MEASUREMENTS OF MASS

INCREASING THE ACCURACY AND EFFICIENCY OF A CONVEYOR BALANCE

V. K. Donis

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A fundamentally new comprehensive conveyor balance design is proposed along with an indirect method of calibration by deadweight loading. Calculated and experimental estimates of the metrological characteristics are given.

Known designs of conveyor balances (CBs) generally do not ensure sufficiently accurate weighing in the performance range established in the standard [1] and their range of application is limited because organizational and technical factors make the method of checking the material unfeasible [2].

Experience gained from the operation of various modifications of conveyor balances and tests carried out with them at test sites with reproduction of all of the potential performance factors showed that the accuracy of the balances and, hence, the efficiency of application, can be increased only if the designers find a comprehensive simultaneous solution to two problems: choice of a rational kinematic scheme for the load receptor (LR) (which determines the main part of the total CB error) and development of an indirect method of calibration and verification by simulating the material with a deadweight load.

This author proposes a fundamentally new solution to those problems, which has become possible by making allowance for factors that explain the interaction in the mechanical system consisting of a loose material, belt, conveyor, and LR; this is in addition to the generally known factors that determine the instrumental error of the recording equipment and sensors [3]. The first group of factors can include the variable belt tension at the site of the LR as the conveyor throughput and the dynamic loads that arise under impacts from lump material and the travel of that material on a curvilinear path in transit, the resistance of the belt to motion, and the asymmetric deformation of the belt on inclined conveyors.

A quantitative analysis of the influence of the indicated factors, which are random in our case, shows that their contribution to the total error may be a substantial one, which varies between wide limits and greatly exceeds the instrumental errors of the best recording equipment.

Comparison of the known kinematic scheme of LRs in regard to the degree to which they compensate for the influence of the aforementioned factors (taking the "sensitivity — cost" criterion into account) showed that a scheme consisting of two single-roller beam-type load receptors, a "matching" receptor LR-1 and a "counter" receptor LR-2 (Fig. 1). This relative position minimizes the influence of all the mechanical actions because the additional instantaneous loads relative to the hinged support of beam-type LRs are compensated completely (or partially). Similar schemes are used in some modifications of CBs, e.g., made by the Schenk Co. In them, however, single-roller LRs are linked; this prevents solution of the second problem of the application of a sufficiently accurate indirect method of CB calibration and verification. Accordingly, I have proposed that LR-1 and LR-2 be mechanically decoupled and independently transfer their loads separately to the weight sensors S1 and S2, which are set up so as to compensate for the influence of the "descent of the belt" on either side of the conveyor. This arrangement makes it possible to implement a structural method of stabilizing the static real transfer function based on the principle of "two-channel" measurement, i.e., ensures that the CB is invariant against perturbations that determine the noninformative parameter of the initial process [4].

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Clearly, with the indirect method of CB calibration and verification it is necessary to start from the condition that simulators reproduce all the aforementioned mechanical perturbations. This condition is satisfied by the indirect method of [3], which has satisfactory accuracy but is rather time-consuming and so is applied to low-capacity conveyors.

The "two-channel" CBs designed can be calibrated and verified by the method of successive addition of special weights to LR-1 and LR-2 as the conveyor transports material [5, 6] with a linear density that is lower by the mass of the special weights. In that case all of the mechanical perturbations characteristic of the conveyor operating conditions are practically reproduced. It is necessary, however, to minimize the possible procedural error of calibration due to three components: the nonuniformity of the belt tension at the site of the CB when special weights are added directly to the LRs and loads of real material of the same mass are added to the tape; the disparity between the actual dimensions of the arm of the suspension of the special weights and the calculated value (inevitably on inclined conveyors and when the belt is grooved); and the incomplete compensation for the influence of the fourth mechanical factor, asymmetric deformation of the belt.

The first component of the error is minimized by using special weights, the mass of which is determined from the following conditions. The reaction of the balance under a load \( G = ql \), which is transferred to the weighing roller by the belt with material [7], is

\[
R_1 = \frac{G}{c + 2\sigma}.
\]

and load is added directly to the weighing roller by the special weight,

\[
R_2 = (G + P_{sw}) \cdot \frac{c}{d + 2\sigma},
\]

where \( c \) is the stiffness of the force transducer, \( l \) is the transit path (weighing section) of the belt, \( \sigma \) is the belt tension at the site of the built-in CB when it is loaded with material of linear density \( q \), and \( P_{sw} \) is the special weight.