CARGO CONTROL ON HANDLING MACHINERY

Dubrovin, Lev M., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*
Nikishechkin, Anatoly P., *MSTU «STANKIN», Moscow, Russia.*
Davydenko, Vladimir I., *Technical Center of Moscow railway – branch of JSC Russian Railways, Moscow, Russia.*

ABSTRACT

Any weighing systems create, if it is necessary to use them, a lot of problems during transportation and handling. The paper proposes a non-contact method for evaluating maximum permissible load mass values of cargo lifted (moved) by handling machines according to the value of magnetic field strength, which is created by a DC motor. Measurements do not require complex and expensive equipment, intervention in electrical circuits and design of devices, but provide sufficient accuracy in determining load on a crane.

Keywords: handling machinery, DC motors, permanent magnetic field, magnetic field strength, ferroprobes, cargo weight, maximum permissible values estimation.

Background. *A large number of process steps of metallurgical and machine-building industries, mining enterprises, in construction, transport are carried out by moving cargo with the help of handling machinery. Such devices are different kinds of pulley blocks, movable hoists, winches, cranes, vertical conveyors, electric excavators and other machines. In carrying out their operations, it is necessary to weigh cargo, including to control weight of lifted (transported) goods as well as to prevent overload of handling mechanisms and improve safety of their work [1–3].*

To date, the only way to estimate the mass of the load raised by the crane, is measurement of forces acting on the elements of its structure [2].

Depending on the point of application of force, which is determined by the purpose of handling device, operating conditions, ease of integration of weighing mechanism, there are different weighting schemes. And in any case, there are following disadvantages:

1. The need for integration of a weighing system in the design of handling devices.

2. The need for current supply for a weighing system.

3. The need for special devices, coiling communication line cables with a weighing system.

The authors propose a fundamentally new method for non-contact weighing of goods according to the magnetic field generated by a DC motor of a handling device. The method simplifies the measurement. They do not require complex and expensive equipment, interference with electrical circuits and construction of hoisting machines and provide with sufficient accuracy of the estimate.

Objective. *The objective of the authors is to consider a non-contact method for evaluating maximum permissible load mass values of cargo lifted (moved) by handling machines.*

Methods. *The authors use general scientific and engineering methods, evaluation approach, simulation.*

Results. *Our solution uses a well-known connection between the strength of the magnetic field generated by the DC motor, and the load on the motor shaft. The load, in turn, depends on the weight of the load and movement conditions – ascent, descent, horizontal movement, speed of movement. Thus, if we provide identical conditions for the measurement, the load will be determined only by load mass, and thus mass measurement reduces to the measurement of the magnetic field strength.*

To measure permanent or slowly varying magnetic fields a variety of sensors can be used, in particular ferroprobes [4–6].

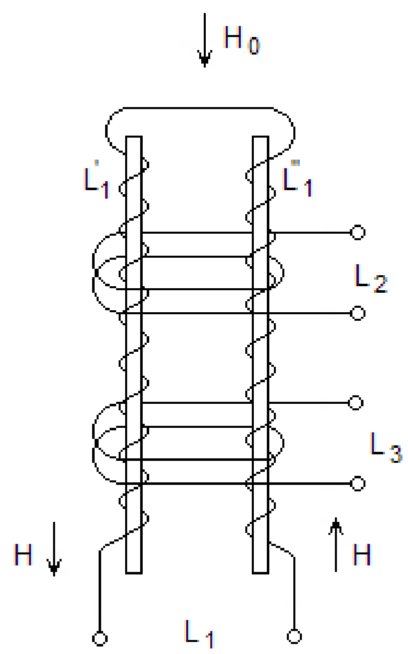
Ferroprobe method of measuring the intensity is quite simple, well studied and allows to achieve required accuracy.

Ferroprobe is highly sensitive and requires little or no signal amplification, when measuring magnetic field strengths there is no need to put it in close proximity to the motor or power circuits. The ammeter (particularly milliammeter), which scale is calibrated in mass units, can be used as a display device.

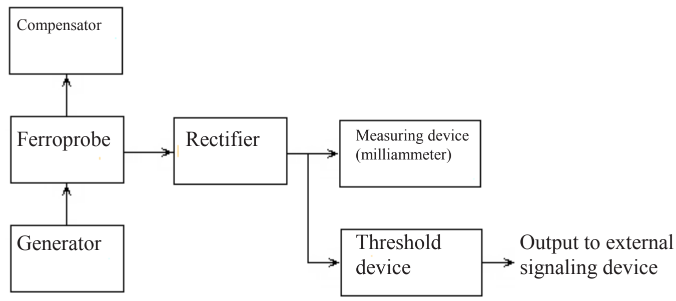
Place of ferroprobe installation is, in fact, not so important – it is only important that it is the same as in calibrating milliammeter scale, and in mass measurement. Milliammeter can be placed in virtually any space convenient for observing.

That is, for implementation of the method requires the device itself, it is necessary to pre-calibrate milliammeter scale in units of mass, and then while mass measurement to provide the goods movement in the same mode in which the calibration of meter scale was performed.

A measuring device is proposed on the basis of differential ferroprobe (Pic. 1) with two permalloy



Pic. 1. Differential ferroprobe.



Pic. 2. Block diagram of a measuring device.

cores with excitation winding L_1, consisting of two halves. One half of the winding L'_1 is on one core, the other L''_1 (wound opposed the first) – on the other [7–9].

The winding is connected to the pulse generator. Half L'_1 creates the field H and L''_1 – the same, but in the counter direction.

Over two cores with windings L'_1 and L''_1 a measuring winding L_2 is located. It is connected via a rectifier to the measuring device, as which is used as a DC milliameter, as well as to the threshold device generating a signal to an external signaling in excess of weight of lifted load. The oscilloscope can be connected to the measuring winding, allowing to observe the output signal distortion under the influence of the external magnetic field H_0 [8–10].

Additional third winding (compensation) L_3, located on top of the main windings, provided for the installation with the help of the compensator zero current of a meter in case of no load.

To protect ferroprobe against mechanical external influences a protective cover is used, which is a tube made of brass [7].

Pic. 2 is a block diagram of the measuring device, whereby the method is implemented.

The block diagram includes:

– A pulse generator that generates rectangular pulses supplied to the excitation winding L_1 of the ferroprobe;

– Ferroprobe comprising three windings;

– Compensator;

– Rectifier;

– Measuring device – DC milliammeter;

– Threshold device, ensuring generation of a signal to an external signaling device in excess of the current corresponding to the limit mass value of lifted load.

Connection diagram of the ferroprobe windings is shown in Pic. 3.

Compensation of a permanent magnetic field generated by the motor in the absence of the load, as well as foreign permanent magnetic fields is carried out by the variable resistor R_3 of the compensator – setting zero current of a milliammeter. The values of resistors $R_2 = R_4$ and R_3 of the compensator are selected depending on the magnitude of supply voltage.

The pulse generator is made on three elements NOT (e.g., K561LN2), powered by a 9 volt source. The fourth element NOT (DD1.4) is useful for reducing the influence of the excitation winding of the ferroprobe on generator operation. Generator frequency adjustment is performed by the resistor R_1 in the range 2–200 kHz [8, 10]. At these frequencies (above 2 kHz) K561 series chips are working steadily with voltage of 9 volts.

The peculiarity of the circuit – C_2 tank, while choosing the size of which or changing the generator frequency voltage resonance can be achieved in series type connection: tank C_2 – excitation winding L_1 of the ferroprobe. This allows to significantly increase voltage on the winding L_1 and increase ferroprobe sensitivity without supply voltage increase. Thus it is necessary to provide resonance frequency equal to that for which ferroprobe is designed.

The magnitude of the magnetic field strength generated by the motor, and hence the value of the mass of the load are determined by the milliammeter. In case of excess in current corresponding to limit value of the mass of the lifted load, the threshold device (optron U_1 and relay K_1) provides a signal to an external signaling device. Resistance value R_5 is selected in such a way as to ensure that when lifting the load, which exceeds the weight limit required for the operation of the relay K_1 LED current and, therefore, collector current of the optron U_1.

Milliammeter scale calibration is performed in the following order [10, 11].

1. When the motor works for lift (displacement) at a certain constant speed without load milliammeter reading through variable resistor R_3 (Pic. 3) is set to zero, corresponding to zero weight load.

2. When lifting (moving) cargo of maximum permissible mass with the same constant speed milliammeter reading corresponds to the maximum permissible weight of the lifted load.

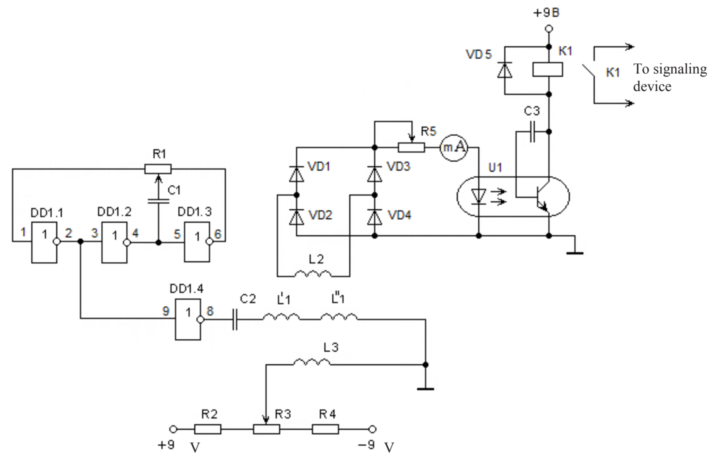
When lifting the load with a weight above the maximum permissible occurs the actuation of the relay K_1 of the threshold device and outputting a signal to an external signaling device.

Scale of calibrated milliammeter is close to linear.

As it is necessary to take into account the weight of the released cable, which is a ballast component of the weight and which is variable and depends on the height of the lifting when calibrating the scale, and when mass measuring. It is therefore necessary to use a rope position sensor. Knowing the mass per unit length of the rope, it is possible to make a fairly accurate account of the impact of the mass of the rope according to the lifting height.

When using the method on handling devices of one type equipped with motors of one brand, there is no need for calibrating the meter scale for each device individually. It is enough to provide only the same installation location of a sensor (ferroprobe).

Conclusions. *The proposed method eliminates the necessity of embedding sensors in electrical circuit and elements of design of the lifting device,*



Pic. 3. The scheme of connection of ferroprobe windings.

does not require complex technological equipment, and significantly reduces the cost of the measurement. The cost of innovation is ten times smaller than currently used methods of measuring the mass of the cargo, lifted by cranes.

The proposed method makes it possible to install the sensor (ferroprobe) in virtually any convenient location in close proximity to the motor of the lifting mechanism and use a milliammeter as a meter, which ensures ease of fixing the measurement results.

The device realizing the method is compact; its dimensions do not exceed the dimensions of a mobile phone. It does not contain expensive elements and does not require special service. Preparing for use lies in calibrating the meter scale (milliammeter) in units of mass.

Application of the method indicates that the meter reading is practically independent on the degree of possible load swinging. Therefore, no special measures when measured weight is required. It suffices to provide the same motor operating conditions as when calibrating the meter scale.

Since the ferroprobe responds to permanent and slowly varying magnetic fields, described measurement is only possible when using DC motors without pulse speed control, which is a limiting factor for the stated method.

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Information about the authors:

Dubrovin, Lev M. – senior lecturer of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, wellew49@gmail.com.

Nikishechkin, Anatoly P. – Ph.D. (Eng.), associate professor of MSTU «STANKIN», Moscow, Russia, anatolij-petrovich@yandex.ru.

Davydenko, Vladimir I. – senior electrician of Technical Center of Moscow railway – branch of JSC Russian Railways, Moscow, Russia, vlad47mir@yandex.ru.

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