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Experimental research procedure of roller forming unit

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Abstract. Experimental research is conducted followed by a comparative analysis of the results, which are obtained in the process of theoretical and experimental studies, to check the theoretical research adequacy of the roller forming unit with the crank drive.

We have developed the experimental research program for the roller forming unit with the crank drive. The research stand of roller forming with the crank drive was used for experimental studies. This research stand allows you to carry out full-value experimental studies on the determination of dynamic loads unrestricted. The experimental research program provides the determination of the interaction force for the compaction roller with the construction mixture, the force in the unit connecting rod, the torque on the unit drive shaft and the power, which is necessary for the realization of the forming process. The determination of these loads will make it possible to realistically assess the condition of the forming unit and rationally carry out its design and operation.

Plan, procedure and processing of experimental research data have been developed. The measuring and recording equipment were selected to determine the force loads of the research stand for conducting experimental studies, which transforms the received numerical data into Microsoft Excel for their processing. The measurement of the force in the connecting rod and the interaction vertical force of the compaction roller with the construction mixture was carried out using strain gauges. These are pasted according to the bridge scheme on the connecting rod and the metal plate, which is located in the form with the building mixture under the compaction roller. RK 435 universal clamps, which make it possible to measure the line voltage, the current strength and the power under unit different load modes, are used to measure the power required for the forming process.

Keywords: unit, forming trolley, motion mode, force, torque, power, experimental research, program, procedure, measuring and recording equipment.

INTRODUCTION

Significant dynamic loads occur in elements of the drive mechanism and forming trolleys in units for roller forming of products from construction mixtures during the operation [1–10]. The motion dynamics of the forming trolley and its influence on the forming process have not been studied until now. This is despite the rather extensive research into the technological process of establishing reinforced concrete products by the vibration-free roller method [1–5]. Little attention was paid to the forces, which arise in elements of the drive mechanism and the forming trolley.

Design parameters and performance of machines for roller forming of reinforced concrete products are substantiated in existing theoretical and experimental studies [1–5]. At the same time, insufficient attention is paid to the research of acting dynamic loads [6–10] and motion modes [11–13], which significantly affects the operation of the unit and the quality of finished products. At the time of constant start-braking motion modes, significant dynamic loads occur in elements of the drive mechanism and forming trolley, which can lead to premature unit failure [6–10]. Thus, experimental determination of the interaction force for the compaction roller with the construction mixture, the force in the unit connecting rod, the torque on the unit drive shaft and the power necessary for the realization of the forming process are an actual problem.

PURPOSE OF THE PAPER

The purpose of this paper is to develop the program and experimental research procedure of the roller forming unit.

RESEARCH RESULTS

As a rule, natural research objects or their models are used for experimental research procedures. In the natural experiment, means of experimental research interact directly with the research object, and in the model experiment – with its simulated prototype. The model acts as the experimental research means and the direct research object at the time of the model experimental research procedure.

An experimental stand of roller forming with the crank drive was used for experimental research [1]. The diagram and the experimental stand of roller forming with crank drive are presented in Fig. 1 and Fig. 2.

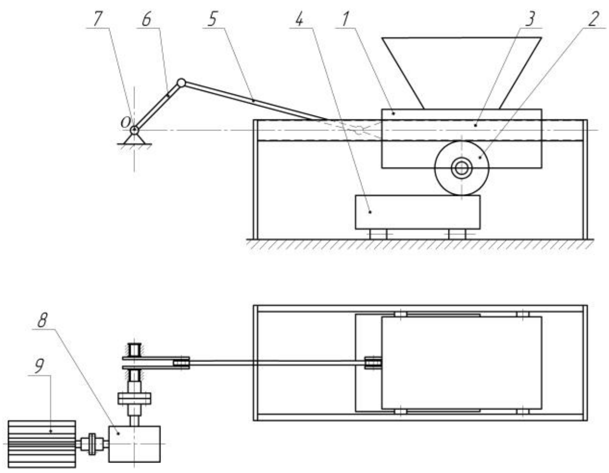

Fig. 1. Stand diagram: *1* – forming trolley; *2* – compaction roller; *3* – motion guides of the forming trolley; *4* – form; *5* – connecting rod; 6 – crank; *7* – drive shaft; *8* – worm reduction gearbox; *9* – electric motor

Fig. 2. Experimental stand of the roller forming with crank drive

The test stand of roller forming with crank drive (see Fig. 1) consists of the forming trolley 1 with the compaction roller 2, which makes the reciprocating movement in the motion guides 3 above the form cavity 4. The forming trolley is driven in the reciprocating direction by the connecting rod 5 from crank 6, fixed on the drive shaft 7. The torque to the drive shaft is transmitted from the electric motor 9 through the worm reduction gearbox 8.

The drive of the test stand for roller forming with the crank drive is carried out by 4A112MA6U3 three-phase alternating current electric motor with 3.0 kW power and 945 rpm rotary speed through the worm reduction gearbox with 24 gear ratio.

The presented research stand allows you to carry out full-value experimental studies on the determination of dynamic loads unrestricted.

Significant dynamic loads occur in the unit and drive elements at the time of operation, which can be several times higher than the average static loads [1–10]. The determination of these loads makes it possible to realistically assess the condition of the forming unit and rationally carry out its design and operation of the developed structures.

The drive shaft with the crank, the connecting rod, which is hinged at one end to the crank and the other to the forming trolley, and the working elements of the forming trolley – compaction rollers are the most heavily loaded elements of the roller forming unit. To determine the loads in these elements we have developed the procedure and scheme of measurements: interaction vertical force of the working element with the construction mixture; force in the connecting rod; torque on the unit drive shaft; power required for the forming process. The scheme of the experimental research procedure on the test stand for roller forming with crank drive is shown in Fig. 3.

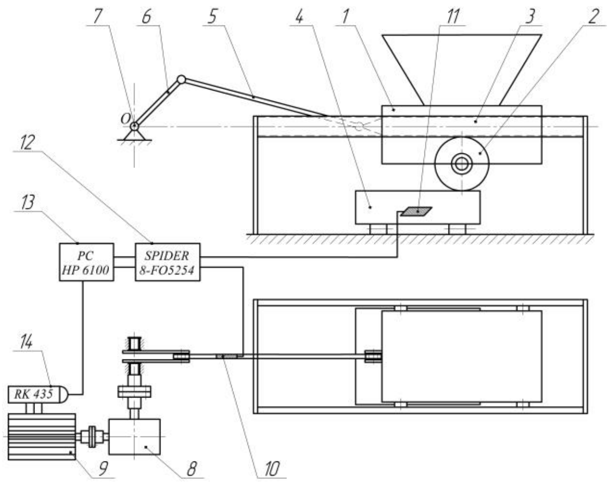

Fig. 3. Measurement scheme of dynamic loads active on stand elements: *1* – forming trolley; *2* – compaction roller; *3* – motion guides of the forming trolley; *4* – form; *5* – connecting rod; *6* – crank; *7* – drive shaft; *8* – worm reduction gearbox; *9* – electric motor; *10* – strain gauge on the connecting rod; *11* – strain gauge on the plate; *12* – amplifier-converter; *13* – personal computer; *14* – universal clamps for engine power measuring

The force measurement in the connecting rod was carried out using strain gauge 10, which according to the bridge scheme [14] is glued on it (Fig. 4). The strain gauge 11 is also used to measure the interaction vertical force of the compaction roller 2 with the construction mixture, which is glued on the metal plate according to the bridge scheme by the known method [14] (Fig. 5). These plates are located in the form under rollers.

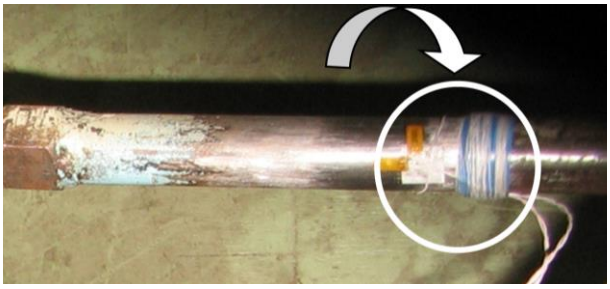

Fig. 4. Location of strain gauges on connecting rod

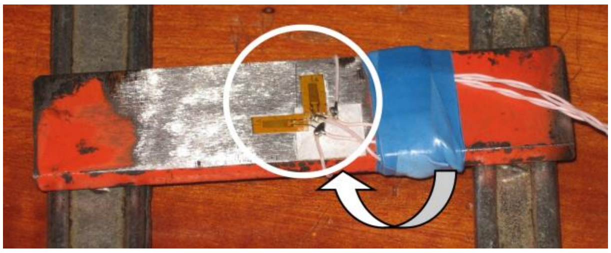

Fig. 5. Location of strain gauges on the plate

Force sensors 10 and 11 were calibrated with the use of fixing equipment. For this, the connecting rod was hung on the bracket at one end (Fig. 6), and the load was attached to the other end. The signal coming from the strain gauge to the recording equipment has a various value for different values of the gravity of the load.

Fig. 6. Connecting rod calibration

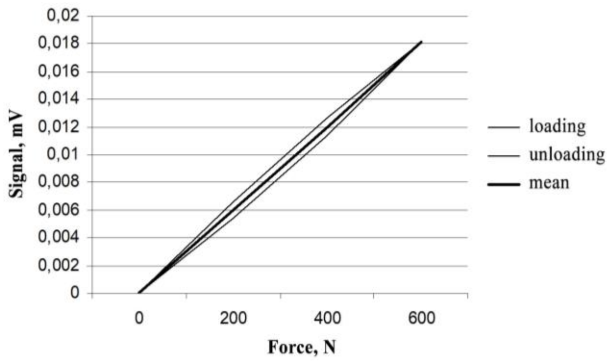

Fig. 7. Connecting rod calibration schedule

The dependence of the signal value on the gravity of the load at the time of loading and unloading, and their mean, are shown on the connecting rod calibration schedule (Fig. 7).

The plate was placed on a stand (Fig. 8) to calibrate, which allowed the creation of loads in the vertical direction. The signal coming from the strain gauge to the recording equipment has a various value for different values of the load. The dependence of the signal value on the load value at the time of loading and unloading, and their average value, are shown on the plate calibration schedule (Fig. 9).

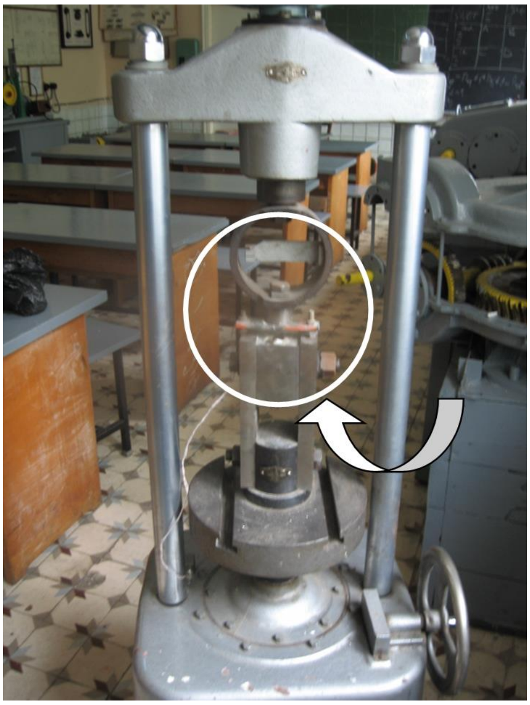

Fig. 8. Plate calibration

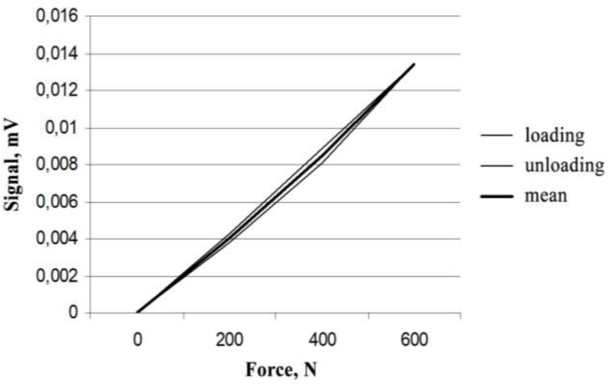

Fig. 9. Plate calibration schedule

RK 435 universal clamps, which make it possible to measure the line voltage, the current strength and the power under unit different load modes, are used to measure the power required for the forming process (Fig. 10).

Fig. 10. Location of RK 435 clamps for engine power measurement

SPIDER 8-FO5254 amplifier-converter and HP 6100 personal computer (notebook) with Catman Express 4.5 software (Fig. 11) are used to read signals from strain gauges, which transforms the received numerical data into Microsoft Excel for their processing.

Fig. 11. SPIDER 8-FO5254 amplifier-converter and HP 6100 personal computer (notebook) with Catman Express 4.5 software

The peculiarity of this measuring equipment is that the selected devices can read from sensors and convert into numerical data up to 1,000 pulses per second and simultaneously record measurement results on 6 parallel channels, taking into account calibration data.

The dynamic load assessment of the laboratory roller forming unit with the crank drive was carried out based on a full-factor experiment thanks to the use of high-tech measuring and recording equipment, which allowed to quickly and without repetition obtain accurate results from primary data.

The force measurement in the connecting rod and the interaction vertical force of the compaction roller with the construction mixture were carried out in the operation mode. The results of the force experimental data in the connecting rod and the interaction vertical force of the compaction roller with the construction mixture on the recording equipment were fixed in force units, in newtons, due to the previous calibration of the strain gauges on the connecting rod and plate.

The power measurement required by the electric motor for the forming process was also carried out in the operating mode.

The values of the line voltage and the electric motor power thanks to RK 435 universal clamps were fixed in manual mode and did not require processing after that.

The experimental data results of the dynamic load of the laboratory experimental roller forming unit with crank drive were processed on personal computer using Microsoft Excel. We developed the proper algorithm for this purpose. It allows us to assess the dynamics of the processes for force changes in the connecting rod and the torque on the drive shaft based on the data obtained.

CONCLUSIONS

The experimental research program was developed for the roller forming unit with the crank drive as a result of the conducted studies. The test laboratory stand of roller forming was used for the experimental research procedure, which allows you to carry out full-value experimental studies on the determination of dynamic loads unrestricted.

The experimental research program provides the determination of the interaction force for the compaction roller with the construction mixture, the force in the unit connecting rod, the torque on the unit drive shaft and the power, which is necessary for the realization of the forming process. The determination of these loads will make it possible to realistically assess the condition of the forming unit and rationally carry out its design and operation.

Plan, procedure and processing of experimental research data have been developed. The measuring and recording equipment were selected to determine the force loads of the research stand for conducting experimental studies. It transforms the received numerical data into Microsoft Excel program for their processing.

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Методика експериментальних досліджень роликової формувальної установки

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Анотація. З метою перевірки адекватності теоретичних досліджень роликової формувальної установки з кривошипно-шатунним приводом проводяться експериментальні дослідження з наступним порівняльним аналізом результатів, отриманих в процесі теоретичних і експериментальних досліджень.

Для роликової формувальної установки з кривошипно-шатунним приводом розроблено програму експериментальних досліджень. Для проведення експериментальних досліджень використано дослідний стенд роликового формування з кривошипно-шатунним приводом. Даний дослідний стенд дозволяє проводити повноцінні експериментальні дослідження з визначення динамічних навантажень без будь-яких обмежень. Програмою експериментальних досліджень передбачено визначення сили взаємодії укочувального ролика з будівельною сумішшю, зусилля в шатуні установки, крутного моменту на привідному валу установки та потужності, необхідної для здійснення процесу формування. Визначення цих навантажень дасть можливість реально оцінити стан формувальної установки і раціонально здійснювати її проєктування та експлуатацію.

Розроблено план, методику проведення та обробки даних експериментальних досліджень. Для проведення експериментальних досліджень підібрано вимірювально-реєструвальне обладнання для визначення силових навантажень

дослідного стенда, що трансформує отримані числові дані в пакети програми Microsoft Excel для їхньої обробки. Вимірювання зусилля в шатуні та вертикальної сили взаємодії укочувального ролика з будівельною сумішшю здійснювалося за допомогою тензодатчиків, які за мостовою схемою наклеєні на шатуні та на металевій пластині, що розміщується в формі з будівельною сумішшю під укочувальним роликом. Для вимірювання потужності, що необхідна для здійснення процесу формування, використовуються універсальні кліщі PK 435, які дають змогу вимірювати напругу в мережі, силу струму та потужність одночасно за різних режимів навантаження установки.

Для зчитування сигналів з датчиків застосовується підсилювач-перетворювач SPIDER 8-FO5254 та персональний комп'ютер HP 6100 з програмним продуктом Catman Express 4.5, що трансформує отримані числові дані в пакети програми Microsoft Excel для їхньої обробки. Особливістю даного вимірювального обладнання є те, що підібрані прилади здатні зчитувати з датчиків та перетворювати у числові дані до 1 000 імпульсів в секунду і проводити одночасний запис результатів вимірювання по 6-ти паралельних каналах.

Ключові слова: установка, формувальний візок, режим руху, сила, крутний момент, потужність, експериментальні дослідження, програма, методика, вимірювально-реєструвальне обладнання.