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THE EFFICIENCY OF THE OILSEED DRYING PROCESS IN SUSPENDED LAYER

Abstract. The drying process of oilseeds in a suspended layer is investigated in order to increase productivity, reduce energy consumption and improve the quality of seeds for multipurpose use. To study the process of drying seeds of agricultural oilseeds, an experimental installation for drying seeds in a suspended layer has been developed, tested, optimized and implemented. The developed plant for drying seeds in a suspended layer is simple in design and easy to use, has high productivity. It also automates the process and has demonstrated a high level of operational safety during testing. To evaluate the effectiveness of the process of drying seeds in a suspended layer using the developed installation, three types of seeds of oilseed crops were selected: flax seeds, grapes and white sea buckthorn seeds. The results of the conducted studies of the drying process using the developed installation are: increasing the speed of the drying process; reducing the processing time; reducing energy consumption; reduction of processing costs; reduction of cost of processed products; improvement of the quality of processed products by increasing the degree of uniformity of drying and ensuring the preservation of the basic properties of seeds during heat treatment, mainly by reducing the degree of oxidation of vegetable fats in their components. Due to the rationalization of the drying process of oilseeds based on processing in a suspended layer, a number of tasks currently facing enterprises engaged in the primary processing of agricultural products have been solved. Using the results of the study will increase productivity, reduce energy consumption and processing costs, reduce the degree of oxidation of vegetable fats in the composition of seeds and improve their quality for subsequent use in the food industry, medicine, cosmetology, pharmaceuticals, etc.

Keywords: drying plant, seed treatment, suspended layer, process efficiency

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ЭФФЕКТИВНОСТЬ ПРОЦЕССА СУШКИ МАСЛИЧНЫХ СЕМЯН ВО ВЗВЕШЕННОМ СЛОЕ

Аннотация. Исследован процесс сушки масличных семян во взвешенном слое с целью повышения производительности, снижения энергозатрат и повышения качества семян для их многоцелевого использования. Для изучения процесса сушки семян сельскохозяйственных масличных культур разработана, испытана, оптимизирована и внедрена экспериментальная установка для сушки семян во взвешенном слое. Разработанная установка для сушки семян во взвешенном слое проста по конструкции и удобна в применении, имеет высокую производительность. Она также позволяет автоматизировать процесс и продемонстрировала высокий уровень эксплуатационной безопасности во время испытаний. Чтобы оценить эффективность процесса сушки семян во взвешенном слое с применением разработанной установки были отобраны три вида семян масличных сельскохозяйственных культур: семена льна, винограда и облепихи белой. Результатами проведенных исследований процесса сушки с использованием разработанной установки являются: увеличение скорости процесса сушки; сокращение времени технологической обработки; снижение энергопотребления; снижение затрат на переработку; снижение себестоимости продуктов переработки; повышение качества продуктов переработки за счет повышения степени равномерности сушки и обеспечения сохранения основных свойств семян в процессе термической обработки, главным образом при снижении степени окисления растительных жиров в их компонентах. За счет рационализации процесса сушки масличных семян, основанной на обработке во взвешенном слое, решен ряд задач, стоящих в настоящее время перед предприятиями, которые заняты первичной переработкой сельскохозяйственной продукции. Использование результатов исследования позволит повысить производительность, уменьшить потребление электроэнергии и затраты на переработку, снизить степень окисления растительных жиров в составе семян и повысить их качество для последующего применения в пищевой промышленности, медицине, косметологии, фармацевтике и т.д.

Ключевые слова: сушильная установка, обработка во взвешенном слое, эффективность процесса
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Introduction. Currently, the rise in energy prices makes it imperative to improve the efficiency of primary agro-food processing technologies. Efficient management of the agro-industrial complex can be ensured both by upgrading existing technologies and by developing and implementing new processing methods [1–3].

Thus, the effort of researchers in the field is particularly directed towards reducing electricity consumed and processing costs, increasing machine productivity and product quality [4–7].

Currently, one of the main problems of electrical seed drying technologies is the long process time and the essential consumption of electricity [8, 5–7, 9–11]. The given problem is exacerbated in the case of oilseed drying, which is rich in unstable vegetable fats in heat treatment processes [6–12]. Therefore, in order to identify solutions in this direction, a suspended layer seed drying plant was developed.

Research has confirmed that the application of the experimental plant, increases the speed of the process and reduces the duration of heat treatment, helping to ensure the quality of the seeds for subsequent use in the food industry, medicine, cosmetology, pharmaceuticals, etc. Moreover, the installation developed allows a reduction in electricity consumption and overall processing costs.

Material and method. The research was carried out on three types of oilseed: grape seed, linseed and white buckthorn seed. These types of seeds were selected for research because at present their drying is a problem, and they have a valuable potential for the industry of food, medicine, cosmetology, pharmaceuticals, etc.

The experimental installation for seed drying in a suspended layer, developed for the research, is shown in Figure 1. On the basis of this installation, the efficiency of the suspended bed drying process was estimated and the results were compared with those obtained by the classical dehydration method.

The suspended layer drying installation consists of the following components: on the casing *1* is mounted the wind tube and the control panel *3*, which operates the inverter *2* and the fan *4*. The fan draws in air at a flow rate of 430 m^3/h through filter *11* and is operated by motor *13* model C 15/2 T with a power of 0.16 kW. The SHF generator *15* with drying chamber *14* is also mounted on the housing. The fan *4* is connected with the tube *6*, to which the supply bank *5* is attached. The tube *6* vertically intersects the drying chamber *14*, which is mounted on the support *8*, and is fixed by the fixing-adjusting levers *12* to the guides *7*. At the top of the tube *6* is mounted the product outlet pipe *9*, and the perforated receiver *10*.

The CPS-AM50 anemometer with ± 1.5 % accuracy, TESTO 400 hot wire thermometer with ± 1 % accuracy was used to measure air velocity, air flow and temperature.

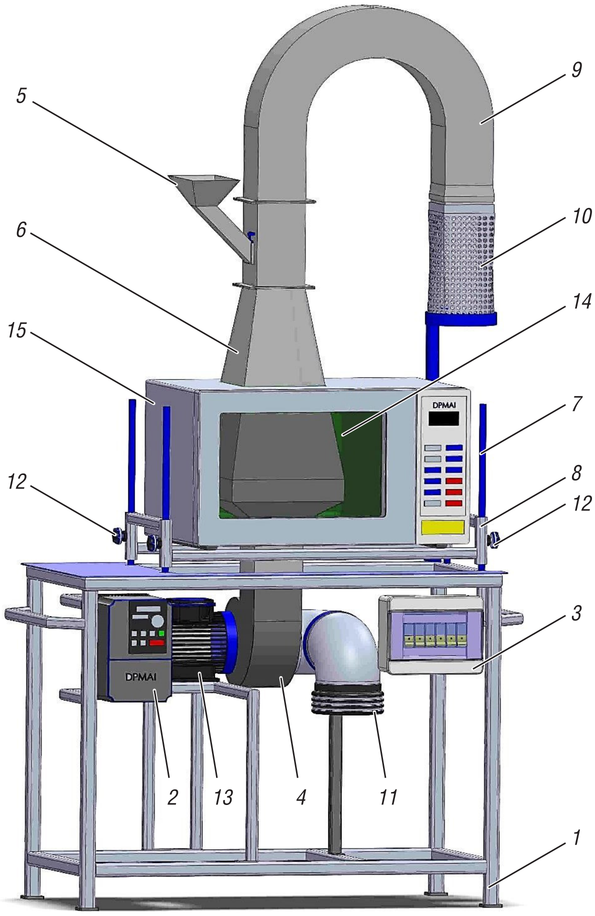

Figure 1. Experimental plant developed for seed drying: *1* – casing, *2* – inverter, *3* – control panel, *4* – fan, *5* – supply bank, *6* – tube aerodynamic, *7* – guides, *8* – support, *9* – product outlet pipe, *10* – perforated receiver, *11* – filter, *12* – fixing-adjusting levers, *13* – fan motor, *14* – treatment room, *15* – SHF generator

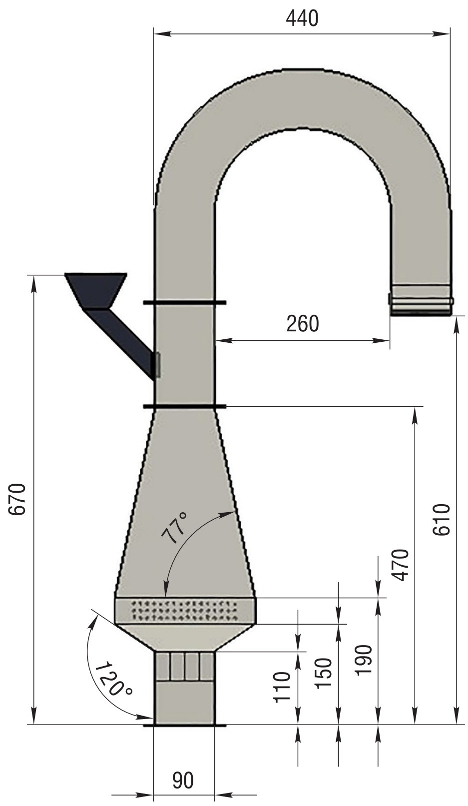

Figure 2. Aerodynamic tube

The process of drying seeds in a suspended layer consists of the following stages:

Stage I consists of entraining the seeds in a suspended layer, which takes place in a tube (shown in figure 2), under the action of an air flow, which develops a speed of 11.4 m/s, with a flow rate of 430 m^3/h.

In stage II, the heat treatment of the seeds trained in the suspended layer takes place for the different regimes examined.

At stage III, the self-separation of the seeds from the suspended layer begins. The separation starts for the first seeds with the lowest mass and moisture concentration, after which they are followed by the rest of the seeds depending on the mass and moisture content for each individual seed, and until the end of the process, all the seeds with more mass and with higher moisture content are separated high.

Results and discussions. During the investigations it was observed that in order for the grape seeds to be kept in the suspended layer, it is necessary that the air speed in the aerodynamic tube be equal to their floating speed. Analyzing the aerodynamic properties of the grape seeds, it was observed that the speed of the air current in the tube is higher towards the central axis of the tube and lower towards the periphery.

The suspended seed layer is formed at a height from the base of the tube equal to 110 mm, where there is an increase in the cross-sectional area of the tube from 0.0081 to 0.055 m^2. The suspended layer with seeds is maintained by air which has a flow rate of 430 m^3/h and develops a velocity of 11.4 m/s, which is also the floating velocity of the seeds. The air pressure at the entrance to the tube is 98.7 kPa, and at the exit is 98.2 kPa. In the area of the suspended layer, a pressure value equal to 98.5 kPa was recorded.

The Reynolds number in the area of the suspended layer was measured and the value of 1905 was found, which is characteristic for the laminar air flow regime, positively influencing the stability of the suspended layer of seeds during the drying process.

As a result of the research on the drying process of the three types of oilseeds (grape seed, linseed and white buckthorn seed), the following was determined for each type in particular: speed of moisture reduction in the seeds, duration of the drying process and electricity consumption.

The results obtained by the suspended layer drying method were compared with those obtained by the classical drying method.

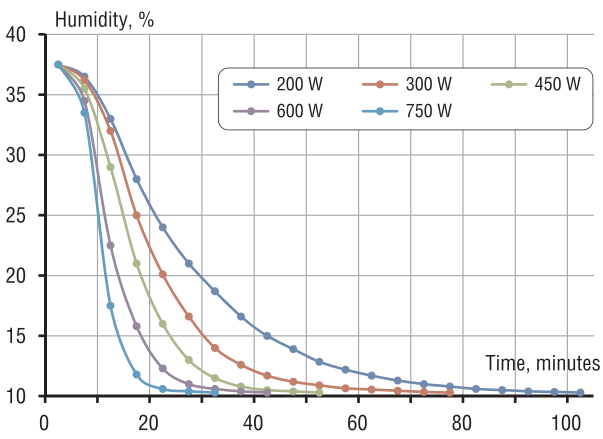

Figure 3. Humidity reduction of dry seed with the developed plant

Figure 3 shows, as an example, the humidity reduction for drying grape seeds in a suspended layer with the developed plant application.

Using the suspended layer treatment method, the seeds were dried to the optimum moisture level of 10.3 % and as a result of examining 5 treatment regimens: 200 W, 300, 450, 600, 750 W, the duration of treatment for each regime was determined, respectively: 103 minutes, 76, 53, 43, 33 minutes.

Following the seed drying process, the kinetics of the process was determined and the results obtained from the suspended layer drying method were compared with those obtained by the classical drying method.

Table shows, as an example, the comparison of the results obtained for drying by the methods analyzed, for grape seeds, for a treatment source power of 450 W.

Analyzing the results of drying with SHF application, we observe that the drying time is 41 minutes shorter for the suspended layer than for the classical drying method. Also the drying speed, with the application of SHF in a suspended layer, is 0.35 %/minute higher than with the application of SHF by the classical method.

The results confirm that, even when drying these seeds by convection in a suspended layer, the drying time is 61 minutes shorter than when drying by convection using the classical method. The speed of convection drying in the suspended layer is also 0.26 %/minute higher than in the classical drying method.

Seed drying results by methods examined

Treatment source applied to drying	Drying process parameters	Drying method	
		Classical drying method	The suspended layer drying method
Convection	Drying speed, %/minute	0,72	0,98
	Drying time, minutes	244	183
	Electricity consumption, kWh	1,83	1,37
SHF	Drying speed, %/minute	1.42	1.77
	Drying time, minutes	94	53
	Electricity consumption, kWh	0.71	0.39

It was found that when drying these seeds in a suspended layer with the application of SHF, electricity consumption is lower than when drying with SHF by the classical method by 0.32 kWh.

Also, for convection drying in a suspended layer, the electricity consumption is lower than for convection drying by the classical method by 0.46 kWh.

Comparing both drying methods, based on the applied treatment source, it is recommended to use the suspended bed drying with SHF application. This method is characterized by increased drying speed and reduced drying time for all three types of seeds examined: grape seed, linseed and white buckthorn seed.

For quality analysis, dried seeds were analysed microscopically. Figure 4 shows, as an example, the microscopic analysis of grape seeds, which were dried by the classical method.

From this figure it can be seen that micro cracks have formed on the surface of seeds dried by the classical method.

This is because in this method, in the drying process, the seeds are subjected to mechanical action, which causes cracks to appear on their surface. These micro-cracks negatively influence the stability of the seeds in the drying process and reduce quality. This is explained by the fact that the vegetable fats in the seed are more sensitive to contact with oxygen in the air. Thus, through cracks in the conventional drying process, oxidation of the fats occurs and the quality of conventionally dried seed is reduced.

Figure 5 shows the microscopic analysis of the seeds, which were dried in a suspended layer.

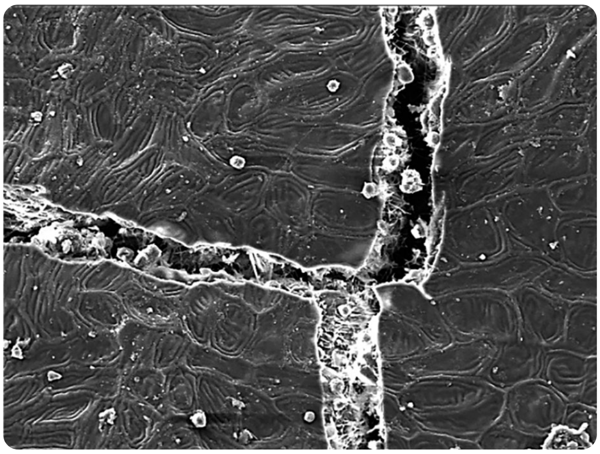

Figure 4. Microscopic analysis of dried seeds by the classical method

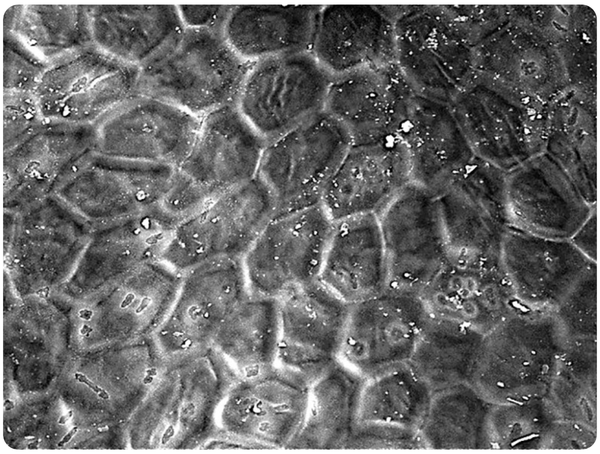

Figure 5. Microscopic analysis of dried seeds in suspended layer

It can be seen that no micro cracks have formed on the surface of the dried seed in the suspended layer. This is due to the fact that, by this method, the seeds are not subjected to negative mechanical actions, as by the classical method, and this fact prevents the appearance of cracks or other defects on their surface. The suspended layer drying method therefore excludes the appearance of micro cracks and prevents oxidation of the vegetable oil in the seeds.

Thus, the results of the research confirmed that the application of the experimental installation significantly increases the speed of the drying process and reduces the heat treatment time, contributing to the increase of the process productivity.

Moreover, electricity consumption is significantly reduced in the application of the suspended layer drying compared to the classical method, and these are the basic technological parameters for a drying process with low electricity costs and high productivity.

Research has shown that the seeds are not subjected to mechanical action during the drying process and the risk of cracks on the seed surface or other defects is absolutely excluded. The risk of oxidation of the vegetable fats in the oilseed content, which can occur through these cracks when in contact with oxygen, is therefore also excluded. This is quite important for the preservation of the quality of seeds rich in vegetable oils for further use in the food industry, medicine, cosmetology, pharmaceuticals, etc.

Conclusions

1. The installation developed for the drying of seeds in a suspended layer allows increasing the speed of the drying process, reducing the duration of the process and the consumption of electricity for all three types of seeds examined: grape seeds, linseed and white hawthorn seeds.

2. The drying in suspended layer does not allow defects to appear in the drying process of the seeds and ensures the preservation of their quality for further use in the food industry, medicine, cosmetology, pharmaceuticals, etc.

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