespective of whether a (covered) ground storage scheme or vessel is utilised, it will be important to try to minimise the time that material is stored in bulk. This will serve to reduce the risk of fermentation (in the event that the material is susceptible) or consolidation effects (increasing the bulk strength of the material and hence its ability to arch or bridge over outlets). Accepting that storage facilities (including vessels) must be capable of being used in conjunction with a very wide range of imported raw materials, it is not uncommon for biomass materials to be stored in equipment better suited to freer flowing products such as cereal crops, and therefore the special storage behaviour of biomass will be likely to lead to an increased incidence of flow stoppages. In the event that the importation of biomass would be a long term prospect, it would be advisable to invest in modifications (or new equipment) to suit the storage characteristics of the biomass. Such changes would require that the storage vessels could be operated on a first in – first out basis (i.e. mass flow, see Figure 3).

To obtain this type of discharge behaviour, the vessel would need to utilise geometry and internal surfaces defined from a programme of flow property measurements using a shear cell. For less biomass materials that exhibit a less 'elastic' bulk behaviour, a conventional shear ring arrangement can be utilised (Figure 4), but for pelletised or more elastic type bulk materials the conventional approach for design reaches its operational limitations. In response to the increasing demand for designed equipment, larger shear cells have been developed that can accommodate larger particle sizes and increased travel to achieve shear of the test materials. Not only can the newer type of large scale annular shear tester be used to generate design information for obtaining reliable flow of biomass products from storage vessels, but the information gathered can also be used to calculate wall loadings.

With respect to the generation of fugitive particles through handling operations, useful improvements can be brought about by designing chutes and transfer points such that streams of particulates are ejected (or fall) in as dense a form as possible. Such approaches may include the installation of cascades or intercepting plates to capture the stream of particles and to densify/decelerate the mass. Compared to a dispersed stream of material, a dense mass of particles is less likely to permit the ingress of counter air flows which would otherwise tend to strip out the finer particles and disperse them over a significant area. In contrast a dispersed stream presents a very large collective surface area for the counter flow of air to interact with.

The deposition of the biomass in a dense (and relatively low velocity) condition will also reduce the influence of one of the contributory mechanisms for segregation to occur upon filling vessels. This secondary benefit should not be underestimated, since if the loaded biomass has a wide size distribution, then a noticeable disparity in blend (or particle size) homogeneity will be evident. The ramifications for the occurrence of segregation through the storage scheme may range from increased dustiness throughout a complete discharge of material, filter blinding, inconsistent discharge behaviour or complete flow stoppages.

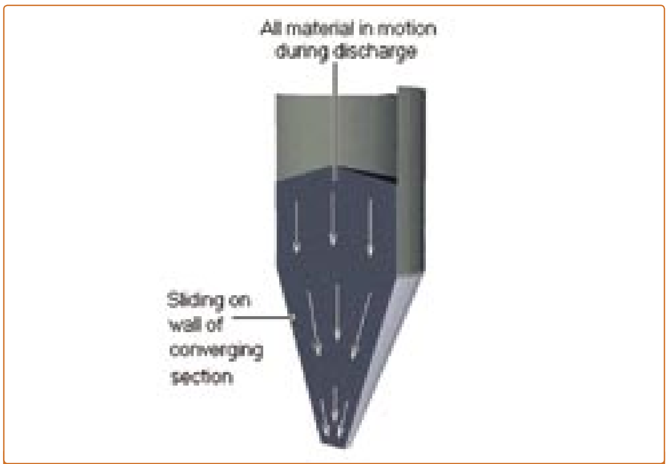

Figure 3. Mass flow discharge (first in – first out material flow).

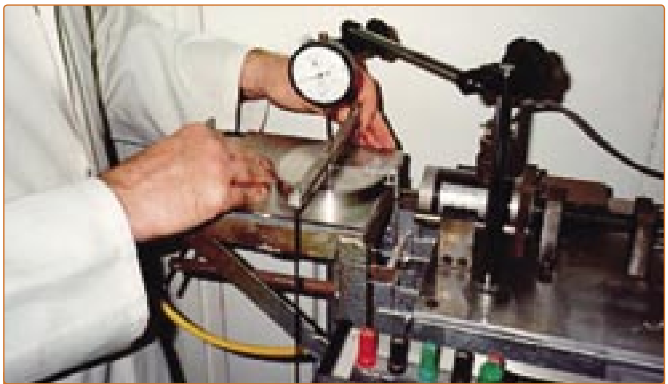

Figure 4. Jenike type tester commonly used for shear testing of bulk solids.

In conclusion, although the bulk handling of biomass materials is on the increase (and is likely to increase further) there are many instances of handling problems. Many of the problems that arise can be attributed to the inherent differences in bulk characteristics of biomass materials compared to more conventional bulk solids, however, existing and proven design procedures can be applied to deliver equipments that will operate reliably with biomass. Modifications to existing plant can often bring about useful improvements in discharge performance and also minimise the generation of fugitive particles – but invariably some degree of characterisation or background knowledge of the bulk behaviour of the bio mass materials is required in order to obtain the best results.

ABOUT THE AUTHOR

Richard Farnish has a B.Eng from the University of Greenwich and has worked extensively on consultancy work on projects ranging from pneumatic conveying, silo design and segregation problems at The Wolfson Centre for Bulk Solids Handling Technology at the University of Greewich, London, UK. Past major projects have concerned extensive investigations into coal and powder flow through silos and chutes and the effects upon flow patterns of doors and operating procedures.

ABOUT THE ORGANISATION

The **Wolfson Centre for Bulk Solids Handling Technology** is a department within the Medway School of Engineering at The University of Greenwich, Medway, Kent and has specialised in solving materials handling problems since 1973. The Centre began its existence researching problems associated with pneumatic conveying of powders and granular solid material in pipelines and has since expanded its areas of interest to include hopper & silo design, and instrumentation & control of bulk solids handling systems. Its extensive test facilities are housed in over 1,000 m2 of floor space. These facilities are continuously being updated to meet research and test requirements of industrial clients.

ENQUIRIES

The Wolfson Centre for Bulk Solids Handling Technology
University of Greenwich
Central Avenue
Chatham Maritime
Kent ME4 4TB
UK

E-mail: r.j.farnish@gre.ac.uk
Website: www.bulksolids.com