Storing FGD Gypsum without any trouble!

JAAP P.J. RUIJGROK, ESI EUROSILO® BV, THE NETHERLANDS, ***DISCUSSING A WELL PROVEN STORAGE CONCEPT FOR NON-FREE FLOWING BULK MATERIALS LIKE FGD GYPSUM.***

Introduction

Today we are technically capable of designing totally enclosed storage and handling systems for storing huge quantities of bulk solids. Most of these bulk solids like coal, FGD-Gypsum, limestone and fly ash are produced and/or stored on site at coal-fired power stations. These enclosed systems are made possible by the application of the Dutch Eurosilo®-concept meeting the requirements of Environmental Protection Agencies worldwide.

Enclosed storage systems applied in the bulk handling industry can be divided into three main categories:

- Longitudinal A-frame type storage shed.
- Circular dome type storage
- Silo storage, bottom discharge type or flat bottom mammoth silo

This paper will mainly discuss the flat bottom storage silo or Eurosilo® system.

Fig. 1. Typical 10,000 m³ FGD Gypsum Eurosilo®

The Eurosilo® system

The Eurosilo® system is a reliable system for storing a wide range of non-free flowing bulk solids in capacities ranging from 1,000 m3 up to 80,000 m3. The heart of the system consists of sturdy screw conveyors and, if necessary, a central slotted column.

Easy access for maintenance and cleaning, achieved by a spacious design of transfer stations, and walkways, etc.

Application of water repellent liners inside transfer chutes, on the screw flights, etc. to avoid hang-ups.

Providing a high percentage of equipment availability.

Design and Construction Details

The structural design of most Eurosilo® walls consists of a steel structure with an inner and outer wall.

The inner wooden lining is supported by horizontal ring beams, to which the horizontal silo pressure is transmitted. The columns are part of silo structure. They enclose the inner part and are pin-jointed to the foundation. The silo structure is externally shielded with standard wall cladding.

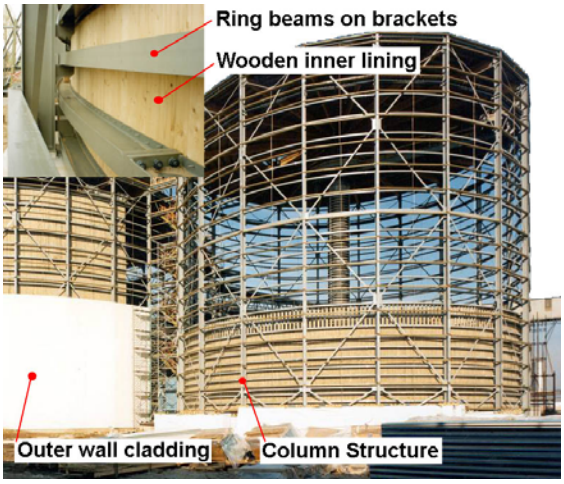

Fig. 2. Typical Eurosilo® Structure

For bulk materials such as coal, soybeans, limestone, and so on, a slip-formed concrete wall structure may be applied.

The foundation produces low bearing pressures and no piles are required, unless very low soil bearing capacity is encountered. Consequently it is not surprising that the Eurosilo® concept was developed in the Netherlands, known for its poor soil bearing conditions.

The Eurosilo® system and Very Cohesive Materials

Very cohesive materials could not be stored in the original Eurosilos® because material was arching and rat holing occurred. Therefore, a slotted column has been developed.

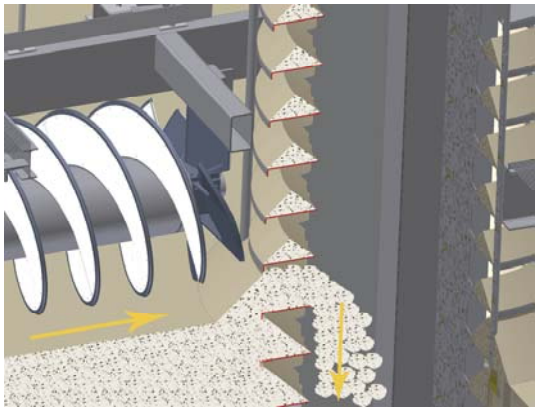

Fig. 3. Basic principle of the Slotted Column

Fig. 4. From design to construction of a slotted column

The material to be reclaimed is fed through the slots formed by horizontal flat rings. Subsequently the bulk material descends freely by gravity through the vertical channel as indicated. This Eurosilo® reclaiming concept eliminates many of the complex influences of bulk material characteristics. Its fully automated mechanism fills and reclaims the bulk material in horizontal layers. In this way, wall loads will be kept minimal, symmetrical and predictable. Simultaneous filling and reclaiming is possible.

An important feature of the Eurosilo® concept is the way the screw reclaim mechanism operates; linked with a slotted column the notorious "flow-no-flow" syndrome is eliminated. This powerful combination ensures the reclamation of even a difficult bulk material like FGD-Gypsum in a controllable way!

Before discussing the handling and storage of FGD-Gypsum in more detail, we are focusing on the poor flow properties of this material.

Properties of FGD-gypsum; Can it be handled?

The poor flow properties of gypsum causes a number of serious problems. By way of an example, the "flowability" of FGD-Gypsum with a free moisture content of 9 % is shown. The unconfined yield strength (σp) has been plotted against the major consolidation stress (σi). The characteristics lie completely in the worst flowability zone as defined by Dr. Jenike. These zones are separated from one another only by differently valued flow functions.

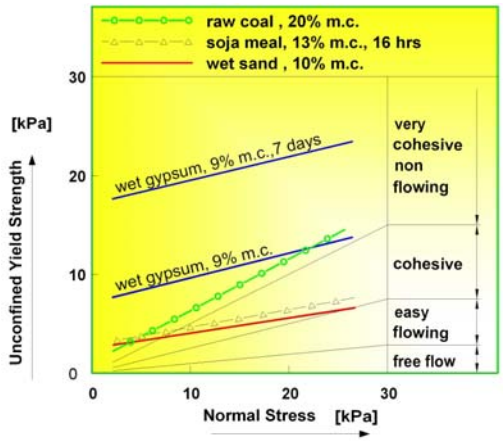

Fig. 5. Flow properties of gypsum with moisture of 9%

As additional reference, the curves of raw coal, soy meal and wet sand have been shown in the figure. Note how far the wet gypsum curves lie above those of soy meal, which in the food industry is traditionally known as one of the toughest materials to handle. The time consolidation after 7 days of storage already has an extremely negative effect on the flowability. Therefore, even experts wonder whether such a material can be handled at all and, even more important, whether it can be smoothly reclaimed and controlled after a certain time of storage. The answer is NO, unless a sound common sense principle is used, like the Eurosilo® system.

Drainage / Dewatering System

It is known that the free moisture content of the gypsum will concentrate in the lower regions of the silo, when it is being stored for a longer period. Therefore the FGD-Gypsum silos are equipped with a drainage system on the silo bottom.

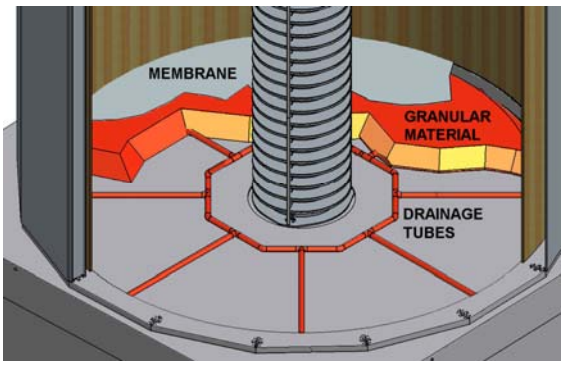

Fig. 6. Drainage system

The free moisture percolates downwards through the material and is drained off via a membrane (geo textile) and a layer of granular material in which the drainage tubes are installed.

By using a Eurosilo® system for storing FGD-Gypsum, an additional dewatering of at least 1% will be achieved by evaporation from the upper layer. The layer thickness during filling amounts approx. 7–10 cm.

At long time storage, due to capillarity, the gypsum mass (which in some ways behave like fine sand with an average particle size of 50 micron) may be saturated with water up to a height of approx. 1 meter above the drainage layer,.

To avoid this layer of wet gypsum we have recently developed a system (patent pending), which creates an under pressure within the drainage system. In this way an additional dewatering of the stored gypsum to an even lower free moisture content can be achieved.

Some specific features of the Eurosilo®

The environmental requirements of today have increased the application of large capacity silos. The general advantages are:

- Protection of the bulk material from environmental influences and vice versa
- Minimal space utilization
- Maximum logistic flexibility
- Reclamation of very cohesive materials. (e.g.: FGD-Gypsum),
- Fully automatic operation, means minimal operating cost (no operators involved)!
- High technical standard, means minimal maintenance cost (Cost amounts approx. 1% per year of investment cost)!
- Easy accessible machinery (all moving parts above gypsum), means easy inspection and maintenance!
- High availability, means minimal down time (by-pass system possible)!

Protection of the bulk material from environmental influences and vice versa

Preventing possible contamination of surrounding land by runoff from outside stockpiles, or polluted drain water at the stockyard itself, are major arguments in favour of covered storage, and against open stockpiles. Covered storage also prevents deterioration of material due to weather conditions such as frost and rain. This is important in order to maintain quality standards, reduce maintenance cost and/or improve operations. Also saving of energy is possible if increased moisture need not to be removed.

Duration of storage

The duration of material storage is important when loading and reclaiming criteria are determined. Usually the costs of components spiral with increasing bulk flows. Clearly, high loading and reclaiming capacities should not be contemplated for long time storage facilities. The optimal storage capacity and the required infeed and outfeed rates are being determined by the logistics of each location.

However, in case of FGD-Gypsum storage silos equipped with a bottom discharge system (plow feeder) the facility is restricted to a maximum storage period of approx. 72 hrs. The Eurosilo® storage system can store the gypsum much longer than three months due to the fact that hang-ups of the material are eliminated.

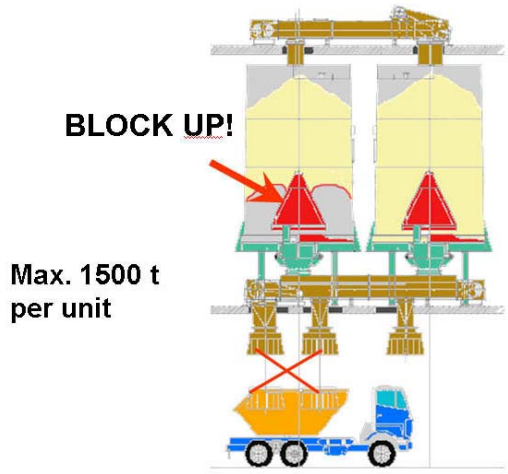

Fig 7. Block Ups occur frequently in bottom discharge silos

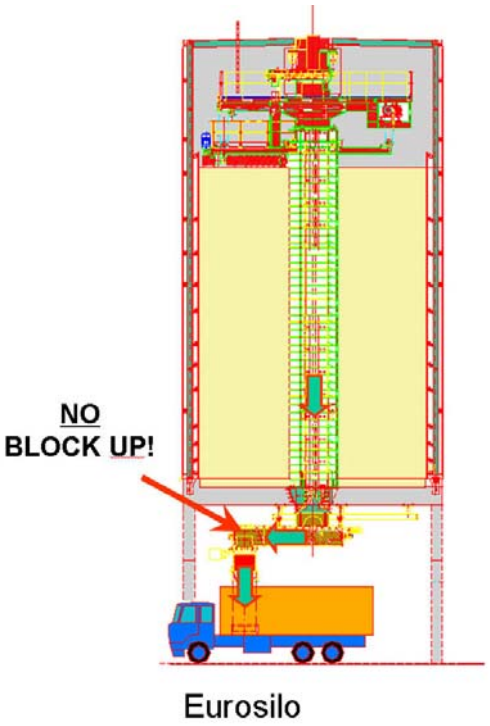

Fig. 8. Block ups do not occur in a Eurosilo®!

Maximum logistic flexibility

The reliability of gravity flow storage systems highly depends on the accuracy of the design parameters, the constant bulk material quality as well as on various other conditions. Mayor deviations from the design parameters often lead to failing gravity flow. Despite the use of automated control systems, constant bulk material qualities are difficult to maintain.

With the Eurosilo® system, the stored material can be changed at any time. Changing characteristics of the stored material does not affect the reclaim; this system offers true flexibility.

Minimal space utilization

Fig. 9 compares the storage capacity and space requirement for the Eurosilo vs. open stockpiles.

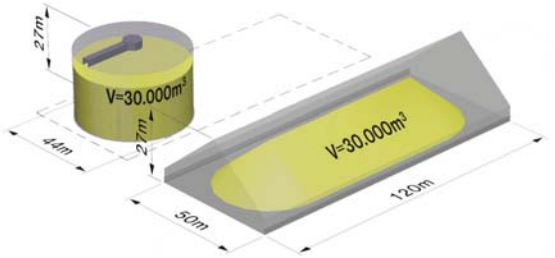

Fig. 9. Land Utilisation

The Eurosilo® system combines minimum space requirement with large storage capacities.

In many cases, existing coal fired power stations have to be equipped with FGD-installations. Very often however, there is not much space left for the installation of the FGD dewatering system. In such cases, extended silo structures are provided; and the entire dewatering installation is placed on top of the Eurosilo® system. With this system the savings are:

- Dewatering building area
- Transport of the dewatered FGD-Gypsum.

The FGD-Gypsum slurry is pumped directly to the dewatering installation on top of the silos.(See Fig. 1).

Financial analysis

Of utmost importance in any new venture is the need for an accurate, up to date assessment of costs and savings of the new system. Initial investment costs give only half the picture. The total cost of the investment must be taken over the expected life span of the project in order to get a true approximation of the total cost. Operating costs include not only the obvious costs such as interest, electrical power consumption, maintenance etc., but also hidden ones; such as the cost of product loss due to dusting, and quality loss due to moisture content.

The Eurosilo® concept has been compared to both open and closed stockpile storage with respect to investment and return. Considering the advantages and drawbacks of the various systems, a comparable initial price has only been available in a few cases. But the economical choice is shifting to the Eurosilo® system quickly, because of the increased need for environmental protection, homogenizing and drying functions, the requirement of transhipment without degradation, the avoidance of segregation, and the need for dust prevention. The aspect of land costs and space availability, especially in urban zones, can also have a great impact on the initial cost of a storage system. The biggest difference is the operating cost. (See Fig.10: Capital cost comparison).

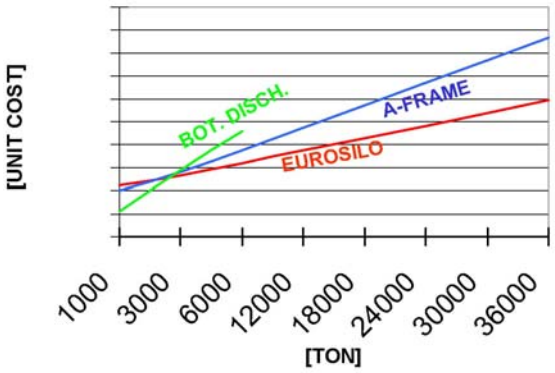

Fig. 10. Capital cost comparison

Installed Eurosilo Systems

In order to illustrate the clearly proven value of the Eurosilo system, the following data are stated. The first Eurosilo® for the storage of FGD-Gypsum came on line in 1982. Since then more than 50 systems have been delivered, ranging:

- Storage volume ranging 350-15,000 m^3
- Infeed capacities 15 – 400 tph
- Outfeed capacities 80- 750 tph

Noticeable examples of the high reliability of the Eurosilo® system are the FGD-Gypsum silos located at facilities, working around the clock, at the numerous power stations in Germany, The Netherlands, UK, Finland, Denmark, Japan, Poland, Singapore, Taiwan and China. For a complete reference list please check our website:

WWW.EUROSILO.COM

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