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DETERMINATION OF PARAMETERS OF WHEEL - RAIL DYNAMIC CONTACT SPOT BY MAGNETOMETRIC METHOD

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Summary. The present article is concerned with the issue of improvement of realization effectiveness of haulage capacity of rail vehicles by obtaining more exact pattern of dynamic distribution of loads in contact area wheel - rail under limiting traction values.

Key words. Measuring transformer, wheel - rail contact area.

INTRODUCTION

Ukraine possesses extensive railroad network with operational stretch of about 22 thousand kilometers. Railroad transport covers more that a half of total freight turnover of the country. Economic growth rates are to a large extent dependent on efficiency and quality of its functioning.

Effectiveness of haulage capacity implementation is considerably defined by processes of frictional contact interaction of the traction wheel, loaded by weight force of the rolling stock and tractive effort torque produced by its power generating system, and rail being guiding railroad element. Actually, tractive resources of locomotives that pull consists with mass up to thousands tons are realized in the contact area between wheel tread surface and a rail, making few square centimeters only.

Linear dimensions of the wheel - rail contact spot can vary in a rather wide range depending on physical properties of materials of the binding band and rail top, wheel diameter, profile of wheel tread surface and rail profile. If unworn surface of wheel tread and rail surface are represented as second-degree roll surfaces, the contact area would be ellipse-shaped [Golubenko 1993].

Alteration of wheel tread and rail surfaces due to wear during exploitation results in strong changes in geometric characteristics and distribution of forces within the contact spot.

When wheel starts movement, the pattern of forces distribution within the contact spot is subject to considerable changes as well. In this context, it would be more correct to use concept of *dynamic contact spot* [Malakhov 2008].

FORMULATION OF PROBLEM

For study of processes occurring in the dynamic contact spot, it is necessary in to measure geometrical parameters of the trace left by a wheel on the roll surface of a rail and to determine distribution of mechanical loadings within the area of this trace in dynamics. It opens ample opportunities for development of measures contributing to increase of the rolling-stock roadhold properties and reduction of wear of wheels and rails.

MATERIALS AND METHODS

In a static condition satisfactory results are provided by technique evaluating the contact spot shape and sizes with the help of films; the technique is described in studies [Kragelsky 1977, Andrews 1975]. However application of the said technique for conditions of dynamic wheel - rail contact area is rather limited. It is required to use other recording media for parameters of the contact spot that would allow real-time recording of information in a format suitable for processing and storing using modern computing machinery.

In essence, determination of material properties is reduced to measurement of changes in certain parameters of the used physical fields. In other words, if the test object with some unknown in advance abilities to resist external actions is impacted by a physical field having known or preset parameters, the changes in parameters of the used field, caused by response of the object, will represent "imprint" of the object's properties over the range, given by the physical field type. At that, "echo" of reaction will be noticeable in spaces of other fields as well, but as indirect "imprints" or secondary reaction. For instance at expose to thermal field, thermal characteristics will represent direct reaction, while mechanical, electromagnetic, etc. – indirect reaction. If object is exposed to a mechanical vectorial field, the direct reaction characteristics will fall into mechanical characteristics, and the indirect effects can be observed in thermal, electromagnetic and other fields.

«Metal magnetic memory» method (MMM) based on interrelation of dislocational processes with physics of the magnetic phenomena in metals has been described in studies [Dubov 1994]. The information-carrying medium about mechanical stress is the intrinsic magnetic dispersion field (IMDF) of physical bodies having ferromagnetic properties. Generation and alteration of IMDF under influence of mechanical loadings is caused by formation and transformation of domain boundary borders on high-density piling-up of dislocations (dislocation wall) under the effect of mechanical loadings.

Basing on MMM provisions the author has developed the method for determination of parameters of a trace left by wheel on the roll surface of rail in conditions of dynamic interaction [Malakhov 2005]. Alteration in topology of IMDF of the roll surfaces of wheel and rail during their force interaction is used as information-carrying medium.

RESULTS AND DISCUSSION

Experimental results confirming main provision of the suggested method are presented in studies [Malakhov 2006].

Plan of installation intended for evaluation of geometrical parameters of the trace left by wheel tread surface of the top rail surface is shown in fig. 1.

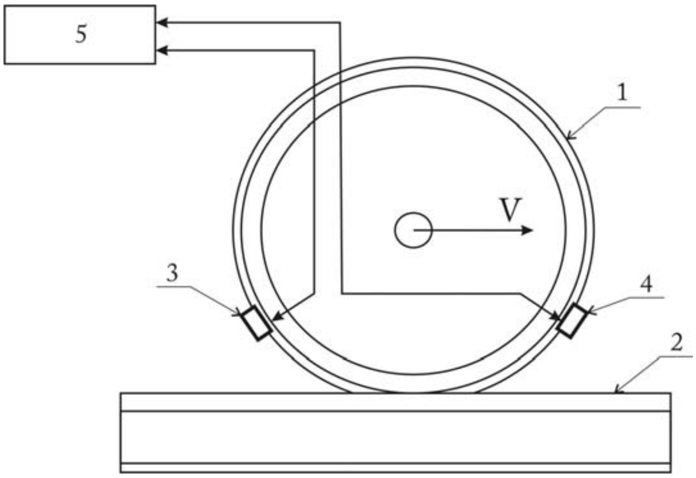

Fig. 1. Plan of the installation for evaluation of geometrical parameters of the trace: 1 - wheel, 2 - rail, 3, 4 – bars of flux-gate sensors, 5 - signal processing device

Two bars of flux-gate sensors are located above the wheel tread surface, the first (3) - before wheel - rail contact spot and the other one (4) – after, relative to driving direction of the rolling-stock. Actually, alternative location of measuring bars above the roll surface of a rail – before and after the contact spot – is also possible. However, practically it is easier to locate the bars against the wheel tread surface, as it provides less risk of damage of the measuring bars during movement of the train. When mounting the bars above the rail surface, it is difficult to maintain the required working clearance (3-5 mm) and in addition to ensure safe passage over turnout switches and rail joints. Experimental studies have proved identity of the obtained results for both mounting variants in slowing-down and traction modes. In the wheel-slipping mode, due to the increased value of slip of wheel and rail, the situation starts to differ, but informativeness of the obtained results is kept.

In motion both bars take continuous measurement of the magnetic-field intensity topology above the roll surface. The signal processing device forms cyclic two-dimensional array that represents the resulting topology of magnetic-field intensity above the roll surface as difference of readings before and after wheel force - rail interaction. Subtraction of instant measurement results is carried out considering time shift defined by final rotary speed of the wheel.

CONCLUSIONS

On grounds of conducted experimental studies, conclusions regarding efficiency of implementation of the suggested method for determination parameters of a dynamic contact spot have been made.

The results of analytical forecasts, proved experimentally, have shown that horizontal component of magnetic-field intensity H_y perpendicular to the wheel rolling direction is mostly informative.

Analysis of changes in parameters of the dynamic contact spot in time allows obtaining forecast for reaching of mode of realization of limiting traction forces, used for generation of the control action on power installation of the rolling-stock for the purpose of avoiding occurrence of the wheel-slipping mode.

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ОПРЕДЕЛЕНИЕ ПАРАМЕТРОВ ДИНАМИЧЕСКОГО ПЯТНА КОНТАКТА КОЛЕСА И РЕЛЬСА МАГНИТОМЕТРИЧЕСКИМ МЕТОДОМ

Малахов О.В.

Аннотация. Статья посвящена проблеме повышения эффективности реализации тяговых свойств рельсовых транспортных средств за счет получения более полной картины динамического распределения нагрузок в пятне контакта колесо – рельс в процессе выхода на предельные величины сил сцепления.

Ключевые слова: измерение преобразования, контакт колесо – рельс.