MASS MEASUREMENTS

WHEEL-BY-WHEEL WEIGHING OF LOCOMOTIVES

AND BASIC REQUIREMENTS FOR THEIR WEIGHBRIDGES

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For the wheel-by-wheel weighing of locomotives, special weighbridges are used which consist of a complex measuring aggregate comprising several weighing devices and tracks.

Until recently our industry did not produce weighbridges for locomotives, and they were weighed at locomotive manufacturing plants on weighbridges made by foreign firms, whereas handicraft means were used for this purpose at the repair plants. Neither were the metrological characteristics of locomotive weighbridges investigated. However, special problems arise in this connection, which are due to the particular features of the measured objects.

The spring suspensions of all modern locomotives without exception cannot be determined statically. Therefore, the wheel-by-wheel weighing entails an experimental evaluation of the thrust reactions in a statically indeterminable system. It is known that the value of these reactions depends not only on the position of the system's center of gravity with respect to the supports, but also on their height and stiffness. Therefore, the value of the loads measured in wheel-by-wheel weighing depends not only on the characteristics of the tested locomotive, but also on the weighbridge characteristics, including the nonuniformity of weighing tracks, their deformations under load, the stiffness of the measuring components, and the location of a locomotive on the weighing track.

In fact, it is logical to assume the "true" distribution of loads to exist when the locomotive is on an absolutely rigid and strictly horizontal track, with the points of contact between the rails and the wheels lying in the planes of their rotation circles. It is obvious that only in such a case will the deviations of the loads from their computed values be due exclusively to the inaccuracies in the manufacture and assembly of the locomotive's propulsion components. It is precisely such a position that the locomotive should occupy at the instant when the loads transmitted by its wheels to the rails are measured.

Provided this condition is met, it is possible to measure the "true" values of the loads exerted by the wheels on the rails, i.e., the values about which the loads oscillate under actual conditions of the locomotives' utilization. Moreover, the precision of measuring the loads in this case is obviously determined by the precision of the weighbridge operation. The latter precision depends both on the precision of the utilized measuring instruments and their horizontal location.

Thus, the basic technical requirements specified for locomotive weighbridges in order to ensure high metrological indexes can be reduced to the following:

The arrangement and installation of the weighing instruments should ensure the possibility of measuring the loads exerted on them with a sufficient precision;

The design of the weighing aggregate as a whole should ensure the placing of the locomotive on the weighbridge during weighing in a position for which the distribution of loads exerted by the wheels on the rails approaches as closely as possible its "true" value.

The second requirement applies only to locomotive weighbridges, and, according to computations and experience, it has the largest effect on the wheel-by-wheel measurement error of the rolling stock.

In accordance with the above considerations, the locomotive weighbridges can be classified by the following characteristics: by the method of ensuring an accurate placing of the locomotives on the weighbridge and the method of locating the weighing devices; by the operation principle of the weighing devices; by the precision of these devices.

According to the existing technical specifications the following requirements are set for the weight characteristics of locomotives: the total weight of a locomotive and the loading of rails by each bogey and each axle must not deviate from the specified values by more than 2-3%; the difference loads on the rails by the wheels of a single axle should not exceed 3-4% of the total axle load.

In order to meet these requirements it is obvious that the load of each wheel on the rails must not deviate from the specified value by more than 3-6%.

It is possible to check that these requirements are met if the error in determining the load of a wheel on a rail does not exceed 0.5-1%. By taking into consideration that the total in determining this load consists of the error due to the deviation of the actual wheel load from its "true" value and the actual load measurement error due to the inaccuracy of weighing devices it is possible to consider that the weighing instrument error should be 2-5 times smaller than the tolerated total error, i.e., it should lie in the range of 0.1-0.5%. For the existing loads of 10.0-11.5 metric tons force exerted by the locomotive wheel on rails, the error of the weighing devices must not exceed 10-50 kg force.

An analysis of the weighbridge operating conditions for a wheel-by-wheel weighing of locomotives shows that it is possible then to use weighing components of any system (lever, spring, hydraulic, electrotransometric, etc.), provided that they are sufficiently precise. However, they must meet one specific requirement that the vertical displacement of the load carrying devices should be as small as possible during weighing. Failure to meet this requirement may lead to a redistribution of loads in the course of weighing.

The meeting of the above requirements does not present any serious difficulties. Thus, a high-precision wheel-by-wheel weighing of the rolling stock can be provided above all by a rational selection of the weighbridge design for an appropriate placing of the locomotive and the weighing devices.

All the known designs of locomotive weighbridges can be divided according to this characteristic into two basic groups:

- weighbridges with fixed weighing elements,
- weighbridges with moving weighing elements.

The second group in turn can be subdivided into three basic types which differ from each other by the method of meeting the requirements of a correct placing of the locomotive during weighing: weighbridges with a split upper track (scales with a balance bridge); weighbridges with a solid upper track (scales of a Schenk type); transportable locomotive weighbridges.

In addition to weighbridges on which the loads of all the wheels are determined simultaneously, there also exist constructions for evaluating the loads of a weighed locomotive's wheel pairs consecutively [1]. This makes it possible to use only two stationary sensing elements for weighing any locomotive, and thus considerably reducing the cost of a weighbridge.

The weighbridges of the first group consist of weighing elements which are located along the track in pairs (Fig. 1), have a similar design, and are intended for the same maximum load.

The lengths of rails which carry the weighed locomotive constitute a part of the weight carrying device. Therefore, the placing of the locomotive on the weighbridge in a position approaching the ideal one and the undistorted transmission of the "true" loads exerted by the wheels on the rail is attained by setting all the weight carrying rails strictly in the same horizontal plane (with an error down to tenths of a millimeter). In this case each measuring element can be set by means of a level with the required precision, thus increasing the precision of the load measurements. Such an installation is a rather complicated, but completely attainable engineering proposition.

The main drawback of a weighbridge of this type consists of the fact that it is difficult to match the location of a limited number of cumbersome, complicated, and expensive stationary measuring elements to the basic dimensions of the rolling stock of various types. For this reason such weighbridges are not normally universal, and they are used for weighing locomotives of a given type or, in the best case, of several types. Thus, locomotive weighbridges made by the firm Fairbanks-Morse [2] with stationary components on elastic supports have a very high wheel-