Continuous Belt Weighers

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Kontinuierliche Bandwaagen
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Vásculas de correa de pesaje continuo
連続ベルト秤量器
连续带称重器
الموازين بالسير التي تعمل بصورة مستمرة

Summary

This paper gives a general introduction to the subject of continuous belt weighing and non-contact weighing and highlights a series of special purpose devices including the new concept of the Nuweigher continuous weigher suitable for incorporation into completely automated processing schemes.

1. Introduction

Accurate continuous weighing of basic raw materials, whether the process be mining or cement manufacture or vegetable freezing, is an integral and vital part of many production processes. There are many reasons why continuous weighing is essential.

Whatever the process, the provision of weight data at each stage of production is a vital aid of management control. This information is most conveniently provided by belt weighers which are unmanned and operate continuously and automatically. Total weight and feed rate are normally displayed locally and can be recorded at a remote supervisory position in any convenient visual/graphical form.

In practice belt weighers are used for monitoring efficiency of such processes as the weighing of vegetables before and after cleaning, providing up to the minute information on fuel stock levels and can even form the basis for operator incentive schemes based on production rather than sales figures.

Applications in mining/quarrying have resulted in increased production by identifying production targets and encouraging a competitive spirit between operators of different shifts.

Plants which receive or dispatch their bulk products by ship or barge, use approved belt weighers on the transfer conveyors. Similar installations are used on conveyors that link coal mines with power generating stations.

As process technology advances and the tolerances to which items of process equipment are expected to perform become narrower, so it has been essential for manufacturers of weighing equipment such as Avery Parsons to improve their products and develop new systems.

By definition, belt weighers are devices which automatically indicate the feed rate and totalise the weight of a loose bulk product as it passes along a conveyor belt. Weighing is performed continuously without interruption to the passage of the product along the conveyor.

Because of the continuous nature of their operation, belt weighers are ideal for incorporating into continuous processing lines. Weighing in static batches is eliminated and the handling plant can therefore be designed for a continuous optimum throughput. But weighers also provide the accumulative weight data completely automatically, without the need for an operator to read and total individual scale readings.

Belt weighing entails the measurement of belt weight and belt displacement and the combination of the two parameters provide feed rate and/or totalized weight indications. Two basic principles are used namely, *summation* and *integration*.

Summation is achieved by weighing successive lengths of belt and adding the weight on each length to the sum of the weights on previous lengths.

Belt travel is measured to synchronise the frequency of *summating* cycles. *Integration* consists of multiplying the weight and speed factors to obtain a feed rate measurement which is then integrated to register total weight.

The Avery Parsons 91 series of mechanical belt weighers use the summating principle for high accuracy totalizing to standards approved by D.P.C.P. for stamping for trade use. For mechanical systems, summating is accepted as being superior to integrating. Mechanical integrators are essentially variable speed drives which adjust the speed of a mechanically driven counter in proportion to feed rate i.e. speed x weight.

Typical devices such as ball and disc or ball and cone integrators often have difficulty in responding to and keeping sympathy with changes in speed and weight. The prevention of slip between the main integrator components is also a problem as a compromise has to be made between weighing sensitivity and pressure in the friction drive.

However, electronic integrators do not suffer these problems and the Avery Parsons type 9511 AI single idler electronic design uses solid state analogue techniques for the multiplication and integration calculations. Virtually instantaneous response times permit the use of a compact single idler weight carriage whilst the *true rate* output, being compensated for belt speed variations, is useful for accurate process control.

Avery Parsons supply their belt weighers to suit the customer's existing conveyor. There is no limitation on capacity, belt width, belt speed or

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incline (other than the material roll back factor). Troughed, flat and chevron belts can be accommodated and no alterations are required normally to the conveyor structure and idlers. Special self-contained units are often supplied incorporating an integral weigh conveyor. These use either troughed or side wall belts to achieve maximum unit loading and avoid material spillage whilst the optimum conditions for accurate weighing can be incorporated.

Traditionally, the belt weigher has accepted a passive role in weighing a product that passes along its conveyor. The weight data can nowadays be transmitted to a remote supervisory point and displayed in digital or analogue form on any type of proprietary indicator/recorder. In addition, the value of the belt weigher can be increased enormously by using the weight reading to control the process automatically at a pre-determined rate.

Closed loop control of process flow rate can be achieved by comparing the weigher flow rate signal with a pre-set reference signal in a 2 or 3 term process controller. If the actual flow rate departs from the desired flow rate then corrective action is automatically initiated, so that the pre-feeder adjusts the product being fed on to the belt until equilibrium is re-established.

2. Latest Developments — The Microprocessor Based Electronic Belt Weigher

To take advantage of the latest technology, Avery Parsons have introduced their new *Microflow Electronic Belt Weigher.* The latest in a long line of proven belt weighers, the Microflow retains the summating principle of its predecessors, but combines the added advantages of digital computation and microprocessor instrumentation to process the weight by precision load cell(s) and belt length by digital odometer.

Digital computation should not be confused with digital display, although this is also provided. The real step forward is in the means of computing the totalized weight from the instantaneous weight and belt length measurements. This is achieved by true digital arithmetic — the simple counting of discrete weight pulses whose value cannot change. Pulses cannot be lost or gained, and circuits, unlike their analogue equivalents, cannot drift with environmental of power supply variations. Totalizing is based on digital summation of weight pulses at measured intervals of belt length travel.

The dual function digital flow rate display acts as a high resolution totalizer for accurate zero setting in the empty belt conditions. Weight variations due to changes in the weight of the empty belt are eliminated by positive/negative totalizing with a push button initiated automatic zero setting device that memorises the belt length travel, computes the required zero adjustment from the net weight change and automatically corrects the zero setting.

The instrumentation is microprocessor based with plug-in circuit boards for standard functions. All input parameters for the measuring ranges and tare values are thumb-wheel selectable for maximum flexibility. The instrumentation is packaged in a wall mounted lockable enclosure to IPSS standards. A stand-by battery system provides backup in the event of power failure. The Microflow is suitable for integration into complex automation schemes with digital data output for computer interfacing and data acquisition systems.

To minimise adverse belt effects, the new instrumentation is supplied with a multiple idler weigh carriage, fully suspended from either multiple load cells or a hybrid lever arrangement with a single load cell.

Standard designs cater for capacities up to 10,000 t/h and belt widths up to 2.2 m. Special designs are available for higher capacity conveyors.

3. Limitations of Conventional Belt Weighing

The first and major limitation of conventional belt weighers is that they can only be used on flexible belts, which may be canvas, man-made fibres, rubber or any combination of the three, or on steel bands. Belt weighers may not be used on more rigid conveyors such as screw conveyors, vibrating conveyors, drag-chains or on air slides.

The main problem then is the belt itself. Weight sensing is through the medium of the conveyor belt which introduces an interference factor. In order to carry its load the belt is highly tensioned particularly on inclined conveyors or adjacent to the head (discharge) end. The belt also has an inherent stiffness which is accentuated when deep troughing idlers are used. The factors prevent the transmission of absolute true mass to the sensing system.

Further complications arise in ensuring correct load distribution between the weighing idler(s) and the adjacent non-weighing idlers. The lining up of idlers throughout the weigh section is extremely critical and eccentricities in idler roller diameter, or rollers being out of balance can affect correct load distribution.

Installation on or near to conveyor curves and catenaries and the use of variable troughing idlers must obviously be avoided.

The weighing system can be further affected by vibration, accumulation of dirt on the weigh carriage and weighing idlers, shock loads from an adjacent loading point and by wind influence, particularly on inclined conveyors.

In order to overcome such problems, in those cases where conveyors are highly tensioned, lightly loaded, steeply troughed or any combination of these, a conventional belt weigher requires a multiple idler weigh section of some metres in length in order to meet the optimum accuracy.

Feeding methods which deliver dribble feeds for long periods should be avoided as weighing errors start to increase at low feed rates, (say 20—30% of design capacity) and can become unacceptable. This is due to no fault in belt weigher design, but is simply a result of the belt interference factor becoming more significant when the weigher is lightly loaded.

In most instances, such limitations can be avoided by careful positioning of the weigher on a suitable straight length of conveyor and by providing a weigher which itself is engineered to much higher standards of accuracy than the final operating requirements.

It will be seen that most of the main factors inhibiting belt weighing accuracy are outside the control of the manufacturer and depend on the user maintaining the original standards of operation. Consistent belt tension, idler concentricity, uniform belt joints and general cleanliness of the belt and idlers across the weigh section must be maintained if accuracy is to remain within acceptable limits. This means that efficient service is essential not only for the weigher but also for the complete conveyor. The latter is often neglected, or difficult to achieve, particularly on large outdoor sites and the manufacturer's reputation can — quite unfairly — suffer as a consequence.

It should be appreciated that assuming the rules are followed, long service and accurate weighing can confidently be expected from a belt weigher. It is when they are used outside their operating parameters that accuracy suffers. The use of a weigher which has no contact parts with the conveyor belt has obvious advantages. Such a weigher is described below.

4. Non-Contact Weighing

This new concept of weigher brings accurate continuous weighing to many of the *no go* areas mentioned previously.

Weighing is by measurement of gamma ray absorption. The weigher is not in contact with, and is therefore unaffected by belt interference effects. In essence, the principle of operation is simple. A narrow beam of high energy gamma radiation, which is unaffected by normal fluctuations in material composition, passes through the material to be weighed, to a special scintillation counter mounted below the belt, which measures radiation absorption. The advantage of a scintillator is that, since its efficiency is many times greater than that of a gas-filled ionisation chamber, precise measurements can be achieved with a low source activity. This ensures that radiation scatter is minimal to such an extent that special safety screening is unnecessary.

The intensity of radiation at the detector is proportional to the mass of material through which the beam has passed, this data, when processed with input from the belt speed tachometer, indicates both flow rate and total weight.

Installation is simplicity itself, with no modification to the conveyor structure normally required. The *C* frame of the *Nuweigher* fits around the conveyor and can be bolted or welded at any convenient location (Fig. 1).

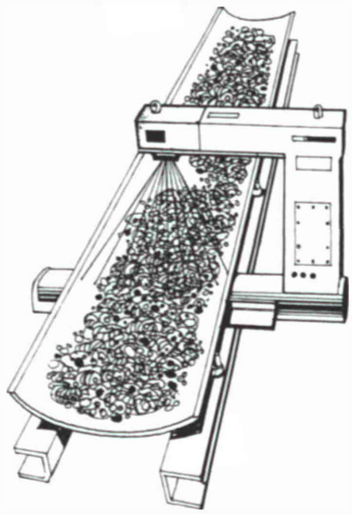

Fig. 1: Diagramatic representation of Nuweigher nucleonic conveyor

Certain major advantages accrue from this principle of weighing. Above it was noted that the weigher is unaffected by belt interference effects. This means that previous reservations due to vibration, belt tension and stiffness, idler concentricity, troughing angle, etc. do not apply.

Furthermore, lift off effects due to belt curvature or wind influence are not so important. Continuous weighing can now, therefore, be used for hot materials on apron conveyors, vibrating conveyors, screw conveyors, drag chains at angles of 45° and over and even for the measurement and automatic control of the suspended load in an air slide.

As with conventional weighers, the *Nuweigher* is suitable for incorporation into completely automated schemes for control of flow rate etc. However, the nucleonic principle of weighing enables the weigher to be positioned much closer to the point of feed so that tight control can be achieved.

One of the main advantages of this type of weigher is the minimal servicing required not only of the weigher itself, but also less diligent maintenance of the complete conveyor.

Although more expensive than equivalent conventional weighers, this weigher can offset its increased cost by maintenance savings alone.

5. Conclusions

Selection of a continuous weigher depends on the application. For high accuracy to better than ± 0.5 %, a conventional weigher has the advantage, provided that its requirements can be satisfied, in terms of conveyor location and maintenance, belt and idler design. Where these criteria cannot be met, the *Nuweigher* will provide reasonable accuracy (between ± 0.5 % and ± 2 %) under conditions which would be considered unacceptable for conventional machines, and where maintenance is a problem.

6. The Future

There is a growing preference for electronic weighing rather than traditional mechanical methods.

With the increased costs of man-power and materials, the trend is towards high accuracy *automated* weighers as part of the total process line, exercising system control functions.

The achievement of a better understanding by the user of the requirements being considered at the time the plant is designed, should lead to the wide acceptance of a very useful weighing device, ideally suited to process weighing needs.