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EXPERIMENTAL RESEARCH ON NOISE SIGNAL EMITTED FROM WHEEL-RAIL CONTACT UNDER DIFFERENT CONDITIONS OF THEIR MUTUAL INSTALLATION.

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Summary. The article touches upon the noise measuring methods. The noise emitted from wheel-rail contact under different angles of attack was tested. The article described construction of roller bench and a computer system for an analysis of experiments' results and their constituent parts, which enables to transform analog sound signals to digital ones and proposed research methods for noise measuring in rigid and rubber wheel pair.

Key words: roller bench, experimental carriage, noise, measuring, wheel-rail contact.

INTRODUCTION

Ukraine's involvement into European integration process and its intentions to gain membership in the World Trade Organization results in the country's participation in European and world economies' development. Consequently, it will contribute to the transportation system development. A considerable part of cargo transportation is due to railway transport, the competitiveness of which depends on the speed and the convenience level of transportation. There arises a necessity to bring the electric train average speed in accordance with European Union standards, which respectively requires measures to be taken in order to provide the safety of traffic. For this purpose an increase of freight transportations and train speed growth makes the role of operative control over railway vehicle's unit parameters more essential. The wheel pair and its interaction with rail track is a key element influencing the safety of traffic.

Present day monitoring systems are imperfect, containing a considerable number of ununified devices and different control methods. A single standard based on TSI developed instructions for work stimulation intended for existing wheel-rail position monitoring systems' perfection is now being worked out in Europe.

At present Ukraine does not conduct a railway vehicles monitoring of the wheel position relative to the rail. In the railway systems of Western European capacity-based and inductive sensors are used for monitoring of the wheel position relative to the rail. The control is most likely put into effect in underground railways and in regions with safety regulation risks (bridges, tunnels, etc).

OBJECTS AND PROBLEMS

The aim of the research is the development of noise measuring methods for the noise emitted from wheel-rail contact under different angles of attack.

According to the investigations in the field of railway transportation, the methods of the angle of attack estimation, judging by the emitted noise, may be applied to wheel position detection [4]. The analytic method may be applied for an estimation of the wheel position relative to the rail, determining the position from angles of attack estimation. An experiment on railway transport roller bench was carried out at railway transport department of East Ukraine Volodymyr Dahl National University.

The roller bench is constructed on the basis of a serial diesel locomotive 2ТЭ10Л triaxial bogie, installed on a base in reverse position, wheel pairs up. The wheel pairs' bands are grinded in rail head' configuration and serve a footprint for the experimental carriage's wheel pairs, installed upon the rollers.

For the retention of the whole construction of the experimental carriage on the rollers in longitudinal direction in the midportion of the roller bench an articulated rod is installed horizontally. It connects the carriage chassis midportion with the bench chassis. The experimental carriage chassis consists of two parts, named for convenience in the following way: elastic wheel pair semi-chassis and rigid wheel pair semi-chassis. Two parts of the chassis are interconnected with hinge and rotary rods.

Fig. 1 demonstrates: 1 – rigid wheel pair semi-chassis (RWP); 2 – elastic wheel pair semi-chassis (EWP); 3 – swing hinge carriage semi-chasses connection; 4 – force sensor; 5 – rail imitation; 6 – support rollers of the roller bench; 7 – wheel pairs RWP and EWP side-travel sensor; 8 – support chassis of rollers fastening; 9 – hinge rod, keeping the experimental carriage on the roller bench; 10 – ballast for the experimental carriage loading, ballast mass is 3,5 t.

Gear of the roller bench support rollers is put into effect from the experimental carriage wheels due to frictional force between the wheels and rollers. Experimental carriage wheels are equipped with individual electric drive for each of the four wheels. Transmission from each traction motor to its wheel is V-belt, it allows to considerably decrease the noise level in the course of research. Speed change is attained due to the voltage regulation, fed by the dynamotor to the electric motors' anchor cable.

Table 1. Basic technical data

1. Wheel base of an experimental biaxial carriage	4200 mm
2. The rollers diameter	1050 mm
3. The wheel diameter	1050 mm
4. The wheel load	115 kN
5. reversed motion speed (limited by elastic wheel pair construction)	150 km/h
6. the experimental carriage gear: electrical with V-belt drive, individual for each wheel	Electric motor ПП-330
7. Nominal power of dynamotor	100 kW
8. Consumed power from wheel roller bench gear at U=220 V	60 kW
9. The sum of consumed power from a roller bench power grid	up to 80 kW
10. Roller bench mass without a ballast	33 t.
with a ballast	53 t
11. HWD of bench, inch	3150x1378x1575

An object of the research is the experimental biaxial carriage, whose angle of wheels and imitated rail rollers attack has been changed.

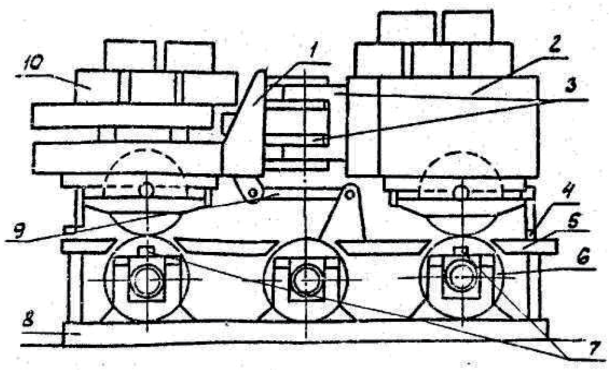

Fig. 1. A circuit of the experimental carriage, installed on the roller bench

Devices with measuring strain sensors (dynameters) are installed in order to measure side-forces in axle-boxes on axial supports of the roller bench's rollers.

The wheel experimental carriage and roller bench electric gear system includes:

power unit – dynamotor with power of 100 kW, generating regulated voltage of direct current for four carriage electric motors' feeding;

four electric motors of direct current, assembled on the experimental carriage, put individual gear of each of the four carriage wheels into practice via V-belt transmission;

start-up and regulating equipment of dynameter;

rotational velocity of RWP and EWP indicators.

Frictional forces' role in horizontal plane is almost excluded due to the application of wheel pairs with non-rotating axes and with loose setting on the right and left wheel axes.

The roller bench with the help of the carrier enables the wheel pair position relative to the rail to be changed. (Fig. 2) The angle of attack is calculated on the following formula:

$$\frac{Y_A - Y_1}{L} = \alpha_1, \tag{1}$$

α_1 – the angle of wheel-rail attack;

□ – the length of the carrier;

□$_1$, □$_A$ – a traverse error according to a wheel pair point □1□ and a carrier guide point □A□.

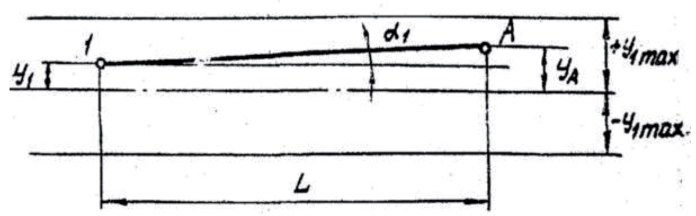

Fig. 2. A circuit of a wheel pair device with a carrier in the rail track

Y – travel was calculated with the eccentric gearing assistance (Fig. 3). Then an angle of wheel-rail attack was calculated. Y-axis travel change was carried out with the help of the device (Fig. 4).

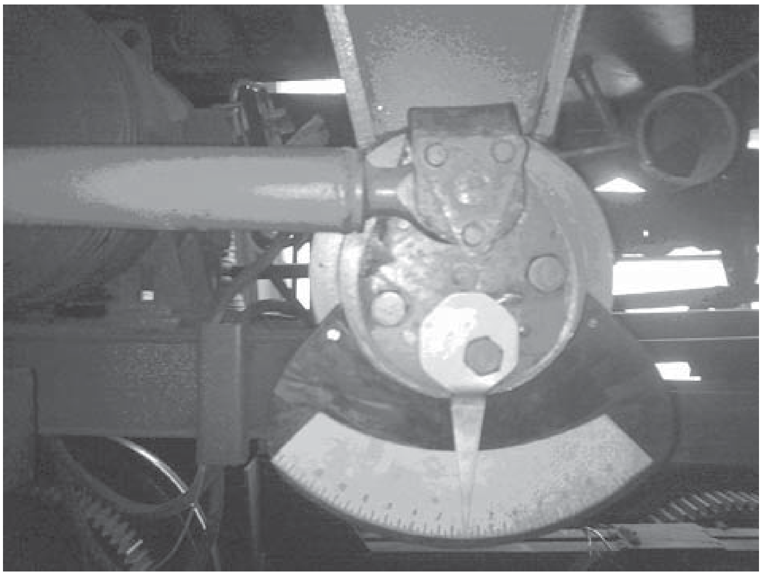

Fig. 3. Eccentric gearing

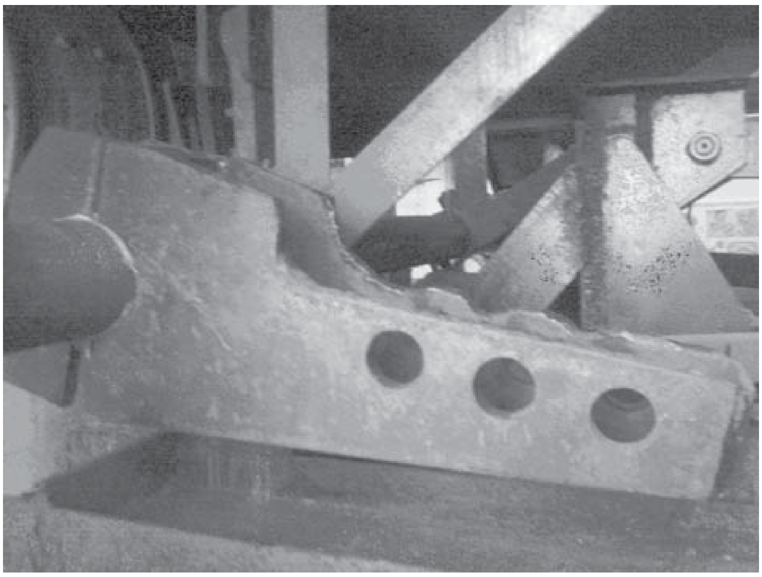

Fig. 4. Device for the wheel-rail (roller bench) travel

For the noise signal study, a roller bench was additionally equipped with a noise-recording device. It consists of a directional microphone with M-101 head, a control console (mixer), card ADC (analog-digital converter) (Fig. 5) and a recording-storage device, a PC in particular. A circuit of measuring equipment is displayed below (Fig. 6).

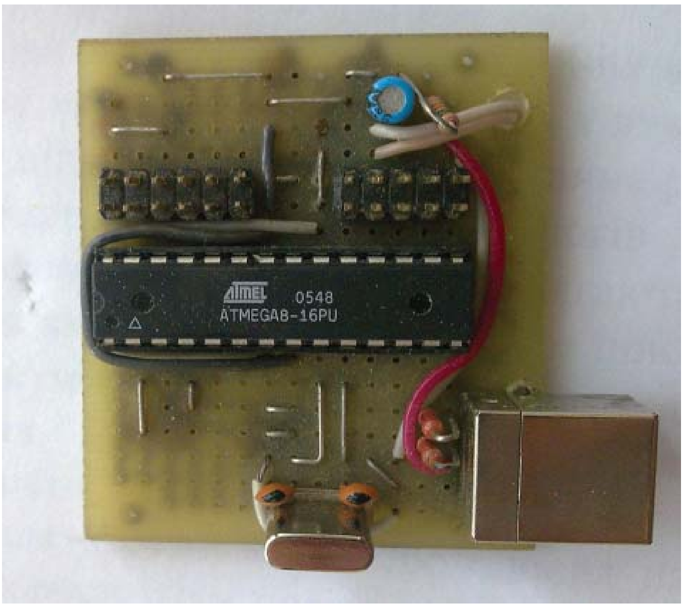

Fig. 5. ADC card

For rotational velocity and wheel-rail (roller) slip velocity measuring the sensors which read magnetic marks' instrumentation data were used (Fig. 7). The data was transmitted to the digitized device and processed by the software, created by authors of the article.

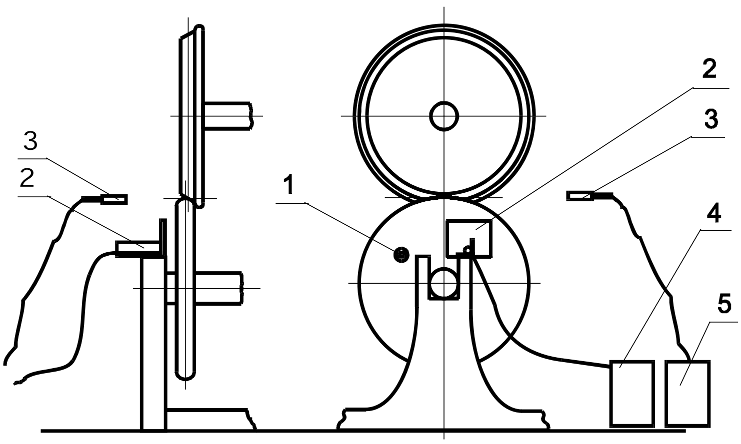

Fig. 6. A circuit of measuring equipment position: 1 – roller bench roller's magnet; 2 – speed sensor; 3 – microphone; 4 – ADC card; 5 – sound-level meter.

Fig. 7. A circuit for the roller bench's wheel pair traverse s peed measuring

The rotational speed is calculated on the following formula:

$$W_k=1/t_k. \quad (2)$$

The rail speed of rotation:

$$Wp=1/tp. \quad (3)$$

The slip velocity is calculated on the formula:

$$V_{ck}=1-w_p/w_k. \quad (4)$$

In the course of test conducting:

– head positioning and noise signal sensor direction in wheel-rail contact with a laser point was carried out;

– a wheel was equally sectored and magnetic marks were put into the corresponding sectors, then a sensor was installed (Fig. 8);

– the digitized device's gauging of the rotational velocity measuring was conducted with the help of the roller bench;

– the microphone gauging was carried out with the assistance of the mentioned ВШВ-003 sound-level meter [5], then the noise was recorded in a computer program Environmental noise Analyzer v.5.0.2.0. An "Automatic Measurement" mode was chosen. In the course of measuring, the noise was recorded only in case of the fixed noise level elevation. Microphone calibration with the help of a sound-level meter was carried out in the course of measuring. When the measurement was over, the data was saved in the database on a PC outer medium and later analyzed with "Noise Analyzer" in Environmental Noise Analyzer v.5.0.2.0. program.-

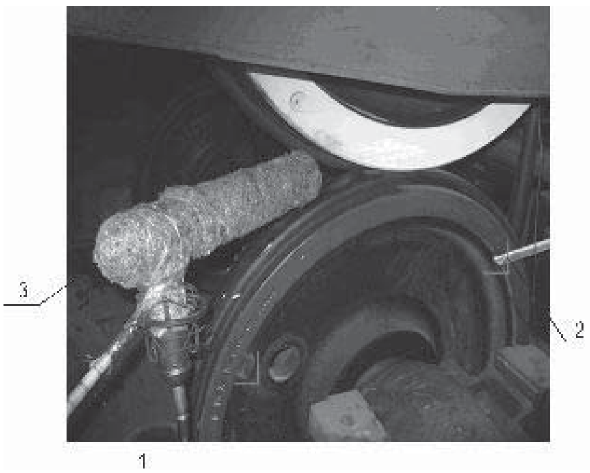

Fig. 8. Measuring device and workspace photo: 1 – roller magnet; 2 – sensor; 3 – directed microphone

In order to reach an accurate measurement, the noise was tested in a premises with no running power units (noise in the premises), then noise-recording with a running power unit was conducted. Later on, the noise recording of a running roller bench in wheel-rail contact was made. In the course of processing the noise in the premises and the running roller bench noise were removed with the help of the Environmental Noise Analyzer v.5.0.2.0. program.

CONCLUSION

The suggested methods enable measurement of noise emitted from the wheel contact at different wheel-rail positions and mutual sliding as well as different rotational speeds (velocity of travel).

According to the measurement results one may form emitted noise and angles of attack dependence characteristics.

The suggested methods provide the implementation of a high-level experimental research of a noise signal emitted from wheel-rail contact under different conditions of reciprocal placement.

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BADANIA EKSPERYMENTALNE SYGNAŁU HAŁASU WYDZIELANEGO PODCZAS KONTAKTU KOLO-SZYNA W RÓŻNYCH WARUNKACH ICH WZAJEMNEJ INSTALACJI

Streszczenie. Niniejsza praca podejmuje temat metod mierzenia hałasu. Testowano hałas emitowany podczas kontaktu koła z szyną pod różnymi kątami. Artykuł opisuje konstrukcję układu kołowego, system komputerowy do opracowania wyników eksperymentów oraz ich części składowych umożliwiający transformację analogowych sygnałów dźwiękowych na cyfrowe oraz proponowane metody badawcze mierzenia hałasu w sztywnych i gumowych parach kół.

Słowa kluczowe: układ kołowy, pojazd eksperymentalny, hałas, pomiary, kontakt koła z szyną.