LOGISTICAL CRITERIONS AND STRATEGIES FOR STORAGE OF BULK MATERIALS

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Abstract: The aim of my paper is to analyze the applicability of criterions used for selection of storage methods of individual units and general logistic strategies for storage of bulk materials. To reach this aim paper gives an overview about the advanced storage methods of bulk materials and their application possibilities. The second part shows the main criterions and logistic strategies in deep and describes their usability for bulk materials.

Keywords: storage, bulk solids, logistical strategies, optimization

Numerous types of raw materials, elements and products used by industrial and commercial processes are bulk solids so can not be stored in the storage systems of individual units.
Bulk solids contain all of the materials which consist of huge quantity, small parts (generally inhomogeneous particle size and homogeneous material type) and can be transported, loaded and stored without packaging or loading units (sand, grains, screws, etc.).
Typical logistic solutions in generally do not deal with logistic tasks and problems of bulk materials because of the different characterization, so they are usually out of the effects of logistic optimizations.
Main aim of this paper is to uncover the specifications of the storage processes of bulk materials and examine the applicability of criterions used for selection of storage methods of individual units and general logistic strategies.

1. Storing specifications of bulk materials

At bulk materials homogenous handling properties can not be defined for the different material types, so the storing process of this materials significantly depends on the individual material properties, which can be sorted as

- inner properties (friction between particles, cohesion, adhesion, wall friction, angle of repose, etc.),
- outer properties (specific weight, moisture content, particle parameters, porosity, surface, homogeneity, etc.).

These parameters have common effects on the storing and discharging behaviour of the bulk materials which can be determined by

- the stresses arose in the bulk material,
- pressure state in the storing equipment.

Beyond these factors special technical solutions can help to modify this characterizations, for example pneumatic or mechanic discharge aid or vibration.

2. Advanced storage methods for bulk materials

In advanced industrial processes the selection of storage method for bulk materials mainly influenced by the quantity and the resistance against the environment of the material (Figure 1.). Cause of it that the aim of the users is to minimize the storing and preservation costs, so the following methods are the most diffused:

- storing of bulk solids in units,
- storing in silos,
- mobile storing equipment,
- open storing at ground floor,
- closed or semi-closed storing at ground floor,
- underground storing, etc.

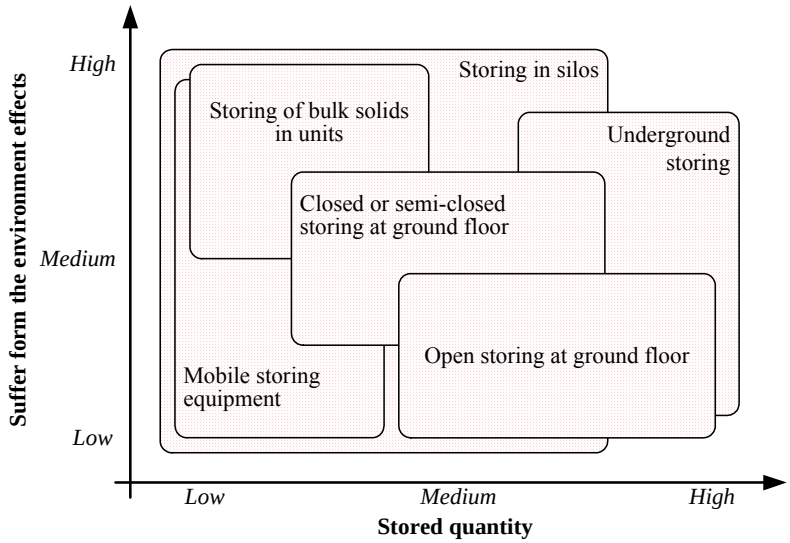

Figure 1. Applicability of storage methods for bulk solids

3.1. Storing of bulk solids in units

In special industrial processes handling of bulk materials is realized in given units (for example boxes, bags, etc.). Quantity of the units is depend on the material and the production or service process, and usually also fitted to the transportation requirements (for example supplying conditions, etc.). As the transportation method handles units so the storage method also has to be selected from storing methods of units (for example shelves). In advanced industrial processes storing of a bulk material in unit can be used if the material has low resistance against environmental effects and the process uses low quantities, or the storing process of the bulk material has to be fitted to the general storing process of other products and elements handled in units. Main advantages of this storage method are the easy handling and the better preservation, disadvantages are the additional costs and tasks (filling, emptying and purchasing of bags or boxes). The storing unit in this case can be boxes or bags in different sizes and smaller special containers.

3.2. Storing in silos

In the aspect of fitting the storing method for the advanced, automated production process the best solution is using storage silos. At storage silos bulk material is stored in a closed bin above the ground floor, filling process is realized by an outer materials handling machine (belt conveyor, etc.), discharging process is automatic, done by the gravity force. The dosing of the bulk material is controlled by a device based on the measuring of the volume or mass of the outflowing quantity. After measuring an other materials handling machine transport the material into the production process.
Application of silos is often in certain industrial processes (food-, chemical-, cement-industry, etc.), its advantages are the simple, automated discharging process and the better preservation. The main disadvantages are the additional filling device or equipment and the expensive structure.

3.3. Mobile storing equipment

In advanced automated logistic systems, if the location of up-loading or discharging points are changing during the process, mobile storing equipment can be applied. These devices are usually small silos which can be shifted along a rail. Main advantage of this solution is that using additional loading devices and transport channels are not required (belt conveyor, pipelines, etc.), so the main application field of it where traditional transport solutions can not be built. Typical example is filling railway cars on shipyards without moving the cars. Disadvantages of this storing equipment are the expensive structure and the huge moving mass.

3.4. Open storing at ground floor

The eldest traditional storing method for bulk solids is the open storing at ground floor. In this case storing is not require expensive structure, but a simple, flat surface is suitable. Application of this method is inevitable for storing coal, sand, ore, etc. which are used in huge quantities and not suffer from environmental effects. Against the minimal storing cost, disadvantage is the application of large, complex loading machines (baggers, excavators, etc.).

3.5. Closed or semi-closed storing at ground floor

An other solution for bulk materials at ground floor if we use closed or semi-closed buildings for storing. This alternative is a better solution for materials which have smaller resistance against environmental effects beside large stored quantities. Disadvantages of this variety are the installation cost of the building and the limited storing place. There are many varieties of the storage building, the advanced ones are made from light structures formed dome.

3.6. Underground storing

Also a traditional storing for bulk materials is the underground storage which has a new form in advanced logistic systems where applies special containers buried under the ground surface. Best property of this solution that it does not require space and objects on the surface area. Because of the environmental protection and preservation of the landscape there is a very important factor (for example: huge coal storage fields, etc.). Disadvantages of this method are the more complex loading (transporting) system and the expensive underground work.

3. Logistic tasks of bulk material storing

Main tasks of bulk material storing systems:

- up-loading (filling),
- bulk material storing,
- out-loading (emptying),
- dosing (measuring).

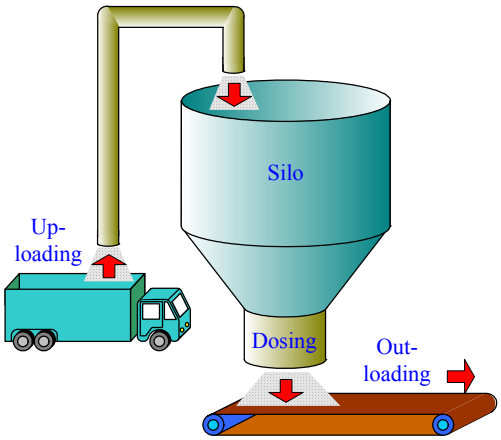

Figure 2. Complex process of the storing in silos

Task of **up-loading** is to load the bulk material transported by an outer device (lorry, railway car, ship, etc.) into the storage place. Equipment for in-loading (depend on the storage method) can be

- cranes for bulk materials,
- loading trucks for bulk materials,
- belt conveyors,
- pneumatic conveyors,
- self-loading vehicles, etc.

Aim of **bulk material storing** is to store, preserve and prepare materials for the technology process between the date of departure and the date of using.
Task of **out-loading** is to load the required (type and quantity) bulk material from the storing equipment into the technology process. Equipment for out-loading (depend on the storage method) can be

- forklifts (for units),
- pneumatic conveying,
- vibration discharging,
- gravity discharging, etc.

Task of **dosing** is to separate quantities of the bulk material required by the technology process and transfer it into the process. Dosing of the exact quantity can be realized based on

- measuring of volume,
- measuring of mass.

4. Applicability of storing aspects used for units for storing process of bulk materials

The most important selection criteriums for storing methods of units are

- fulfillment of the FIFO-principle,
- fulfillment of direct reaching of the materials,
- utilization and performance of the storing process,
- utilization and performance of the serving of storing processes.

4.1. Fulfillment of the FIFO-principle

During the storing process of bulk materials there are three possibilities to fulfill the FIFO-principle (FIFO – First in First out):

- at certain storage methods FIFO-principle can not be fulfilled, because of the storing characterizations, for example if we use open storing at ground floor the later loaded material levels cover the earlier ones (particular solution of this problem can be the partitioning of the storage area),
- at silos FIFO-principle is automatically fulfilled, because up-loading is realized at the top and out-loading at the bottom of the silo (except in dead-zones, if they occurred),
- at storing of bulk solids in units fulfillment of the FIFO-principle is depend on the applied storing method of units.

At certain application areas of bulk materials FIFO-principle has a significant role, for example in food industries (storing of grains, sugar, etc.).

4.2. Fulfillment of the direct reaching of the materials

Direct reaching of the materials in generally can not play too important role in the storing processes of bulk materials (except at storing of bulk solids in units). At storing in bulk form individually parts of the material can not be separated (except if we use separated storing regions). In silos only one kind of material can be stored at the same time so the direct reaching is simply fulfilled.

4.3. Utilization and performance of the storing process

Comparing the storing methods of the units and the bulk materials we can see that in the second case the space for storing is definitely determined. Maximum value of the storable quantity and the actual utilization can be simply calculated and depend on the stored quantity, the material parameters and the geometry of the storing surface or the silo.

4.4. Utilization and performance of the serving of storing processes

Serving (up-loading and out-loading) equipment of the storing methods for the bulk materials in generally are directly related to the storing process so sharing of these devices is usually not possible. Because of it design and dimensioning of the serving equipment is simple and during the calculation only one kind of storing process can be taken into consideration. In advanced storing systems serving of more than one storing points is practicable, but the moving of these huge machines is a complex task and requires high energy.

5. Applicability of advanced logistic strategies for storing of bulk materials

The control strategies of advanced logistic systems used for handling units have to appear during the storing processes of bulk materials, but their applicability and effects are less significant than in the storing processes of units.
One of the main advantages of JIT supplying is the reduction (or disappearing) of the raw material and element stocks. In the production processes using bulk materials validation of the JIT conception is very difficult, because of the huge quantity of the materials (transportation in lower quantities is not economic - for example the transportation in railway cars). Beside it the storage costs are usually less than at the storing of units so the reduction of the cost of the stocks is not so significant. An other side, production processes using bulk materials often require continuous technology process which demands also continuous supplying so the JIT conception is not usable. Where the production process requires only small amount of bulk material JIT conception can be applicable, but in this case, transport and storing of the bulk material are usually done in units.
The outsourcing of the storing processes of bulk materials is a real alternative, but because of the huge quantities for storing using of outer storages is so rare and this kind of possibility is also limited.
The outsourcing of the serving processes of bulk materials for storing is already an applied solution, but the optimization of this process in the aspect of logistics is not solved yet.
As the companies who use bulk materials are mainly raw material processing firms so the "Make or buy" concept is not so important.
Applying of outer distribution stores is appearing in chemical and food industrial processes, but their role are not too important so far.

6. Summary

According to the above mentioned facts it can be seen that only some of the selection criteria for storing methods of units and the control strategies of advanced logistic systems has considerable role in the bulk material storing systems. But avoiding of this possibilities can cause significant economic deficit (cost and competition) for the companies. Some of the factors has significant effects on the storing process but in many cases the application is not solved so far.
Beside it, it is worth to think about new logistic aspects, storing possibilities where the logistic strategies and selection parameters are better applicable.
Our research can not involve all of the development possibilities of the logistic system (we shown only the most important factors) so our future task is to cover more field of it and to go more deeply into the logistic strategies.
The main aim of this research is to create a new parameter system which can be applied to optimize the storing processes of bulk materials with high effectivity and define new aspects and strategies.

References

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