RATIONALIZATION AND EXCHANGE OF EXPERIENCE

LEVERLESS AUTOMATIC BATCHER FOR CONCRETE PLANT

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The ever-increasing volumes and rates of hydraulic construction have given rise to the need for developing new high-efficiency equipment for the concrete plants at large hydraulic structures to be constructed. Of great importance in this connection is to increase the productivity of the preparation process of the concrete mix, while simultaneously ensuring high technical parameters and strength properties of the concrete.

The cyclic-action batchers being mass-produced at the present time are lever-actuated, load-measuring installations, with low outputs. These installations ensure the required batching accuracy only for small quantities of materials, delivered at a rate of not over 20-25 kg/sec. They are practically unsuitable for batching variable loads of granular materials delivered at rates which reach 150-200 kg/sec at present-day concrete plants. As shown by investigations,1 the error in the lever-actuated batchers at existing projects reaches 8-10%, and in some cases 15%. It is possible to increase substantially the output, while maintaining the required batching accuracy, by using high-speed leverless systems with electric converters. Tensiometric methods of measuring loads are highly promising. Tensiocverters make it possible to obtain a unified output signal and to develop modern digital systems for processing the output information. High dynamic parameters permit using tensiocverters for practically any quantities of batched materials.

However, the tensiocverters being produced at the present time are subject to substantial static errors, caused by changes in external factors, in particular, the temperature, baseline drift, and nonlinearity of the conversion function. A reduction of these errors is of primary importance for the development of high-efficiency tensiometric batching systems.

Investigators at the Kuibyshev Branch of the Orgdnergostroi Institute developed a new method6 for increasing the accuracy of load-measuring systems and, in order to make practical use of this method, designed and fabricated an automatic cyclic-action leverless batcher with tensiometric converters for concrete plants at large hydraulic construction projects. The essence of the method lies in obtaining additional information on all the types of static errors which occur during the batching process and in excluding them from the measurement results.

The conversion function for the tensiometric mass-batching system (Fig. 1) can be expressed with a sufficiently high degree of accuracy in the form of the relation

\[ Y = aP + b + KP^2, \]

in which \( P \) is the weight of the measured load; \( Y \) is the electric output signal; \( a \) and \( b \) are parameters of the conversion function for the batching system; and \( K \) is a coefficient of nonlinearity. The variation of the parameters \( a \) and \( b \) under the effect of variations in the external conditions, as well as the time drift of the characteristics of the individual elements, is a source of static errors in the batching system. The variation of parameter \( a \) determines a multiplicative component (sensitivity error), and the variation of parameter \( b \) determines an additive component (zero error). The nonlinearity of the output characteristics of existing tensiometric converters is in the order of 0.5-5%.


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The effect of the parameters $a$ and $b$ on the batching accuracy is eliminated by introducing an automatic correction which is provided for in the batcher and which solves a special algorithm for operation of the batcher. A flow chart for the automatic batcher is shown in Fig. 2. The charge-receiving hopper 1 rests on the tensiometric converters 2.

Initially, two loads of known value $P_0$ (Fig. 2) are fed into it by means of the electromagnets 23. The value of the given proportion of an ingredient, multiplied by the coefficient of nonlinearity of the tensioconverter, is fed as $KP_{gp}$ into the reversible counter. At the same time, the value of $P_{gp}$, as multiplicand, and of $1/P_0$, as multiplier, are fed into the multiplying unit 18. The result of the first measurement $Y_1$ of the total weight of the charge-receiving hopper and loads $(P_0 + P_b)$ passes through the amplifier 4 and the analog-digital converter 5 of the measuring device 3, and enters the reversible counter 9, which, after receiving a signal from the operating unit 16, is set in the addition direction. During the first measurement, the reversible counter 11 and the memory register 13 remain closed.

At the end of the first measurement a signal is sent by the operating unit 16 and the electromagnets 23 are closed; as a result, the loads 22 are removed from the charge-receiving hopper 1, the reversible counter 9 is set in the subtraction direction, and the memory register 13 is opened. The result $R_b$ of the second measurement $Y_2$ of the deadweight of the charge-receiving hopper enters the memory register 13 and the reversible counter 9. Thus, at the end of the second measurement the value of $(Y_1 - Y_2)$ is recorded in the counter 9, and the value of $(Y_3 - Y_2)$ is recorded in the memory register.

The first two measurements are executed while the gate 25 of the delivery hopper 24 is closed. The segment between points 1 and 2 (Fig. 1), corresponding to these measurements, occupies a small portion of the characteristic curve of the tensioconverter. This portion can be assumed to be linear, with a sufficiently high degree of accuracy for engineering work. It has the equation

$$Y_{1r} = Y_{1t} \text{ and } Y_{2r} = Y_{2t},$$

in which $Y_{1r}$ and $Y_{1t}$ are the real values of the electric input signal at points 1 and 2; and $Y_{1t}$ and $Y_{2t}$ are the corresponding theoretical values; thus, the following relations are valid

$$Y_1 = a(P_b + P_0) + b \text{ and } Y_2 = aP_b + b,$$

and the difference $Y_1 - Y_2$ is proportional to the sensitivity $Y_{1r} - Y_{2r} = aP_0$ of the batching system.

After completion of the second measurement, by a signal from the operating unit 16 division of the content ($KP_{gp}$) of the reversible counter 11 by the content $(Y_1 - Y_2)$ of the reversible counter 9 starts. The division is executed by the method of successive subtraction until a zero state signal of the reversible counter 11 arrives from the indicator 14 into the operating unit. This signal causes the division process to stop, and the result $KP_{gp}/(Y_1 - Y_2)$ passes through the u-cell 17 into the multiplying unit 18, where it is added to the quantity $1/P_0$ recorded in it as a multiplier. This sum is multiplied by the multiplicand, and the result

$$P_{gp} \left( \frac{1}{P_0} + \frac{KP_{gp}}{Y_1 - Y_2} \right)$$

passes to the first point of entry of the comparing unit 19.

Since all electronic control assemblies of the batcher use high-speed semiconductor elements, the measurement and computation processes are short, not exceeding a few milliseconds.