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EXPERIMENTAL STUDIES METHOD OF CONTROLLED GRAVITATIONAL LEAKAGE OF GRAIN MATERIALS FROM PHYSICAL MODEL OF DUMP HOPPER

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Abstract. In the article, for the purpose substantiate the parameters and operating modes of the harvester`s unloading devices, the method of experimental studies of controlled gravitational leakage from the dump hopper and its physical model is proposed. The peculiarity of the program for the study of free-flowing material`s leakage involves three stages, which include a joint common goal, individual experiments, the execution of which ensures the verification and, if necessary, the correction of the theoretical provisions, considerations and conclusions on improving the efficiency of the production process of harvesting grain crops. The research consisted of: the original experiment (the establishment of mechanical and technological properties of the working grain material of the main crops); modelling (construction and verification of the dump hopper`s physical model); the main experiment (studying the movement of grain from the dump hopper).

Key words: grain harvester, tipper bunker, technique, experimental study, gravitational turn, grain materials, method.

Introduction

The development of structures and justification of the parameters and operating modes of the unloading devices is an important part in solving the general problem - increasing the efficiency of the production process of harvesting grain.

Formulation of Problem

The identified scientific problem is an important part of the implementation of the scientific program of the mechanization of production processes in crop production and is executed in accordance with the topics of scientific research: «Optimization of the modes of movement of Hoisting-and-transport machines and mechanisms used in the mechanization of production processes in livestock and crop production» state registration 0105U007502 and the state budget theme «Development of the concept dynamic optimization of transportation vehicles» state registration 0115U003551. The decision of this important scientific and practical task was attended by the scientists of the National Scientific Centre "Institute of Agriculture of the National Academy of Agrarian Sciences of Ukraine" (Nedovesov V.I.), the National University of Life and Environmental Sciences of Ukraine (Loveykin V.S., Chovnyuk Yu.V., Matuhno N.V., Shymko L.S.). Within the framework of the study, one patent for the invention and three patents for the utility model of Ukraine were obtained [1-4].

The experimental confirmation of research on the physical and mechanical properties of the working (bulk) material, as well as the structural, kinematic and dynamic characteristics of rapid gravitational currents, makes it possible to substantiate the technological and structural parameters of the tipping-off unloading devices, which significantly affect the quantitative and qualitative parameters of the unloading process.

Analysis of Recent Research Results

Most of the scientific works on flows in a loose environment are devoted to studies of internal leakage in bunkers and funnels. Takahasi [5] researched the gravitational leakage of dry sand of different structures in straight trays of a rectangular cross-section at different angles of slope trays. The scientist highlighted two types of leakage of a friable body: the first is that the upper thin layer of particles flows over their stationary layer that covers the bottom of the tray, and the second - in that all particles of the flesh body are moving, moreover, each of the particles chaotically deviates by chance trajectory and interacts significantly with neighboring ones.

Roberts [6, 7] studied the leakage of millet seeds in Plexiglas trays with a rectangular cross-section. Applying in his studies of high-speed cinematic, the scientist determined the velocities profiles at various points along the flow and revealed a small velocity gradient along the depth of the stream.

Ishida M., Shirai T. [8] were measured the velocity profiles using fiber optic probes located on the central trench line, and not on the side walls, as in Sevidzhi experiments [9].

Thus, the analysis of the above-mentioned studies and experimental results obtained by scientists shows that in the shear flow of granular material there can exist three main mechanisms of the emergence of stress: a) dry

friction; b) impulse transfer due to the transfer of particles from one layer to another; c) impulse transfer due to collisions between particles [10].

Dolgunin V.M. and Borshchov V.Ya. [11, 12] are used to check the adequacy of the experimental-analytical method by the X-ray method of determining the profile of a distinctness in the gravitational flow of grains. The method proposed by these scientists is based on the use of penetrating X-ray irradiation and fixing it on an X-ray film.

Unfortunately, in Ukraine, experimental studies concerning the processes with bulk materials are not so numerous and there are no studies related to the study of the laws of the gravitational leakage of grain and vegetable material from the dump hopper of combine harvesters.

The problem is rampant that grain material is damaged by screw working organs thoroughly studied and experimentally investigated in the works [13-15]. However, due to the existing imperfection of the process, along with the widespread distribution and use of various unloading systems of harvesters and a significant number of variants of their constructions, scientific the problem of justification of the parameters and modes of unloading devices requires further study and development.

Purpose of Research

The purpose of the article is to develop a method for experimental study of the controlled gravitational leakage of grain materials from the physical model of the dump bunker.

Results of Research

In previous theoretical studies, a granular material model was developed that was adequate to the properties of agricultural grain materials [17]. Proceeding from this, the program and the experimental research methodology were based on the scheme presented in Fig. 1.

The purpose of these experiments is to determine the characteristics of the gravitational leakage of various grain materials, depending on the value of the dump bunker's turning angle.

In connection with this, in accordance with the analytical model of the free-flowing grains materials unloading process from the dump bunker, described in [17], it was important to determine and experimentally verify the unloading volumes of the experimental grain material at certain fixed values of the bunker`s rotation angles.

The following equipment and materials were used: the physical model of the dump hopper (Fig. 2), the laboratory electronic weights AD 3000 (technical characteristic: the price of the division - 0,01 g; the price of the authorized divisions - 0,1 g; the limits of weighing: the largest: 3000 g, the smallest: 0,5 g; the weight bucket is 150 mm; the weighing time is less than 5 seconds; the operating temperature range is from 18 to 33 ° C.); Variable capacities for weighing of grain material; investigated grain material of the main crops.

When the rash is stopped, the container with grain material should be replaced with empty.

Next, weigh the dropped grain and record in the magazine the number of screw`s full revolutions and the measured weight of the investigated grain material.

In the event that the complete wrapping of the handwheel did not cause leakage of grain material from the dump hopper, carry out the next rotation before the start of the spillage.

If the spill has occurred – repeat the weighing procedure described above.

The research with the next experimental grain material continued until the empty emptying of the experimental dump hopper.

With the same grain material, the experiment was conducted with fivefold repeatability.

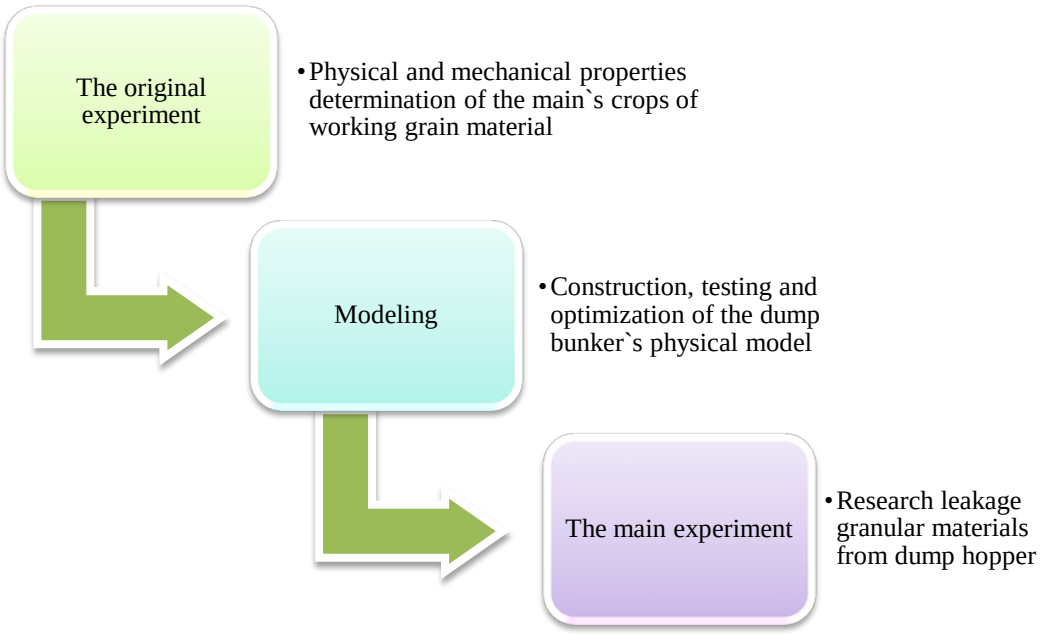
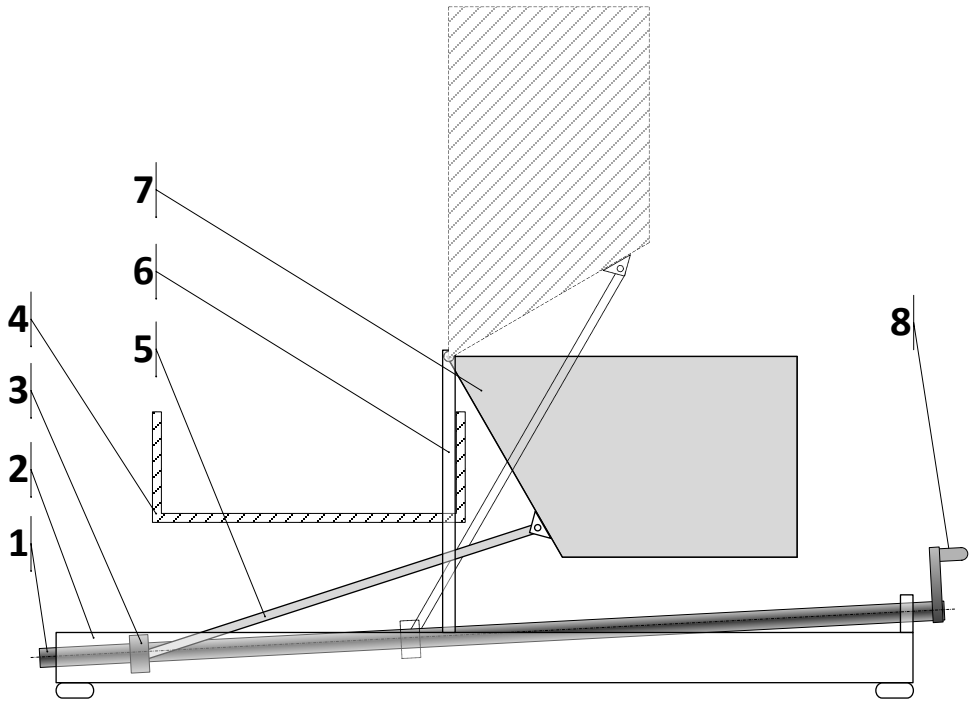


Fig. 1. The scheme of experimental research of a tipper unloading device`s operational characteristics and modes.



1 – a screw; 2 – a foundation; 3 – a nut; 4 – a container;
5 – a lever; 6 – a hinged rack; 7 – a dump hopper; 8 – flywheel.

Fig. 2. The installation`s scheme for experimental studies of controlled gravitational leakage of grain materials from the dump bunker`s physical model.

Table 1. The documenting form of the data for controlled gravitational leakage of grain from the dump bunker`s physical model.

Grain material	Repeat experiment	The flywheel`s revolutions number of the screw mechanism – n_i	The weight of the grained material that has fallen – P_i

Based on the speed of the lifting screw according to the method described in detail in the previous section of this work, the rotation angle of the dump bunker`s physical model was calculated by the formula:

$$\alpha_i = n_i \cdot \frac{90°}{128}, \quad (1)$$

where α_i – is i-th tilt angle of the dump bunker; n_i – is the flywheel`s revolutions number at the beginning of the displacement in the variable capacity of the i - th grain material.

The obtained experimental data were entered in the journal in the form of Tabl. 1.

After each repetition of the experiment, we checked the weighted total volume of the studied grain material, carried out at the beginning of the repetition, with the sum of the results obtained in the course of the experiment in different positions of the hopper. The experimental data were taken up to further analysis and included the repetition of the experiment, if the difference between the sum of the weights in the process of measurement and the total weight of the material did not exceed ± 0,5% of the latter. The systematized trial data was processed and tested according to the standard method of statistical randomization and independent testing of the results using the Microsoft Excel 2016 Analysis Package. The mean square deviation and coefficient of variation were also determined.

Conclusions

1. It is evident that the mechanized technological process of grain-vegetable material's leakage from bunkers-storage vehicles into transport vehicles depends on the parameters under study and the operating modes of the unloading devices of grain-harvesting machines and combines.

2. In turn, the scientific justification of which is impossible without a detailed study of the technological processes and operations peculiarities that associated with the accumulation and overload of grain and vegetable material from the dump bunker [16, 17].

3. In connection with this, the necessary program and experimental research methodology has been developed, which involves three stages, which include a joint common goal, separate researches. The implementation of which provides for verification and if necessary the correction of theoretical provisions, considerations and conclusions on the increase the efficiency of the production process of harvesting at the expense of reasonable parameters and operating modes of the harvester`s unloading devices.

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МЕТОДИКА ЕКСПЕРИМЕНТАЛЬНИХ ДОСЛІДЖЕНЬ КЕРОВАНОГО ГРАВІТАЦІЙНОГО ВИТОКУ ЗЕРНОВИХ МАТЕРІАЛІВ ІЗ ФІЗИЧНОЇ МОДЕЛІ САМОСКИДНОГО БУНКЕРА

Л. С. Шимко

Анотація. У статті, з метою обґрунтування параметрів і режимів роботи вивантажувальних пристроїв збиральних машин, пропонується методика експериментальних досліджень керованого гравітаційного витоку із самоскидного накопичувального бункера збирального комбайна та його фізичної моделі. Особливість програм дослідження витоку сипких матеріалів передбачає три етапи, що включають в себе об'єднані спільною метою, окремі експерименти, виконання яких забезпечує перевірку та, при необхідності, корегування теоретичних положень, міркувань і висновків щодо підвищення ефективності виробничого процесу збирання зернових культур. Дослідження складалися із первинного експерименту – встановлення механіко-технологічних властивостей робочого зернового матеріалу основних культур; моделювання – побудова та перевірка фізичної моделі самоскидного бункера і основного експерименту – дослідження руху зерна із самоскидного бункера.

Ключові слова: зернозбиральний комбайн, бункер, самоскид, техніка, експериментальні дослідження, гравітаційне поле, зерновий матеріал, спосіб.

МЕТОДИКА ЭКСПЕРИМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ УПРАВЛЯЕМОГО ГРАВИТАЦИОННОГО ПОТОКА ЗЕРНОВЫХ МАТЕРИАЛОВ С ФИЗИЧЕСКОЙ МОДЕЛИ САМОСВАЛЬНОГО БУНКЕРА

Л. С. Шимко

Аннотация. В статье, с целью обоснования параметров и режимов работы разгрузочных устройств уборочных машин и комбайнов, предлагается методика экспериментальных исследований управляемого гравитационного потока с самосвального накопительного бункера зерноуборочного комбайна и его физической модели. Особенность программы исследования выгрузки сыпучих материалов предусматривает три этапа, включающих в себя объединенные общей целью, отдельные эксперименты, выполнение которых обеспечивает проверку и, при необходимости, корректировки теоретических положений, рассуждений и выводов по повышению эффективности производственного процесса уборки зерновых культур. Исследования состояли из первичного эксперимента – установление механико-технологических свойств рабочего зернового материала основных сельскохозяйственных культур; моделирование – построение и проверка физической модели самосвального бункера и основного эксперимента – исследование движения зерна с самосвального бункера.

Ключевые слова: зерноуборочный комбайн, бункер, самосвал, техника, экспериментальное исследование, гравитационное поле, зерновой материал, способ.