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V. Petrov, Ph.D., Associate Professor, E-mail: 0673972002@ukr.net,

ORCID: 0000-0003-3262-9463

A. Zhdanov, Ph.D., Associate Professor, E-mail: zhdanov45@rambler.ru,

ORCID: 0000-0002-3304-5729

R. Mazej, Ph.D., Associate Professor, E-mail: matzey1946@mail.ru,

ORCID: 0000-0001-6393-8678

Odessa State Academy of Civil Engineering and Architecture, 4, Didrichson street, Odessa, 65029, Ukraine

AGGREGATED COMPLEXES FOR RICE GRAIN PROCESSING

Abstract

The paper considers various designs of aggregated complexes for the processing of rice grain. Their technological schemes were built and analyzed, and a breakdown into modules was performed. This allowed us to group the various designs of units and summarize their technological capabilities. The general reduced technological scheme of rice grain processing is considered. The noted variations are as far as practical applications with and without a grain cleaning module. Various schemes of hulling of grain and selection of hulled grain from unhulled are presented. The technological schemes with various hulling machines are analyzed (the Engleberg hulling machine, with rubberized rolls, centrifugal action), which have their own characteristics. The differences in the use of paddy machines and trimmers for sorting grain after hulling are considered. The cylindrical triers used to select the rice kernel have an original technological scheme (company Yanmar). This allows you to simplify technological communications and make the unit more compact. The units use more compact paddy machines (reduced size, number of tiers, etc.), which, of course, affects their performance.

The most common combined machine with a single-pass technological scheme (which was named after the first inventor and manufacturer, a hulling machine from Satake) is considered. In addition to laboratory equipment, centrifugal hulling machines are used in grain processing units, which gives additional advantages (a more compact scheme, due to the combination of several technological operations, hulling, transporting the grain stream, and air separation. For the majority of broken and unbroken grains sieve separators are used for simple circuits. Separators with vertical rotation axis, that allows to transport the rice to a predetermined height. This makes it possible to link this separator, for example with electronic scales.

Keywords: stoner, separator, huller, grinding machine, polishing machine.

Introduction

In many countries, along with powerful rice processing enterprises, there is integrated equipment for processing mainly 0.3 - 2 tons of rice per hour. This allows you to quickly use equipment to meet the demand of the population of both agricultural and areas remote from large industrial centers. In some cases, combined machines are used to perform hulling and grinding operations, as well as various stages of grinding. In some areas of Ukraine, farmers grow rice. Currently, the Ukrainian industry does not produce the necessary technological equipment for farmers' rice processing enterprises. The equipment that is imported into our country does not always satisfy consumers in terms of quality. Therefore, the authors provide an overview of modern technological equipment manufactured in various countries.

Analysis of recent research and publications

Unfortunately, there are few publications in the academic literature describing the design of aggregated complexes for the processing of rice grain. Also, there are no technological schemes by which these combined machines are built. The literature mainly describes comparative tests of various technological operations and equipment for their implementation [1-4]. Research is aimed at choosing the most optimal equipment for performing the basic operations of the technological process - hulling, separation at various stages, grinding and polishing. Optimization is performed to reduce energy costs, increase the percentage of

finished products and improve the quality of the final product (for example, reducing the number of broken kernels). A large number of models of aggregated complexes for the processing of rice grain were reviewed, mainly leading companies that have a significant percentage of equipment sales on the international market [5, 6]. This made it possible with the help of technical documentation to compile and analyze various technological schemes of units and combined machines.

The aim of this work is the construction and analysis of structural schemes of existing structures of aggregated complexes for the processing of rice grain.

Research Methodology

The methodology of this study consisted in sequentially performing the following procedures in the analysis of constructive solutions for the processing of rice grain:

- structural division of structures into various technological modules;
- compilation and analysis of technological modules;
- development and identification of common features for classifying the design of technological modules;
- analysis of the advantages and disadvantages of the selected technological modules and assemblies in general.

Research results

Given the need for equipment mobility and its

power from mobile diesel generators, the equipment is maximally compacted, performing part of it in the form of combined machines or as a universal installation made according to the general scheme. During the development of aggregated complexes, most of them refuse to weigh and rough clean grain (Fig. 1).

The grain mixture I elevator 1 raise for cleaning on the air separator 2. Dust and light aerodynamic impurities II are separated from the main stream III. Grain stream III enters the sieve separator 3, which emit large IV and small impurities V. Grain stream VI is directed to a stoner 4, where mineral impurities VII are selected. From the stoner, the cleaned grain VIII is lifted by a fan 5 to a certain height and fed to the hulling head 7. After hulling, rice and husk grain is fed to an air separator 8, which collects dust, flour and husk IX. The punctured grain X is also taken, and the grain mixture from husked and not hulled grains is fed to the paddy machine by fan 9. Unhulled grain XII is usually fed again by fan 5 to the husk head 7. The husked grain XIV is sent to the grinder 11. Stream XIII (the undivided mixture of husked and unhulled grain) is wrapped back in the paddy machine 10. In the grinding machine 11, due to the abrasive action of the rotor and the mesh shell, as well as due to frictional loading between the grains, the upper brown powder is removed, which leads to bleaching of rice grains. Grinding products XV are removed, and grain XVI with a fan 12 is usually fed to a combination machine, which consists of a screen separator 13 and electronic scales 14. In this machine, broken grain XVII is taken from a non-broken XVIII, which is weighed and packaged.

This technological scheme (excluding the grinder) is very common among Japanese, Chinese and other (Korea, India, Thailand, Malaysia) manufacturers of technological equipment for rice processing. The air separator 2 is very often mounted on the material pipe to feed the initial mixture into a complex unit consisting of the main technological equipment: a screen separator 3, a stoner 4 (sometimes not included in the diagram), a peeling head 7, an air separator 8 and a paddy machine 10. Separately install a combined machine, which consists of a screen separator and electronic scales.

Recently, there has been a tendency to replace the peeling head with two elastic rollers with a centrifugal hulling machine, which gives some advantages.

It should be noted that some firms install in the unit a cylindrical trieur, which selects the found grains. Recently, due to increased requirements for the quality of finished products, a scalper is installed separately at the beginning of the line.

A large percentage of rice processing units is performed without a grain cleaning section. Then the technological scheme takes the form shown in Fig. 2.

The unit becomes compact and mobile for operation in several locations. In some models, there is also no grinder 9. Consider an assembly consisting of a hulling head, an air separator and a trieur (Fig. 3). The cleaned grain I is loaded into the hopper 1, from which it enters the hulling head 2. After passing through the working zone between two rubberized rolls, the husk breaks off the grain and a mixture of husk, kernels and unhulled grains II is fed to the air separator 3. Inlet air stream III picks up husk and dust and carries them out of the separator in the form of a stream IV. The hollow grain changes the flight path and is also removed in the form of stream V. The cleaned grain VI is fed to the elevator 4, which picks it up and directs it to the trieur 5. Inlet VII is fed by a screw 6 to the opposite end of the trieur. On the meshed surface of the trieur, the flow changes its direction. Unhulled grains VIII, as a longer fraction, fall out of the cells first and remain on the alveolar surface or fall on screw 6. Rice kernel IX, as a short fraction, falls on the second stage and falls on screw 7.

The rice kernel is transported and removed from trieur in the form of stream IX, which is purged with fresh air XI. This air stream finally takes aerodynamic light impurities and flour, and is reused in the form of the previously considered stream III. Non-husked rice grains that could not rise and get onto screw 6 are removed from the trieur by flow X and sent for re-hulling in the hopper 1. The cleaned rice core (stream IX) is sent to elevator 8 and after rising goes to packing (stream XII), or for further processing.

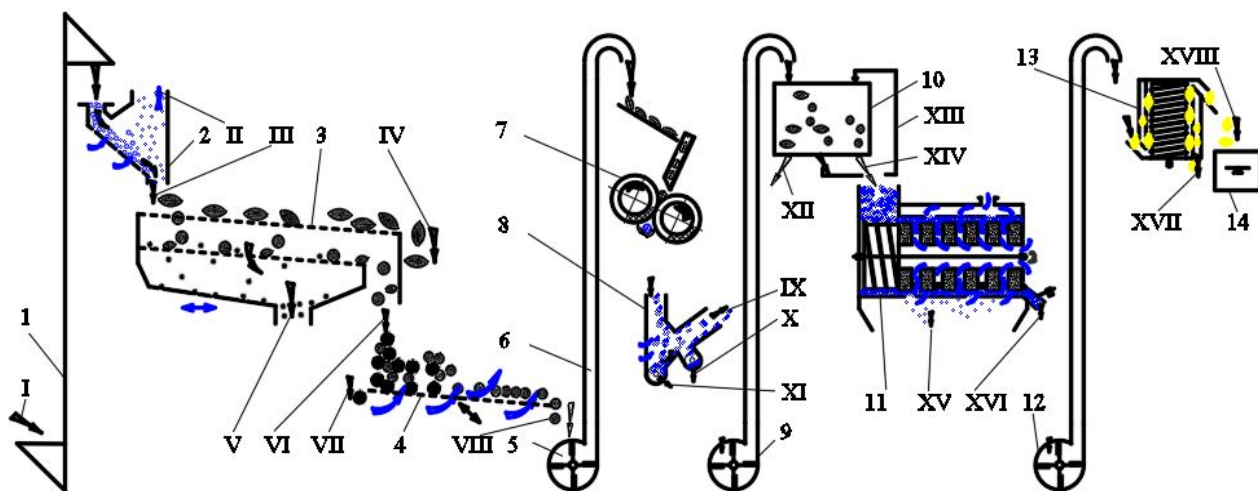


Fig. 1 - An abbreviated technological scheme of rice grain processing:

1 - elevator, 2, 8 - air separators, 3, 13 - sieve separators, 4 - stoner, 5, 9, 12 - fans, 6 - material pipe, 7 - hulling head, 10 - paddy machine, 11 - grinder, 14 - scales. I - XVIII - technological flows.

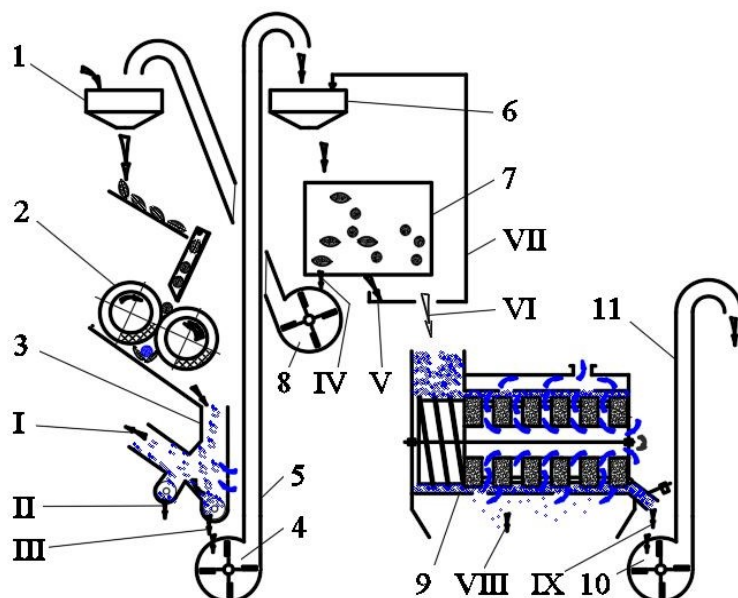


Fig. 2 - The technological scheme of rice grain processing without cleaning:
1, 6 - bins, 2 - peeling head, 3 - air separator, 4, 8, 10 - fans, 5, 11 - material pipelines, 7 - paddy-machine, 9 - grinding machine. I - IX - technological flows.

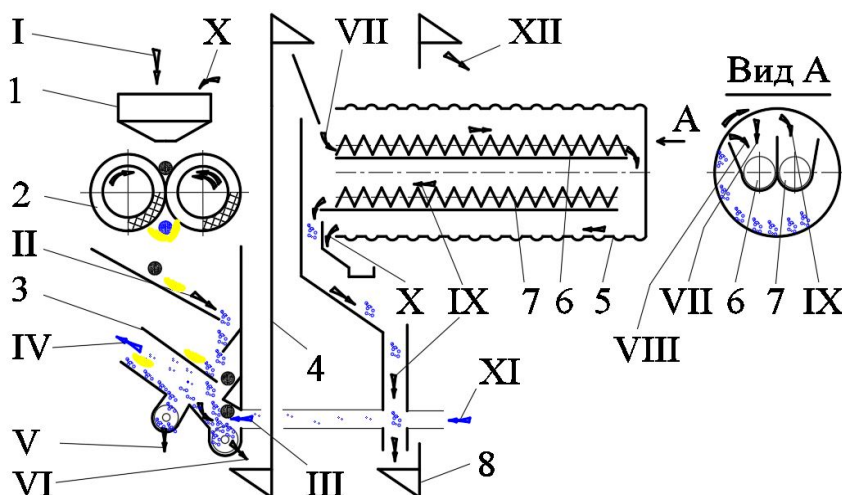


Fig. 3 - The technological scheme of rice grain processing using trieur:
1 - hopper, 2 - hulling head, 3 - air separator, 4, 8 - elevators, 5 - trieur, 6, 7 - screws. I - XII - technological flows.

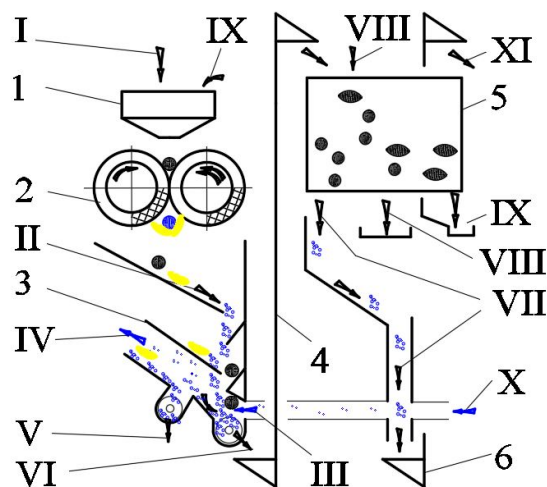


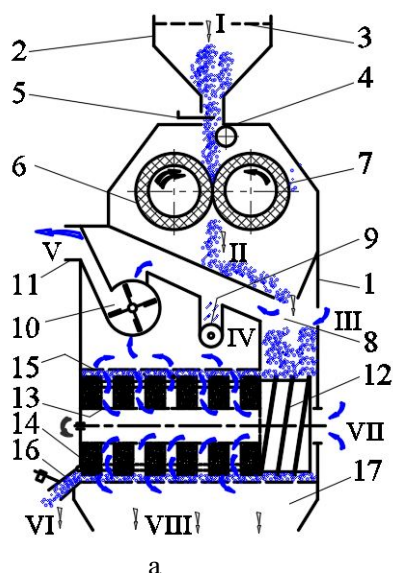
Fig. 4 - The technological scheme of processing grain rice with a paddy-machine:
1 - hopper, 2 - hulling head, 3 - air separator, 4, 6 - elevators, 5 - paddy-machine. I - XI - technological flows.

Instead of trieur, paddy-machines are also used in the hulling and separation modules (Fig. 4). The designations in the diagram are the same as in the previous diagram. They differ in the separation zone in which the paddy-machine 5 is installed. Three process streams emerge from this machine. Stream VII represents husked grain, which is finally blown through with air stream X and elevated by elevator 6 to supply the kernels (stream XI) for packing or further processing.

An inseparable mixture of hulled and unhulled grain (stream VIII) is wrapped at the entrance of the paddy-machine. Unhulled grain that flows in stream IX is returned to hopper 1 for re-hulling.

However, the most popular machines in rural areas of South-east Asia are machines made according to the scheme developed by Satake back in the fifties of the last century, and which is shown in Fig. 5a. These are the so-called single-pass machines. They include a peeling head with two rubberized rolls 6 and 7, which can dramatically increase the efficiency of the hulling operation, an air separator 8 and a machine with abrasive disks 12 for a high-quality grinding operation. Such a combined machine allows you to get a fairly high-quality product at the output. True, sometimes instead of an abrasive machine for a grain, a friction action machine is used that performs the same technological operation.

Consider the technological scheme of a combined machine (Fig. 5a). The machine consists of a casing 1, over which a hopper 2 with an oscillating sieve 3 is mounted. In the casing 1 there is a feeder 4, which feeds the grain to the hulling head. When the machine is operating, the grain flow is manually controlled using the gate valve 5. The husking head is made with two rubberized rollers 6 and 7, which rotate in different directions at different speeds. An air separator 8 is located under the hulling head. A screw 9 is mounted to output the immature grain, and a fan 10 with an air duct 11 is installed to remove the husk.



a



b

Fig. 5 - Scheme a) and general view b) of a combined machine for peeling and grinding grain from Satake:

1 - housing, 2 - hopper, 3 - sieve, 4 - feeder, 5 - valve, 6 - fast-rotating roller, 7 - slow-rotating roller, 8 - air separator, 9 - auger for the withdrawal of immature grain, 10 - a fan, 11 - a nozzle for the output of husks, 12 - a forcing screw, 13 - a hollow perforated shaft, 14 - abrasive discs, 15 - sieve shell, 16 - cargo valve, 17 - collection.
I - VIII - technological flows.

A grinding machine is also mounted in the housing 1. A feeding screw 12 is mounted on the hollow shaft 13 of this machine, creating grain back-up in the grinding zone, and abrasive wheels 14. A rotor representing the shaft 13 with abrasive disks rotates in the sieve shell 15. At the exit from the machine, a cargo valve 16 is mounted to regulate grain back-pressure, and under the sieve shell a collection for the flour 17.

Consider how the machine works. The grain stream I enters through the vibrating sieve 3 into the receiving hopper 2, coarse impurities remain on the screen surface. Then, by the feeder 4, the grain is fed to the rollers 6 and 7 rotating in different directions, where they grab the grain and, under the action of compression and shear forces, carry out the hulling operation. The mixed stream (husked grain, unhusked grain, husk particles and dust) in the form of stream II, is subjected to a purge of air (stream III). The air stream, picking up husk products and dust, carries them out and delivers them to the fan 10. The weak rice grains are lost over the screw 9, which carries them out in the form of stream IV. Dusty air and husk exit the machine in the form of stream V through the nozzle 11. The husked grain by a feeding screw 12 is fed into the milling zone with abrasive disks 14, where additional layers are removed from the grain under the influence of the abrasive action of the disks and sieve shell 15 and the frictional effect of surrounding grains. Particles removed from the kernel are carried out of the working area by a stream of air VII entering the machine through a hollow perforated shaft and passing through a sieve the shell fall into the collection 17 (stream VIII). The main stream of polished grain, overcoming the resistance of the cargo valve 16 comes in the form of stream VI.

In aggregates of small capacity, centrifugal peeling machines are used (Fig. 6). In the housing 1, a centrifugal hulling machine 2 is installed, over which a hopper 3 is installed. A fan 5 is installed on the same

shaft as the hulling machine 2, for air intake with rice hulls and for transporting hulls and dust from the machine (material pipe 6). This allows you to compactly place two process units and simplify the drive of the machine. A material pipe 4 departs from the hulling machine 2 for feeding the mixture into the air separator 7. After the air separator, an oscillating sieve 8 is mounted to separate the unshelled grains.

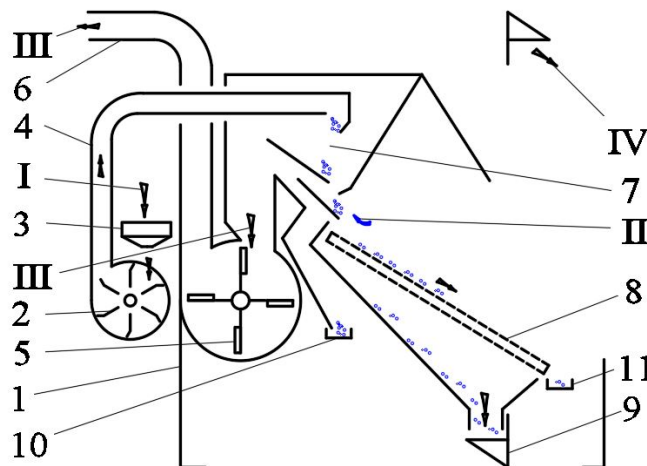


Fig. 6 - Scheme of a combined machine for hulling and sorting grain:

1 - case, 2 - hulling machine, 3 - hopper, 4, 6 - material pipelines, 5 - fan, 7 - air separator, 8 - sieve separator, 9 - elevator, 10 - tray for immature grain, 11 - tray for unhusked grain. I - IV - technological flows.

The machine operates as follows. Grain I is poured into hopper 3 and the valve controls the flow of grain to the rotor of the hulling machine 2. The grain is picked up by the blades of the hulling machine and, under the action of centrifugal forces, slides from the blades, strikes the inner surface of the shell, which is covered with a layer of polyurethane. The grain husk



deforms and opens, and the kernel falls out of the shell. The elastic layer of polyurethane does not allow to split the rice kernel. Grain husking products, husk particles and dust are transported by the pumping air stream through the material pipe 4 to the air separator 7. When the mixture falls in this separator, dust and shells are captured by the inlet air stream II. The air with husk enters the fan 5 and, under the action of centrifugal forces, is discharged through the air duct 6 behind the machine (in some models, the air duct length is up to 30 meters). The immature grain deviates from the vertical trajectory and is sent to the tray 10. The main grain flow enters a sieve 8, designed to separate the unhulled grain, which is collected on the tray 11. And the selected kernel is sent to elevator 9 for feeding it (stream III) for subsequent technological operations or packaging. In some machine models, a broken core is also selected.

Consider the scheme of a machine for grinding a rice kernel of small productivity (Fig. 7). A shaft 2 with a screw 3 and a rotor 4 is located in the housing 1. The grain inlet to the working area is regulated by a valve 5. At the outlet of the working area, a lever 7 with a valve 8 and a handle 9 is mounted on the axis 6. The position of the valve 8 is fixed by the handle 9 on the gear sector 10. To unload the processed grain, a valve 11 is pivotally located on the axis 12. The lower part of the body in the working area is made in the form of a mesh 13, to remove the flour.

The machine operates cyclically as follows. In the hopper of housing 1, hulled rice grain is poured (stream I). The timer sets the time for processing a portion of grain. The drive of the machine is turned on, which drives the shaft 2 with the screw 3 and the blade rotor 4. The valve 5 is opened to feed grain into the working area of the machine. The grain is carried away by the screw 3 and is pumped into the area of the rotor 4. The blades pick up the grain and due to friction between the grains, grains and blades, as well as the net, the surface brown layer is removed from the grain of rice. The separated particles of the surface layer in the lower part of the working area are removed from the machine through the mesh 13 (stream II). The main grain flow rises again into the hopper, overcoming the resistance force of valve 8. By changing the position of valve 8, the resistance force of the valve and, as a result, the residence time and pres-

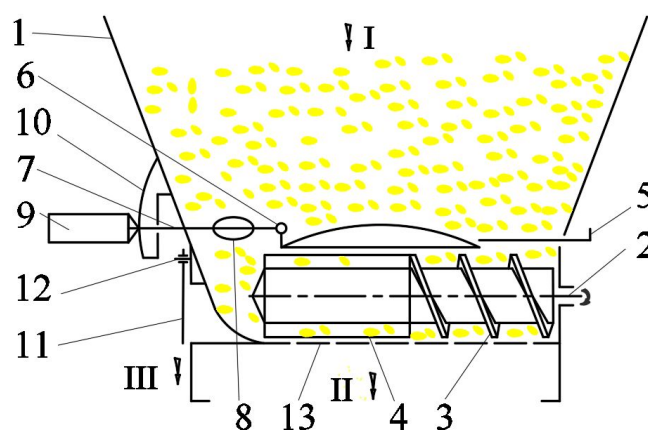


Fig. 7 - Diagram of a machine for grinding rice grains of small capacity:

1 - hopper, 2 - shaft, 3 - auger, 4 - blade rotor, 5 - valve, 6 - axis, 7 - lever, 8 - valve, 9 - handle, 10 - gear sector, 11 - valve, 12 - axis, 13 - sieve.

I - III - technological flows.

sure of the grain in the working area are regulated. Grain for the specified processing time passes several times through the working area and part of the surface layers, which are mainly brown in color, are removed from it, the kernel remains with a good white color. After processing the rice kernel, the valve 11 is opened and the machine is unloaded (stream III).

The machine is mainly used in catering with small volumes of production.

Conclusions

1. Aggregate equipment of small capacity is carried out mainly modular, which allows you to equip the base unit with the necessary modules (cleaning, grinding, polishing, separation and weighing).

2. The hulling module and the separation of hulling products have been adopted as the base module.

3. In such equipment, the percentage of hulling machines with centrifugal action has increased.

4. Instead of mechanical separation, a photo-separation module is installed, which separates the particles by color and shape.

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В. Петров, канд. техн. наук, доцент,

0673972002@ukr.net, ORCID: 0000-0003-3262-9463

О. Жданов, канд. техн. наук, доцент,

zhdanov45@rambler.ru, ORCID: 0000-0002-3304-5729

Р. Мацей, канд. техн. наук, доцент,

matzey1946@mail.ru, ORCID: 0000-0001-6393-8678

Одеська державна академія будівництва і архітектури, вул. Дідріхсона, 4, м. Одеса, 65029, Україна

АГРЕГАТОВАНІ КОМПЛЕКСИ ДЛЯ ПЕРЕРОБКИ ЗЕРНА РИСА

Анотація

В роботі розглянуті різні конструкції агрегатованих комплексів з переробки зерна рису. Побудовано та проаналізовано їх технологічні схеми, і виконана розбивка на модулі. Це дозволило згрупувати різні конструкції агрегатів і узагальнити їх технологічні можливості. Розглянуто загальну скорочену технологічну схему переробки зерна рису. Зазначені її варіації що до практичного застосування як з модулем очищення зерна, так і без нього. Представлені різні схеми луцення зерна та відбору луценного зерна від нелуценного. Проаналізовано технологічні схеми з різними луцильними машинами (луцильна машина Енглеберга, з гумовими валами, відцентрової дії), які мають свої особливості. Розглянуто відмінності застосування падді-машин і трієрів для сортування зерна після луцення. Циліндричні трієри, що використовуються для відбору ядра рису мають оригінальну технологічну схему (фірма Yanmar). Це дозволяє спростити технологічні комунікації і виконати агрегат більш компактним. В агрегатах використовуються більш компактні падді-машини (зменшені габарити, кількість ярусів і т.д.), що, звичайно, відбивається на їх ефективності роботи.

Розглянута найбільш поширена комбінована машина з однопроходовою технологічною схемою (яка отримала назву від першого винахідника і виробника, луцильна машина фірми Satake). Крім лабораторного обладнання, в агрегатах для переробки зерна використовуються луцильні машини відцентрової дії, що дає додаткові переваги (більш компактна схема, за рахунок сумісництва декількох технологічних операцій, луцення, транспортування зернового потоку, і повітряної сепарації. Для виконання поділу битого і небитого зерна в більшості простих схем використовують ситові сепаратори. Також для підвищення продуктивності ситових сепараторів, в деяких моделях агрегатів їх виконують циліндричними з вертикальною віссю обертання, що дозволяє транспортувати ядро на певну висоту. Це дає можливість скомпонувати цей сепаратор, наприклад з електронними вагами.

Ключові слова: каменевідбірник, сепаратор, луцильна машина, шліфувальна машина, полірувальна машина.

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