Computer controlled receiving and discharge weighing system for grain

by Walter Vordermark

The quantities of materials entering and leaving a feed and milling plant must be measured by weighing devices which are subject to official calibration. The subsequent interruptions caused by this procedure should be kept as short as possible, so that weighing and batching have the minimum influence on the continuous flow of materials. Optimum results are obtained when the load cells and the associated intelligent electronic weighing system are combined with electro-pneumatically controlled weigher containers. This gives high performance weighing systems which come very close to the ideal, fully continuous throughput of material. The application of electronic systems leads to substantial simplification of the mechanical system components. The article describes the implementation of this type of system and deals with the weigher control and data processing. The described system design results in significant rationalization in, for example, warehouses and milling plants.

Introduction

The activities in a feed and milling plant are determined by continuous receiving, mixing, batching and discharge of products such as for example, grain, flour and animal feed. Various ingredients are batched and mixed in defined proportions. To conform to the laws on weights and measures all products must be checked and weighed during processing. The ideal situation would be if the product could be arranged to flow continuously from a ship or a silo transport vehicle into the intended storage silos. From here, the products would be handled by screw-conveyors, vane-wheel feeders, etc., again with defined percentages or weight proportions to give new products or mixtures.

The weights and measures regulations require the weighing of all incoming and outgoing quantities. This means that all goods must be routed via weighing equipment subject to official approval. lt is only the calibrated batching and mixing of ingredients that guarantees a constant quality level in the mixed, final products. The flow of the product, which in the ideal situation would be continuous, must be interrupted for weighing and routed via a weighing machine. Here, it is important to keep the period of interruption as short as possible and to carry out the calibrated weighing and batching quickly. This is implemented by mechanically operated, electro-pneumatically controlled weigher containers which form approved, high performance weighing systems when combined with load cells and an intelligent, electronic weighing system. These systems very closely approach the throughput of the ideal situation.

The flow chart in Fig. 1 shows an example of a receiving, mixing, batching and discharge system in a mixed-feed plant. lt provides an overview and guide for the following article. This schematic can also used on an illuminated control panel for the supervision of all operational processes or as graphics on a computer monitor to give a visual interpretation.

Origins

The history of the weighing system described here began in 1982 with the registration of a utility patent for an automatic discharge weighing machine. The patent described a weighing container with an automatic mechanical shut-off system which was supplied for receiving and discharging bulk goods such as grain. The container had already been supplied in 1981 by a weighing machine manufacturer to a customer. The patent described as its claim an automatic discharge weighing machine with a discharge container, compressed-air operated entry flaps with a coarse/fine controller and discharge flaps at the bottom also operated by compressed air. This was all controlled by the weighing indicator through non-contacting limit switches. A throughput of 80 t per hour was achieved with a container volume of 420 liters.

A significant simplification of the mechanical construction was possible by converting the weighing machines and fitting them with load cells and an intelligent electronic weighing system. At the same time, new opportunities arose for automating the process, leading to significant increases in the performance of milling, storage and mixed-feed operations.

Simplification of the mechanical design

The main advantage in the use of load cells was quite clearly the initial effect on the mechanical design of the weighing machine and its manufacture. A large proportion of the mechanical levers and joints became redundant, saving considerable complication in manufacture and fitting. This led in turn to a substantial reduction in assembly and service costs, since the mechanical parts often had to be replaced and adapted on site.

The illustrations in **Figs. 2 and 3** clearly show the differences in design. The photograph in **Figure 2** shows the functional principle of the beam-type bulk weigher with its complicated mechanism of levers, knife-edges and cups.

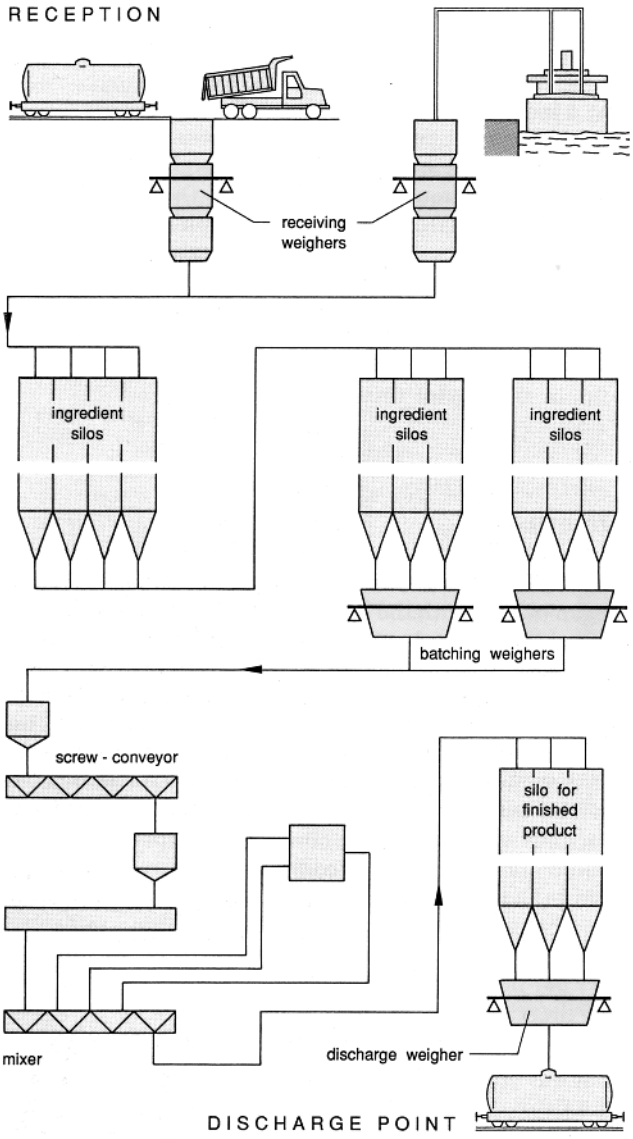

Fig. 1: Flow chart of a receiving, mixing, batching and loading facility at a mixed feed plant with modern weighing equipment in the product line.

The fast and accurate receiving and loading system described here incorporating a number of networked weighers is just one example which highlights the coarse and fine flow optimization. With the aid of this intelligent optimizing function, the microcomputer in the SW 9002 switches the turn-off point for the coarse flow so that the filling and discharge processes take place with priority given to the coarse flow. In this way short filling and discharge times are achieved, not only for the weighing containers, but also for the transport vehicles and silos that are loaded or discharged. Similarly, these methods ensure the optimization of the milling and mixing processes. The system processes large quantities of the product.

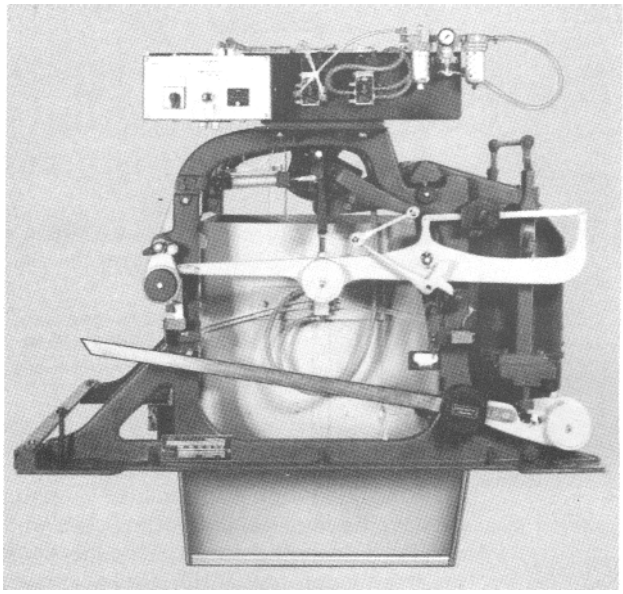

Fig. 2: Photograph of the beam-type bulk weigher with the complicated mechanical system consisting of levers, knife-edges and cups.

With regard to the guaranteed filling accuracy, the minimum fine flow of the product should not fall below a certain minimum. After the end of the filling and discharge process and with the weigher in a steady state, the electronic weighing unit measures the relevant actual weight and compares it with the pre-selected set weight. If there is a deviation, the point of changeover from coarse to fine flow for the next weighing is corrected so that the error reduces and the weighing process becomes more accurate. For the operator, this has the advantage that changing product characteristics, such as for example, the flow properties or the grain size do not mean complicated adjustment to the weigher. The microcomputer in the SW 9002 Electronic Weighing Unit takes care of all that.

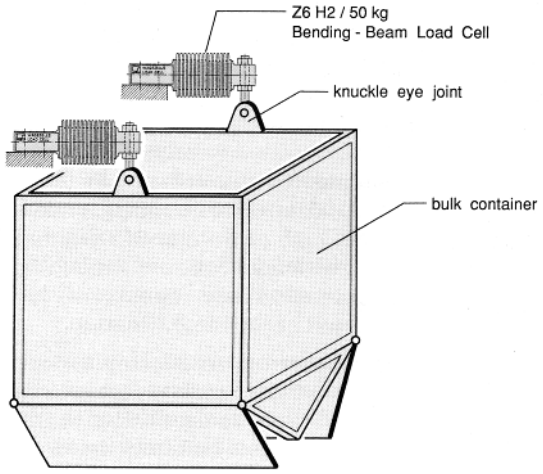

Fig. 3: Weigher container design using electrical load cells.

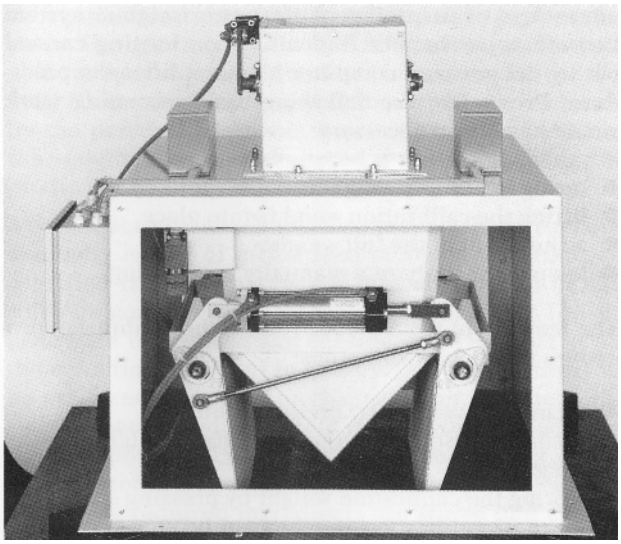

Fig. 4: Showing the weigher unencumbered by the mechanical system which has been made redundant by the application of type Z6H2 Bending-Beam Load Cells.

The design of a container weigher with electrical load cells is shown in **Fig. 3**. Here, all moving mechanical parts are discarded and the container is only suspended from two bending-beam load cells. This meant that the introduction of the load cells also led to a new design of container with completely vertical, self-cleaning side panels, double bottom flaps with four ball-bearings in welded stainless steel and fitted with rubber seals.

The photograph in **Fig. 4** gives an impression of the weigher which is now unencumbered by the mechanical system made redundant by the application of bending load cells of the type Z6H/50 kg. The load cells are located under protective covers which guard against mechanical impact and prevent the ingress of dust into the bellows of the load cells. This reliably prevents force shunt effects which could lead to weighing errors and faults in operation. The mounting arrangement of the load cells in the weigher is shown in **Fig. 5** with the protective cap removed.

Test device for predicting performance

After the conversion of the formerly pure mechanical weigher into an electronic weigher with electropneumatically controlled discharge, a performance test was carried out using the SW 9002 Electronic Weighing Unit before the weigher was delivered to the customer. A facility which could be used as a test system was available. Here, test weighings could be carried out with actual products such as grain, powders or pellets. With this facility realistic predictions could be made on the discharge performance of machines taking into consideration the flow characteristics of the particular product.

Intelligent electronic weighing unit

The SW 9002 Electronic Weighing Unit includes a 225 Hz carrier frequency amplifier with high resolution and stability [2]. **Figure 6** shows the design of the electronic weighing unit which is capable of operation in harsh environments. Originally, this system was developed for the weighing and control of bagging processes on rotary packers. The electronic circuit is accommodated in a steel housing which protects it from dust and splashed water. When the cover is opened and the printed circuit board folded back all the parts of the circuit become easily accessible for servicing. Experience has shown that servicing is seldom required once installation and adjustment have been completed.

All the balancing, adjustment and matching to a particular weighing application can be carried out by entering parameters via the buttons on the front panel. The inte-

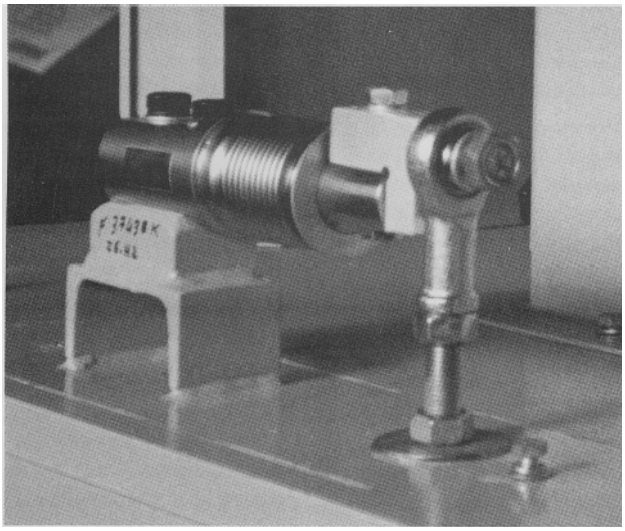

Fig. 5: Arrangement of the load cell on the weigher. The protective cap on the load cell has been removed.

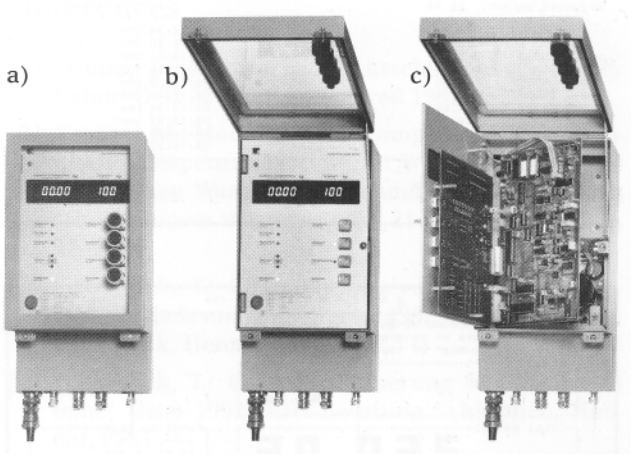

Fig. 6: The construction of the SW 9002 Electronic Weighing Unit has been designed for harsh environments:
a) ready for operation
b) with opened protective window
c) hinged PCB enables easy servicing.

gral microcomputer uses these parameters to adapt the unit to the application. The installer of the weighing equipment is therefore not confronted with the setting of potentiometers and balancing switches or with the soldering of resistors on PCBs. All these functions are comprehensively described in [2].

As examples of completely different characteristics, damp rye from a rainy harvest period which did not flow very well and coarse-grained, dry maize with very good flow characteristics were compared. For both products only the filling weight was selected and the optimization was dealt with by the microcomputer. For remote control and for the networking of a number of weighers the SW 9002 has a data interface which is electrically isolated through optocouplers.

Carrying out calibration

In line with national regulations, the receiving and discharge processes for the commercial products mentioned in this article are subject to calibration. All the components of the weighers described here need the appropriate approval. German approvals are granted by the approvals board, the Physikalisch Technische Bundesanstalt (PTB). Other countries have their own calibration authorities. Submission of the approvals for the weigher container, load cells and the electronic weighing system is required to obtain acceptance of the weighers. During the acceptance of the complete weighing system on site, the accuracy must be verified in the presence of a weights and measures official. Here, the

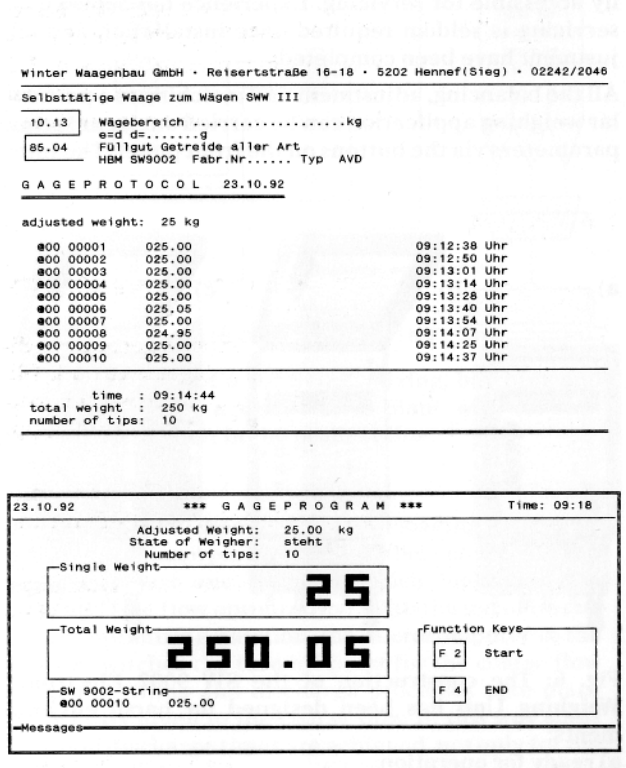

Fig. 7: Calibration log for the receiving weigher produced on a PC.

advantages of an intelligent electronic weighing system become apparent, but the calibration logging carried out by the personal computer also simplifies the procedure. Previously, the following time-consuming work would have been necessary:

- taring the empty weigher,
- lifting the calibration weights into place,
- adjustment of the full weigher,
- keeping an elaborate manually entered log.

The features of the SW 9002 reduce the calibration procedure to the following steps:

- taring the weigher by pressing a button,
- lifting or suspending the calibration weights on the weigher,
- storing the calibration weight by pressing a button,
- up to 32 calibration weights can be stored consecutively.

Then a specified number of fillings and discharges or pouring processes are carried out. The weighing data is entered into the calibration log by the calibration program and then printed out for documentation purposes. This document is then stamped, i.e. it becomes a certificate indicating that the user can maintain the accuracy values and keep within the permissible deviations specified by the regulations. In other words it is a certificate regarding the correctness of the weighing. **Figure 7** shows a calibration log for the weigher produced on a personal computer.

Weigher control and the processing of weighing data

As illustrated in the flow chart in **Fig. 1**, a total of five weighers of the same type, but applied to different tasks, are connected to a programmable logic controller and to a personal computer. The delivered grain is fed and weighed to the appropriate ingredient silos and held ready for further processing.

To make the mixed feed the products are passed to a mixer from the silos via a batching weigher. From there they are transported from storage silos via transfer and loading weighers to the end-user, dealer, etc.

Previously, all these sequences were manually controlled and supervised. The system described here enables a largely automated system to be employed in which the operating personal only need to intervene via the computer keyboard, observing the process on the computer monitor. The separate processes, which previously required manual intervention at each operating point, are monitored by personal computer using two different computer programs and controlled with the aid of a PLC. For the handling of the milled products, the software computer control provides management and storage of all the master data for the receiving and discharge weighers. This might include the customer, supplier number, address, product specifications and quantities of the supplied product.

Each discharge automatically carried out by one of the receiving or discharge weighers in conformance to the

calibration laws is monitored and recorded by the computer. The relevant total weight is found and made available for further processing. The parameters for the SW 9002 Electronic Weighing Unit described above are set by the personal computer, i.e. they are preselected in the weighing range and altered if there is a change of product or quantity.

Another activity which was also previously carried out manually is that of mixed feed produced according to specified recipes. This task is now undertaken by the software computer control for batching systems [4]. No errors are introduced and consideration is taken of all the conditions relevant to quality. The total quantity to be produced is entered on the computer together with the percentage proportions of the separate ingredients. The computer calculates the separate weights necessary to produce this quantity, finds the places or silos where the required ingredients are stored and checks whether they are available in sufficient quantities so that the orders can be processed on time and to the required quality demands.

Then all the ingredients are passed via a batching weigher to a mixer. From here they go on to a temporary storage silo for the finished product or are bagged or discharged into transport. Since products with different product data such as relative density, humidity content and grain size are passed consecutively via the same weigher during these mixing processes, the intelligent characteristics of the SW 9002 are fully exploited. The

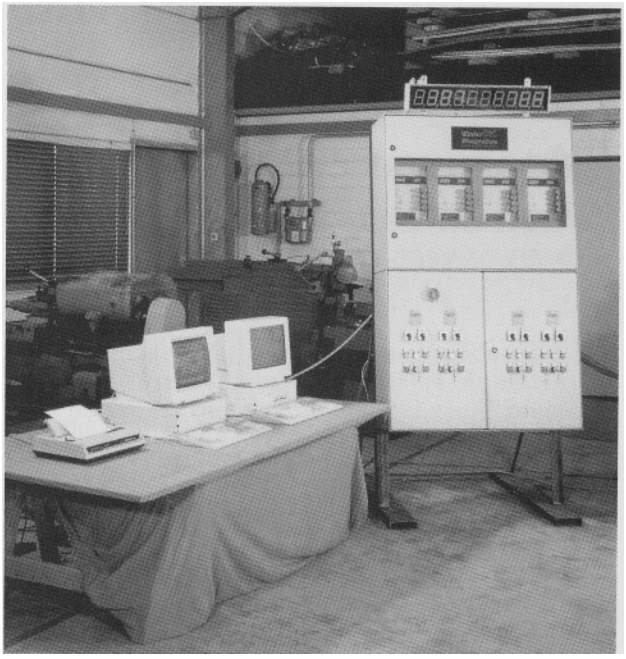

Fig. 9: The system during works trials with the PC for weigher control and evaluation of operational statistics as well as the production of delivery notes and invoices.

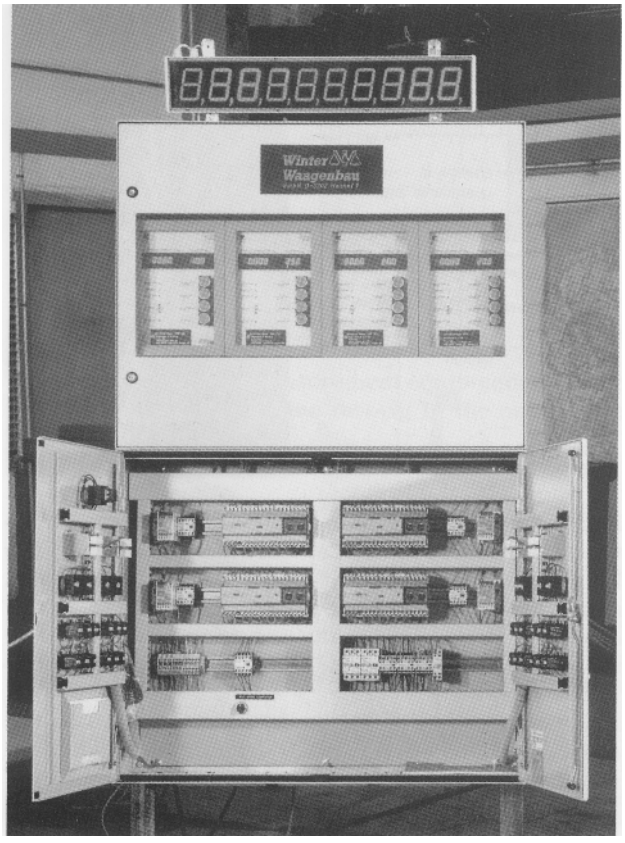

Fig. 8: Open control cabinet for a mixed feed plant: the SW 9002 Electronic Weighing Units installed for the receiving, batching and discharge weighers can be seen in the upper section.

batching weigher automatically optimizes itself when the product data changes and ensures accurate weighing of the separate ingredients. This is very important for the manufacture of quality mixed feed. The photograph in **Fig. 8** shows the open control cabinet for a mixed feed facility. The upper section contains the four SW 9002 Electronic Weighing Units built in for the receiving, batching and discharge weighers. **Figure 9** illustrates the arrangement during factory trials with the PC for weigher control and evaluation such as operational statistics and production of delivery notes and invoices.

References

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