BROWN SUGAR BAGGING AND STORAGE: NEW ADVANCES IN TECHNOLOGY

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Abstract

The bagging, storage and loading of sugar has traditionally been a labour intensive and time consuming operation. A new sugar bagging station and warehouse has been built at Simunye Swaziland, by the Swaziland Sugar Association to improve productivity in this regard. As a result of this experience, similar technology is now being incorporated in sugar stores elsewhere in the world.

This new facility incorporates advances in bagging and storage technology. It can pack up to 70 tons of sugar an hour and store up to 40 000 tons of bagged sugar under cover. Fast stacking and destacking techniques are used involving overhead cranes and slingbags. The store was built to bag and store 25 kg, 50 kg and one ton production. The new loading arrangements allow a 34 ton truck to be loaded within 30 minutes compared with previous methods of loading of up to six hours. The store employs 20 people per shift and the system around the bagging machines is automatically controlled from a centralized control room using SCADA software.

It is also possible to load bulk tankers from concrete silos. Each silo holds 550 tons of sugar. Loading is done by means of a clam gate and takes place in a fast and effortless manner. The store has now been operating for a year and is achieving production and storage capacities in excess of the original design parameters.

Keywords: raw sugar; bagged sugar; bagging; storage; warehousing

Introduction

South Africa has always been acknowledged as a world leader in Sugar Engineering and Technology. However, with respect to sugar storage and bagging, the sugar industry has lagged behind the advances made in other similar industries.

In the last 20 years, there has been a trend to pack and/or refine sugar for the local market at the sugar mill where the sugar is made. This would then make use of the free power available at the mill through the burning of bagasse.

Bagging stations and warehouses that have been built to cater for this requirement have been very simple in design and labour intensive, very often growing in a haphazard fashion. Bagging stations have typically been equipped with bagging machines and a few bagged sugar conveyors to assist with mechanised handling.

In addition to this, stock has been stacked in the warehouses manually using human chains from the floor up the side of a sugar bag pyramid sometimes as high as 20 m. The loading of road transport has also been done by hand and it would take up to six hours to load one 30 ton truck.

The system installed at Simunye has been a major departure from these traditional methods.
Objectives of the new Simunye installation

In 1998 a project was conceived by the Swaziland Sugar Association to build a new mechanised bagging station and bagged sugar warehouse at Simunye Swaziland. This project was approved in November 1999 and the design team appointed in January 2000.

The store was to be designed to achieve the following objectives:

1. Sugar was to be bagged direct from production, untouched by hand.
2. The buffer storage to the bagging station was to be a minimum of 2 000 tons in four silos of 500 tons each.
3. The system was to provide for rapid bulk loading of road sugar tankers from clamgates below the silos.
4. The bagging plant was to be capable of 70 tons/hour in 1 ton, 50 kg or 25 kg bags.
5. Sugar from any silo was to be bagged by any bagging machine.
6. The plant was to process raw sugar and higher grade (VHP) sugar.
7. The warehouse was to store a minimum of 36 000 tons. Stacking and destacking was to be mechanised.
8. The loading of 34 ton flatbed trucks was to be fast, particularly with 50 and 25 kg bags.
9. Customers were to have the option of receiving sugar in one of the following forms:
   a. Sling bags.
   b. Stretchwrapped, palletless loads.
   c. Individual bags.
   d. Palletised, stretchwrapped loads.
10. Cost effective mechanisation and automation was to be employed thereby reducing the labour compliment.
11. Reduced dependence on forklifts.
12. The store was to be ventilated in such a way that it would be kept cool with no air or dirt entering from the roof ventilators. The store was also to be made bird and vermin proof.
13. Increased security.

Overview of system used at Simunye

Figure 1 is a flow diagram of the system installed at Simunye in Swaziland. There are a number of subsystems shown on this flowsheet:

a. Bulk sugar conveying system.
b. Bulk sugar storage system.
c. Bagging machines.
d. Bagged sugar conveying system.
e. Bagged sugar storage system.
f. Bagged sugar dispatch system.

Most of the bulk sugar system existed before the new bagging station and warehouse was built. The new store began with the extension of the existing belt onto the top of the 500 ton silos.

The system was designed for a milling capacity of 500 tons cane/hour. This allows for future expansion requirements. The mill presently runs at 375 tons/hour and makes 45 tons sugar/hour.
Figure 1 Flow Diagram

Figure 1a. The brown sugar bagging and storage building.

Features incorporated in the new building

Figure 2 shows a plan and elevation of the new store building erected at Simunye, Swaziland.
Figure 2 Building plan and elevations

Warehouse floor
The floor of the warehouse is concrete capable of withstanding the movement of heavy vehicles as well as the mass of stockpiled sugar. The floor was built to 1:125 falls from the centre spine of the building to the perimeter wall. This was to assist with cleaning and wash down of the store.

In the bagging station area, the floor was coated with an epoxy paint. This was applied to protect the concrete from sugar attack.

Ventilation and dust control
The building has been designed to prevent dust and dirt from entering the building via the ventilation system. This has been achieved with the use of natural turbine ventilators which allow only hot air from inside the building to be expelled through the roof. The number of ventilators is increased over the bagging station area to improve airflow where most people work.

Most other sugar stores adjacent to sugar mills have a lot of airborne dust and debris from the mill boilers settling onto the bagged sugar.

For the same reason, openings at the eaves or where the side cladding meets the dwarf wall on the perimeter are closed.

Vehicle and personnel access
All access to this building is provided by roller shutter doors in the south-east corner of the structure. This point also provides direct access to the bagging station and offices for the stores management. This limited access to the building assists in keeping the store secure.
**Rainwater management**
This system has been designed with the environment in mind. The building has a large roof space (14 500 m²) and consequently, special attention was given to controlling rainwater. No Gutters were used at the eaves. Rainwater falls from the bullnose at the eaves to large open gutters at the base of the perimeter wall.

The rainwater is then diverted from the building through a network of drains to natural river courses, thus protecting the environment against erosion.

![Figure 2a. Interior view of the warehouse.](image)

**Operation of the system**

*Sugar silos*
Sugar entering the new store from the mill, is stored in one of four cylindrical concrete silos. Figure 3 shows a layout and elevations of these silos and the attendant bulk conveyor system. Four silos were built so that two grades of sugar could be stored. These silos were built off the ground so that 20 ton sugar tankers could drive underneath them and load from pneumatically operated clam gates if required.

Each silo is capable of holding up to 600 tons of sugar although 500 tons was required by the client.

The silos were built using concrete as this material has better insulating properties to help prevent moisture migration through the sugar. Level indication is provided by radar sensors which can give an accurate measurement even in the presence of dust.
Figure 3.

Figure 3a. Roadway beneath the silos.
**Bulk sugar system after the silos**

Figure 3 also illustrates how sugar leaves the silos and arrives at one of the four bagging machines. It was a requirement that sugar from any one of the silos would be capable of feeding any one of the bagging machines. This was achieved by a network of screw conveyors and elevators.

Sugar enters the first screw conveyor from a sliding gate placed on the underside of the silo. There is one screw conveyor per silo and each one has a variable speed inverter drive so that the amount of sugar released can be metered to the packing station.

The whole system is closed to ensure that dust is contained. Explosion panels have been provided in strategic positions to relieve any pressure that could result from a dust explosion.

The sugar enters one of four hoppers situated above the bagging machines. Feed to these hoppers is automatically controlled using butterfly valves and sensors on the hoppers themselves. Prior to reaching the hoppers, the sugar passes through rotary screens to remove lumps. Sugar also passes over a magnet to remove any extraneous material.

If the hopper sensors record that all hoppers are full then the whole system shuts down automatically and starts up again when one of the hoppers indicates that it is almost empty.

Unlike similar sugar bagging plants elsewhere in the sugar industry, no attendance is required to this system.

**Bagging machines**

Four bagging machines have been installed in this system. There are two 50 kg bagging machines complete with sewing machines. These are manually operated and are conventional in design. Two one ton bagging machines have also been installed. All four machines use loadcell technology.

The one ton bagging machines are capable of producing up to 30 bags/hour/machine whilst the 50 kg machines run at up to 5 bags/minute or 15 tons/hour.

These machines are not automated and require labour for bag placing, sewing and heat sealing. There are two operators per packing machine station on both one ton and 50 kg bagging lines.

**Figure 3b. Bagging station.**
**Bagged sugar conveyor system**

This is where some major changes to standard procedures in the sugar industry have been made. Figure 4 shows a plan view of the system installed.

![Diagram of the bagged sugar conveyor system](image)

**Figure 4.**

This whole system is automatically controlled from a central control room in an elevated position. Situated below the control room are the electrical panels and computer hardware. This system consequently uses very little labour.

The bagged sugar conveyor system can be divided into five specific areas as follows:

- **50/25 kg bagged sugar conveyor system**

  This system removes bags from 50 kg machines and transports them to a palletising area indicated in Figure 4. There is one conveyor system per 50 kg machine. Bags are filled on the machine and then sewn with the bags standing upright. They then pass onto a narrow belt conveyor being held upright by guides until they reach a transfer point where kickers have been installed. The kickers are pneumatically operated and kick the bottom of the bag out onto the next conveyor once the bag has been properly positioned by the preceding conveyor. This conveyor moves the bag, now in a horizontal position to a bend and palletising point. There are three conveyors at the palletising points each one acting as an accumulating conveyor to allow for peaks in the supply of bags and the change of pallets at the palletising point. All this is controlled automatically by the PLC using photocells and proximity switches where required.
Figure 4a. 50 kg palletising system.

- **50 kg pallet conveyor system**
  Once the bags have arrived at the palletising point an operator using a vacuum lift, lifts the bag off the conveyor and onto a pallet next to him. This pallet has a polywoven sling bag on it with straps spread out. The pallet station is situated on load cells so that the operator can see when the pallet is fully palletised. The conveyor system will only release the pallet from this place when the correct weight has been recorded. The pallet is loaded to 1.25 tons of product at which point the pallet is released and replaced. The pallet transfers onto a pallet waiting station to await the arrival of a shuttle car. The shuttle car then transfers the pallet to a stretchwrap machine where the pallet can either be stretchwrapped or not. Thereafter it passes to another shuttle car and pallet waiting station to await the arrival of the main shuttlecar in the system SC1 (see figure 4).

- **Automatic palletisation**
  This was considered in the initial design of this system but it was decided not to automate but to mechanically assist palletising as:
  a. The plant was designed to work 16 hours/day.
  b. Throughputs were not high enough.

Auto-palletising in this instance did not prove cost effective.

- **1 ton bagging system**
  This system removes 1 ton bags on pallets from the machines and transfers them to the main shuttle car SC1. Once the bags have left the machines, the bag liner is heat sealed closed and tied off to be made ready for lifting by overhead crane. Two palletised 1 ton bags are placed on shuttle car SC4 which acts as the waiting station for SC1.

- **Pallet conveyor to warehouse**
  The system has been designed to allow for maximum flexibility of product storage in the warehouse. The warehouse is in two sections and the use of the shuttle car SC1 allows product from any source to be stored in any part of the warehouse. The system has the shuttle car SC1 feeding gravity conveyors which act as accumulation conveyors for the palletised sugar. These are also shown in Figure 4 The gravity conveyors are arranged so that pallets are separated by pneumatically operated lifting rollers. These rollers are controlled by photocells which determine where the pallets are on the conveyor. Once in position the bags are lifted off, either by overhead crane or by forklift and taken into stock. In the case of 50 kg bags, the loops are tied off at this point so that the crane can lift the whole slingbag and take it into stock. The pallets are then removed and placed in an empty pallet store for reuse later.
• Empty pallet conveyor system

Empty pallets are supplied automatically from a pallet magazine to each one ton bagging machine and also to each palletising point for 50 kg bags. The pallet magazine is fed with stacks of pallets 10 high. They are automatically dispensed into the system which has accumulation on it prior to the palletising points. Accumulation for the one ton bags is situated on chain conveyor PC3 and PC2, whilst accumulation for 50 kg palletising area is on shuttle car SC3 and roller conveyors PR2, 3, 4 (see figure 4). This system works automatically.

Plant automation

The whole conveyor system including the bulk sugar conveyors and the conveyors downstream of the bagging machines is controlled automatically by a PLC and SCADA system. This means that
there is very little labour required in handling of bagged and bulk sugar. The centralised control room is operated by one person who can reach any problem area very quickly. The MCC and PLC immediately below the control room means that cabling to sensors and motors in the field have short runs.

**Warehouse storage system and capacity**

Figure 2 shows an illustration of the storage area in the warehouse. Although the flowsheet indicated a capacity of 36,000 tons, the actual capacity is 40,000 tons.

Product either in one ton bags or 1.25 ton slingbags is lifted off the gravity conveyors at the bagging station by high speed overhead cranes. The cranes stack the bags in pyramid form up to 10 levels high and interlocked to assist with stability. This is a new departure from existing methods of stacking which has been achieved by hand up to now.

When sugar is dispatched it is removed from the pile using the overhead system again and is placed directly on waiting flatbed vehicles. There is also a facility to remove the slingbags from the 50 kg bags by inverting the load in a pallet inverter.

![Warehouse storage system](image)

**Figure 4d. Storage/retrieval of 50 kg bags.**

**Road system and weigh bridge**

Figure 5 shows a plan view of the road system installed at Simunye for the handling of sugar from the bulk facilities and the packed sugar warehouse. Vehicles arriving at the gate before the weighbridge await their turn to mount the weighbridge. Once the truck has been weighed in empty, it proceeds via the road network either for, bulkloading in the new store under the silos or loading of bagged sugar. Once the flatbed 30 ton trucks arrive in the store they park below the crane gantry and are loaded with product within ½ hour. They then return to the weighbridge for weighing of the loaded truck and the net weight is recorded.
In other warehouses it will take up to six hours to load a truck manually. The bulk loading of trucks can also be loaded within \( \frac{1}{2} \) hour using the pneumatically operated clamgates below the silos.

**Figure 5**

**Figure 5a.** 30 ton interlink transport at the weighbridge.
Labour requirement

This whole bagging station and warehouse operates with 20 people per shift which is a marked reduction from other sugar bagging and warehousing systems.

Conclusion

This bagging station and warehousing system has been operating since April 2001, and has achieved all its design requirements. The 50 kg bagging, in particular, has been an unexpected success. Demand for this product has increased rapidly due to the fact that it has been the first time clean raw sugar has been available in 50 kg bags and is fit for human consumption. This facility cost R34m to build and took 16 months to complete.

Figure 6. General view of 50 kg sling bags in store