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Analysis and Management of a Grain Storage System

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ABSTRACT

Grain storage in Tunisia is a crucial process for food security. In fact, taking into account the need of grain consumption and production capacity, dependent of weather data that the fashion and cultural driving strategy, the storage process is a regulator between the supply and demand. In this paper, we present a system analysis and an identification of the parameters of grain storage (physical parameters, quality parameters, management parameters, economic parameters). This analysis is necessary because it allows us to contribute to the analysis, the monitoring and the management of grain silos.

Keywords: grain storage system, parameters of storage, monitoring, management.

1. INTRODUCTION

A storage system is a phenomenon of grain from a destination outside or local transit and called to be transported to a place of transformation, storage (transfer case) or consumption.

A grain storage system (Lakhoua, 2013a ; Khanchel & Ben Kahla, 2016) is characterized by health, hygiene and safety indicators that can be classified according to two categories (JORT, 2018): indicators of health, hygiene and safety inside the grain silo and indicators of health, hygiene and security outside the grain silo (See Figure 1).

Figure 1: Metal storage infrastructure of grain silo

An example of a grain silo in Tunisia is composed of cylindrical cells (See Figure 2) and square cells made of concrete (See Figure 3).

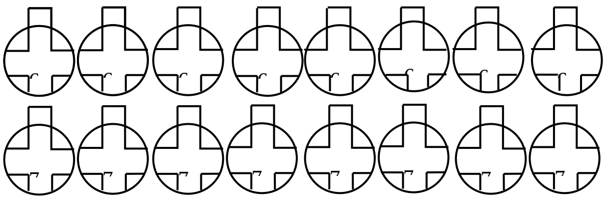

Figure 2: Cylindrical cells made of concrete in a grain silo

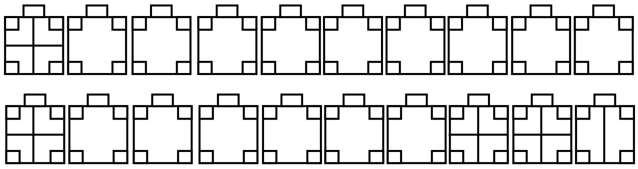

Figure 3: Square cells made of concrete in a grain silo

In a grain silo, the capacity of a cylindrical cell is 15000 quintals and the capacity of a square cell is 5000 quintals.

In addition to a simple storage, the role of the grain silo is to classify the grain, to weigh it, to clean it, to dry it, in short to prepare a certain type of grain according to the customer's request (Lakhoua, 2013b). The operator must respond to these different needs by defining a circuit to follow between an original cell and an arrival cell with the possible passage in treatment equipment (calibrator, rocker, dryer...).

By means of a significant example, the objective of this paper is to show interests of the use of the analysis and the management in grain storage system. The next section briefly describes the methods of the conservation of grain and the problems linked to its storage. In Section 3, we present the results of the identification of the different parameters of a grain silo in particular physical parameters. These parameters are the level of grains, the humidity of grains and silothermometry. The last section presents a conclusion of the analysis used.

2. METHODS

We can appreciate the ability to measures on stored grain storage: analysis or tests on samples (acidity or microbiological analysis); measure temperature (thermometer sensors); measurement of moisture of samples taken at the reception or in the transilage (Lakhoua & al., 2013). We can then refer to diagrams of conservation and we see immediately whether to intervene or not, how

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quickly and with what means (Lakhoua, 2018 ; Lakhoua & al., 2015) ; Lakhoua & Rahmouni, 2011).

During storage, the seeds may undergo different changes. These alterations can have different origins: biological origin (rodents, birds, insects...); microbiological origin (microorganisms); enzymatic origin; origin biochemical or chemical; mechanical (grain broken during handling). Several factors favour these various alterations (Paliwal & al., 1999 ; Majumdar & al., 2000):

- ✓ Time of storage: dominant factor, it determines the duration of the damage. So quickly treat grain after harvest.
- ✓ Water content: it affects the intensity of damage, especially if the grain is very wet. An increase in moisture from 1.5% multiplies by two the breathing of the grain.
- ✓ Temperature: 5°C increased double respiratory intensity. There is interest to lower the temperature of storage by ventilation. Insects do not breed below 18°C. Mold can develop based on interstitial humidity (to more than 70% of H.R).

Many researches are presented based on system analysis in order to contribute to the study of monitoring system and medical equipments (Lakhoua, 2011 ; Lakhoua & al., 2016).

3. RESULTS

Remember that a silo has for first task the storage of grain products. After the harvest, farmers come to deposit their cereals. Using elevators, the cereals are first mounted at the end of the grain silo (up to 50 meters in height) and then directed in a predefined way to the storage cells. The grain is directed through pipes by simple gravity. Horizontal conveyors placed above the storage cells take care of routing the grain towards them.

We have identified four categories of operation of grain storage parameters:

- ✓ Physical parameters: mass of cereals, temperature, residence time, time of grain, flow of grain, level of grain in storage cells, electric energy consumption.
- ✓ Quality parameters: specific weight, impurity rate, moisture.
- ✓ Management parameters: reception of grain, grain shipping program, program operations of the grain silo, cutting of cereals, security, environment, infrastructure, maintenance.
- ✓ Economic parameters: operating cost of the grain silo, cost of demurrage, cost of freight and other cost of transfer to the silos of folds, price of the quantity sold to millers, purchase cost of the imported quantity, depreciation.

Many researches are presented for the classification of grains by optimal features and intelligent classifiers (Visen & al., 2004 ; Choudhary & al., 2008 ; Douik & Abdellaoui, 2010).

In this part, we present a study of different physical parameters in a grain silo (level, humidity and silothermometry).

3.1. Level of grains

The pallets probe is a max and min level indicator. It installs the device outside the silo. The tree and the pallet pass through the wall of the container to be in contact with the stored material. An electric motor operates a range running freely in the absence of matter. The rotation of the shaft is controlled continuously continuously (Zhan & al., 2018 ; Yigit & al., 2018).

The continuous level probe is an indicator of level max and min (See Figure 4). It's a sensor for continuous level, equipped with a cable or a rod of measure. Short radar pulses are moving along cable or a rod. In contact with the surface of the product these waves are reflected to the sensor. A signal processing system analyzes the time of propagation of the wave and delivers a signal proportional to the level.

Figure 4: Continuous level probe

3.2. Humidity of grains (moisture meter)

On the rate of moisture of the product, it should be noted in general that this is the setting trigger the fermentation which led to a rise in temperature which usually tops out at 60-70 °C.

The comparison of the size of the storage to the critical size is only valid to set humidity and does therefore not degraded operating situations (entry of moisture in the cell) or during/accidental sequences (Chi & al., 2017 ; Karoui & al., 2011). In these conditions and if the storage size exceeds the critical size for this level of humidity and the product under consideration, the warm-up can lead by chemical oxidation (generated by the presence of oxygen) to self-ignition therefore none phase change (melting, evaporation) hinders this process (See Figure 5).

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Figure 5: Humidity probe

3.3. Silothermometry

Silothermometry is the set of techniques for measuring and monitoring temperatures inside the grain silo using well-placed sensors in the cell. It is usually associated with the ventilation system in a modern grain silo. The thermometric probe is a temperature sensor installed inside the grain silo (See Figure 6).

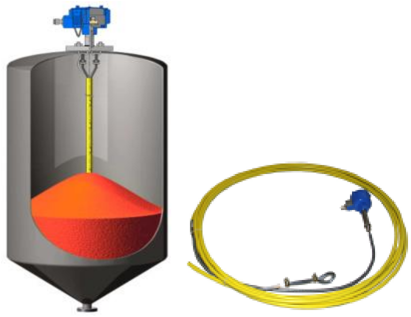

Figure 6: Thermometric probe

The fixed silothermometry consists of probes fixed in the superstructures of the grain silo. These probes withstand very high vertical forces during the emptying of cells, their attachment points must be widely dimensioned, which makes them generally incompatible with flat-bottomed boxes whose frames are not designed to support such loads (Denis & al., 2013 ; Hamdani & al., 2018).

The role of silothermometry in a grain silo is twofold:

- Safety role for both the stock and the plant itself, the silothermometry allows the detection of abnormal heating in the grain silo.
- Essential role for a rational management of ventilation in fact the silothermometry is a decision tool for triggering ventilation.

4. CONCLUSION

In order to manage the activities of grain storage, we identified in this paper the different parameters of a grain silo in particular physical parameters. These parameters are the level of grains, the humidity of grains and silothermometry.

Of the fact that the environment of a grain storage system is an important component on both strategic and operational analysis and management of a grain storage silo, it is therefore necessary to solve the problems caused by nuisance factors: dust, noise, vibration, ventilation, lighting... and this by implementing systems dust collection allowing eradication more effective particulate matter with grains, reducing the impact of noise and vibration, and by improving the conditions of aeration indicatively.

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