TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2011, 11B, 161-166

THE DISPERSIVE FIELD OF THE MARK, WHICH APPLIED U-SHAPED RECORDING HEAD

Mykhaylo Smirny, Arkadiy Bikhdricker

Volodymir Dahl East-Ukrainian University, Lugansk, Ukraine

Summary. The methodology of determining the optimal location of fluxgate sensors for reading the information on the magnetic carrier, record to which is carried out U-shaped recording head is offered.

Key words: wagon weights, fluxgate sensors, external magnetic field, magnetic mark, U-shaped recording head.

INTRODUCTION

The railway transport of Ukraine is important to the livelihoods of the economy, consisting of the provision of timely and high-quality passenger and cargo transportation. Recently, there has been as increase of volumes of transportations, and the growth of deficiency of a rolling stock, first of all freight carriage [Belov V., 2003]. For sustainable operation of the industry at the expense of improvement of quality indicators of work of railway transport, the increase of traffic speed, use of reserves acceleration of the turnover of railcars, minimization of unproductive idle runs railcars and locomotives should create the required reserve weight measuring points [Kurlaev A., 2003]. Such a possibility exists, taking into account the increased availability of railway-owned highways means of information-measuring engineering [den Buurman G., 2005].

Amenities such weight measuring points anchor wagon weights does not in all cases justified economically because of the high cost of weights and high labor-intensiveness of their installation[Sergeev A., 2000]. To solve this problem it is suggested magnet metric weighing system railcars [Bikhdricker A., 2010], intended for weighing of railcars in motion in the train with documentary registration of the weight of each railcar. It can be easily installed on the routes of the railway stations and access roads of open pits, mines, ports, and other industrial enterprises.

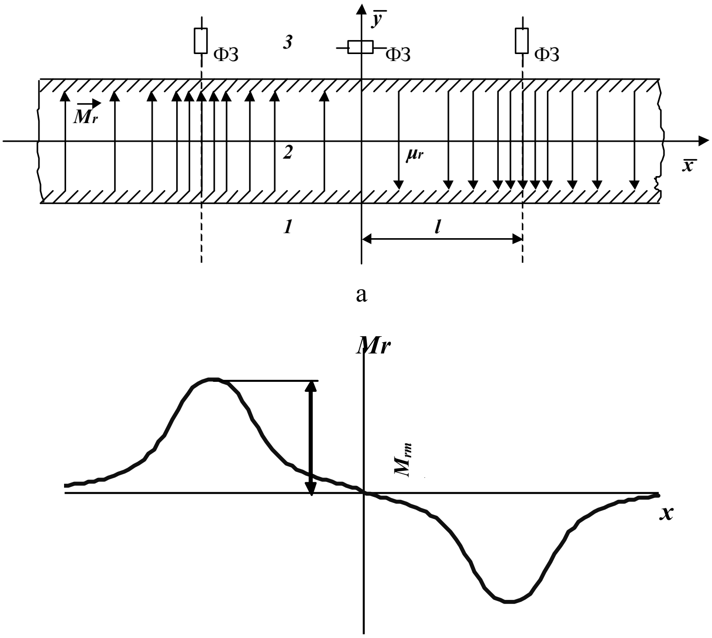
RESEARCH OBJECT

For weighing it is proposed to use the method of magnetic recording on the railroad track. It is known, that the intensity of the external magnetic field of a marking depends on the impact of dynamic loads [Bikhdricker A., 2001], and the degree of reduction of the strength of the magnetic field depends on the weight of the railcar. It is expedient to apply the magnetic marks on the neck of the rail to determine the weight of railcars.

The purpose of the article is the analysis of the mathematical model of the dispersive field of the mark, which applied U-shaped recording head in the magnet carrier and determine the best location for fluxgate sensors on magnetic fingerprint.

RESULTS AND THEIR ANALYSIS

Residual magnetization mark creates, the configuration of which we find in the assumption that in this apply the same idealization, which were introduced in the analysis of fields of permanent magnets[Smirny M., 1982]. Model of magnetic carrier which has a thickness of ***2d*** is depicted in fig. 1, where indicated $y/d=\overline{y}$, $x/d=\overline{x}$.



a

b

Fig. 1. The magnetic field of the marking: a – model of magnetic carrier; b – the distribution of residual magnetization

The nature of the field in a plane ferromagnetic body when recording a U-shaped head makes approximated the residual magnetization of the mark by using expressions [Smirny M., 2009, Pavlukov V., 1977, Polivanov K., 1975]:

$$\vec{M}_r^+(x) = \vec{j} M_{rm} \frac{\beta^2}{\beta^2 + (\bar{x}+l)^2}\,; \tag{1}$$

$$\vec{M}_r^-(x) = -\vec{j} M_{rm} \frac{\beta^2}{\beta^2 + (\bar{x}-l)^2}\,, \tag{2}$$

where: the ***M***

M_{rm} is the amplitude of the residual magnetization;

$\beta>0$ is the coefficient, depending on the length of the magnetic marking.

Decomposition (2) and (3) in the Fourier integral has the form:

$$\vec{M}_r^+(x) = \vec{j} M_{rm} \frac{2}{\pi}\int_0^\infty \frac{\pi}{2}\beta e^{-\beta\omega}\cos(\bar{x}+l)\omega d\omega\,; \tag{3}$$

$$\vec{M}_r^-(x) = -\vec{j} M_{rm} \frac{2}{\pi}\int_0^\infty \frac{\pi}{2}\beta e^{-\beta\omega}\cos(\bar{x}-l)\omega d\omega\,. \tag{4}$$

After the solution of the boundary value problem for one of the harmonics (3) and (4) which has a frequency $\omega = \Omega \neq 0$ $\vec{M}_{r\Omega} = \vec{j} M_{rm\Omega}\cos\Omega(x+3)$, where $M_{rm\Omega} = M_{rm}\beta e^{-\beta\Omega}$ is the amplitude of the magnetization [Bikhdricker A., 2007], the magnetic potential is determined in the area of 3, caused by all of the harmonic spectrum and then the components of the intensity of the external mark field are determined [Chatskis L., 1973, Loufer M., 1973]:

$$\begin{aligned}\varphi_3^+ = \beta\frac{M_{rm}}{\mu_r+1}\Bigg[&\int_0^\infty \frac{e^{-\beta\omega}}{\omega}\sum_{\alpha=0}^\infty c^\alpha e^{-(\bar{y}-1+4\alpha)\omega}\cos(\bar{x}+l)d\omega - \\ &-\frac{2\mu_r}{\mu_r+1}\int_0^\infty \frac{e^{-\beta\omega}}{\omega}\sum_{\alpha=0}^\infty c^\alpha e^{-(\bar{y}+1+4\alpha)\omega}\cos(\bar{x}+l)\omega d\omega + \\ &+\frac{\mu_r-1}{\mu_r+1}\int_0^\infty \frac{e^{-\beta\omega}}{\omega}\sum_{\alpha=0}^\infty c^\alpha e^{-(\bar{y}+3+4\alpha)\omega}\cos(\bar{x}+l)\omega d\omega\Bigg],\end{aligned} \tag{5}$$

where: $c = \left(\dfrac{\mu_r-1}{\mu_r+1}\right)^2$;

$$\begin{aligned}\varphi_3^- = \beta\frac{M_{rm}}{\mu_r+1}\Bigg[&\int_0^\infty \frac{e^{-\beta\omega}}{\omega}\sum_{\alpha=0}^\infty c^\alpha e^{-(\bar{y}-1+4\alpha)\omega}\cos(\bar{x}-l)d\omega - \\ &-\frac{2\mu_r}{\mu_r+1}\int_0^\infty \frac{e^{-\beta\omega}}{\omega}\sum_{\alpha=0}^\infty c^\alpha e^{-(\bar{y}+1+4\alpha)\omega}\cos(\bar{x}-l)\omega d\omega + \\ &+\frac{\mu_r-1}{\mu_r+1}\int_0^\infty \frac{e^{-\beta\omega}}{\omega}\sum_{\alpha=0}^\infty c^\alpha e^{-(\bar{y}+3+4\alpha)\omega}\cos(\bar{x}-l)\omega d\omega\Bigg].\end{aligned} \tag{6}$$

Bringing the integrals into the forms which are tabulated and considering the relationship $\vec{H} = grad\varphi$ [Polivanov K., 1964], the expressions for horizontal and vertical components of the intensity of the field from the magnet pole are derived [Bikhdricker A., 2007]

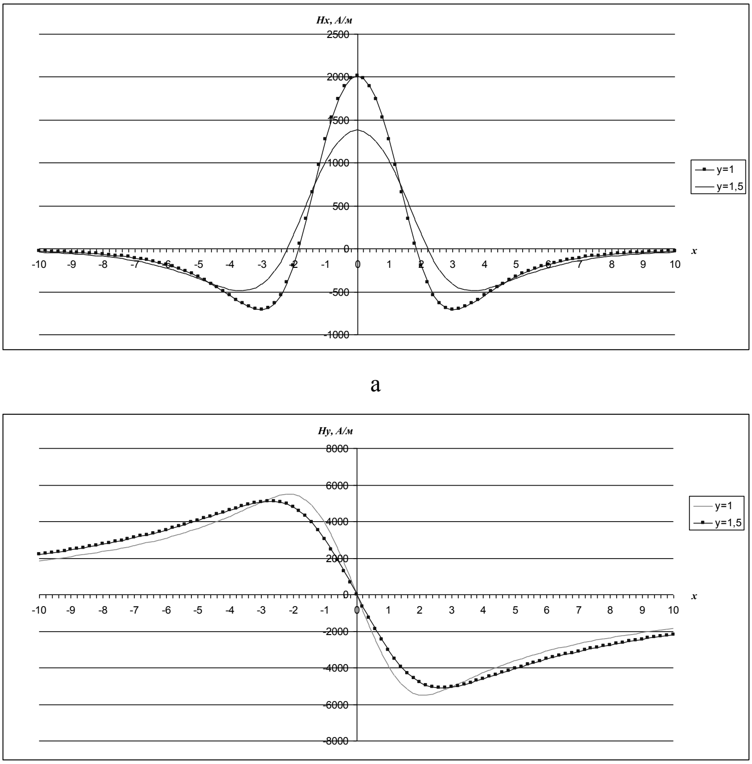
$$\begin{aligned} H_x^+ = \beta \frac{M_{rm}}{\mu_r + 1} \Bigg[& \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{x}+l}{(\bar{y}+\beta-1+4\alpha)^2 + (\bar{x}+l)^2} - \\ & - \frac{2\mu_r}{\mu_r+1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{x}+l}{(\bar{y}+\beta+1+4\alpha)^2 + (\bar{x}+l)^2} + \\ & + \frac{\mu_r - 1}{\mu_r + 1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{x}+l}{(\bar{y}+\beta+3+4\alpha)^2 + (\bar{x}+l)} \Bigg]; \end{aligned} \tag{7}$$

$$\begin{aligned} H_y^+ = \beta \frac{M_{rm}}{\mu_r + 1} \Bigg[& \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{y}+\beta-1+4\alpha}{(\bar{y}+\beta-1+4\alpha)^2 + (\bar{x}+l)^2} - \\ & - \frac{2\mu_r}{\mu_r+1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{y}+\beta+1+4\alpha}{(\bar{y}+\beta+1+4\alpha)^2 + (\bar{x}+l)^2} + \\ & + \frac{\mu_r - 1}{\mu_r + 1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{y}+\beta+3+4\alpha}{(\bar{y}+\beta+3+4\alpha)^2 + (\bar{x}+l)} \Bigg]; \end{aligned} \tag{8}$$

$$\begin{aligned} H_x^- = \beta \frac{M_{rm}}{\mu_r + 1} \Bigg[& \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{x}-l}{(\bar{y}+\beta-1+4\alpha)^2 + (\bar{x}-l)^2} - \\ & - \frac{2\mu_r}{\mu_r+1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{x}-l}{(\bar{y}+\beta+1+4\alpha)^2 + (\bar{x}-l)^2} + \\ & + \frac{\mu_r - 1}{\mu_r + 1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{x}-l}{(\bar{y}+\beta+3+4\alpha)^2 + (\bar{x}-l)} \Bigg]; \end{aligned} \tag{9}$$

$$\begin{aligned} H_y^- = \beta \frac{M_{rm}}{\mu_r + 1} \Bigg[& \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{y}+\beta-1+4\alpha}{(\bar{y}+\beta-1+4\alpha)^2 + (\bar{x}-l)^2} - \\ & - \frac{2\mu_r}{\mu_r+1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{y}+\beta+1+4\alpha}{(\bar{y}+\beta+1+4\alpha)^2 + (\bar{x}-l)^2} + \\ & + \frac{\mu_r - 1}{\mu_r + 1} \sum_{\alpha=0}^{\infty} c^{\alpha} \frac{\bar{y}+\beta+3+4\alpha}{(\bar{y}+\beta+3+4\alpha)^2 + (\bar{x}-l)} \Bigg]. \end{aligned} \tag{10}$$

For a marking, caused by U-shaped recording head with the most appropriate width of poles 2Δ = 4,6d [Smirny M., 1986], β=2, The calculated curves H_x and H_y depending on $\bar{x}$ at various $\bar{y}$ presented in fig. 2. Parameter l is calculated as the optimal under fixed $\bar{y}$ and H_x →max [Smirny M., 2009].



b

Fig. 2. The magnetic field of the mark: a – horizontal components of the field intensity **H_x** of the mark; b – vertical components of the field strength **H_y** of the mark

CONCLUSIONS

After the consideration of the curves we conclude that at $\bar{x}=0$ there is the maximum value of the horizontal component **H_x**, and maximum values **H_y** are within the absolute values of the (2,2…2,6) $\bar{x}$, that is, at a distance from the center of the mark, approximately equal to the width **Δ** of the recording head pole.

Received the maximum values can be used as informative parameters using the fluxgate sensors to control weight rail industrial vehicles.

REFERENCES

1. Belov V., Buyanov V., 2003.: The management of railway transport on the basis of automatic identification of rolling stock. Bulletin VSRIRT V. 1. p 25-36.

2. Bikhdricker A., 2010.: Magnet metric system of control of the weight of railroad cars. Lugansk : Knowledge. p. 306-308.
3. Bikhdricker A., Smirny M., 2001.: Device for weighing of railway vehicles. Bulletin SNU V. 5. p. 94-99.
4. Bikhdricker A., Smirny M., 2007.: Magnet-metric system of weighing of railway vehicles. Hoisting-and-transport technics. V. 3. p. 52–61.
5. Chatskis L., 1973.: Scientific research of static fields. Electricity. V. 2. p. 1059-1062.
6. den Buurman G., 2005: Measuring system Qui Vadis. European Railway Review, V 3, p. 80 – 86.
7. Kurlaev A., Sidorin Y, Ptentsov V., 2003.: Laser scales for weighing of railcars in motion. Bulletin VSRIRT V. 3.S. 35-43.
8. Loufer M., Chatskis L., 1973.: The analysis of the fields of magnetic heads. Electromechanics. V. 10, p. 1059 –1062.
9. Pavlukov V., Smirny M., Evtukhov V., 1977.: Programming rail vehicles with the help of magnetic recording. Odessa.
10. Polivanov K., 1964.: The distribution of magnetic flux in the rail when his magnetization of a plunging solenoid applied to the led system flaw detectors F.M. Karpova . Problems of ferromagnetism and magnetic dynamics. Moscow. AS USSR. p. 147-166.
11. Polivanov K., 1975.: Theoretical fundamentals of electrical engineering. V. III. Moscow.
12. Sergeev A., 2000.: Railway scales. Lawa 2000. Railways of the world. V. 2. p. 12.
13. Smirny M., 1982.: To the question of calculation of fields magnetizing device. Dep. UkrSRINGI. P 3534-D82.
14. Smirny M., 1986.: The calculation of the chain of magnetization in a transverse magnetic recording on the head of railway rail. Dep. UkrSRINGI, P 304-Uk86.
15. Smirny M., Bikhdricker A., 2009.: Definition of the optimum sizes of recording heads of device for weighing of railway vehicles Bulletin SNU. V. 12. p. 119–124.

ПОЛЕ РАССЕЯНИЯ МЕТКИ, НАНЕСЁННОЙ П-ОБРАЗНОЙ ГОЛОВКОЙ ЗАПИСИ

Михаил Смирный, Аркадий Бихдрикер

Аннотация. Предложена методика определения оптимального расположения феррозондовых датчиков для считывания информации с магнитного носителя, запись на который осуществляется П-образной головкой записи.

Ключевые слова: взвешивание вагонов, феррозондовый датчик, внешнее магнитное поле, магнитная метка, П-образная головка записи.