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New power-saving complex for drying seeds of corn

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The purpose. To determine technical-technological parameters of new power-saving complex which consists of standard chamber corn dryer and generator of warm, working from incineration of rods of corn. Full substitution of traditional not restored power resources on vegetable biofuel ensures saving of power. **Methods.** Generalization of literary data, holding experimental, laboratory and field experiments. **Results.** Basic technical-technological indexes of new power-saving complex, namely temperature and ventilation regimes, parameters of relative humidity of working and completed heating medium, speed of drying, drying capacity and quality factors of the exsiccated seeds are specified. The temperature regime in the complex oscillated within the limits of 38 – 43°C, depending on damp of corn cobs. Ventilation regime consisted depending on power of ventilation aggregates and service conditions of fuel-air compartment. Relative humidity of working heating medium made 10 – 12 %, completed — 20 – 44 % depending on stage of drying. Speed of drying oscillated within the limits of 0,16 – 0,39 %/ , productivity made 1,2 – 6,0 t-%/hour, depending on mass of corn cobs, their damp and exposure of drying. New method of drying had no negative effect on quality of seeds of hybrids of corn and their parent ingredients. **Conclusions.** Technical-technological parameters established by authors may be recommended for new power-saving complex and ensure fast and uniform mealies drying, exit of high-quality conditioned seeds, full substitution of traditional fuel (liquid, gaseous) for biofuel (plant residues).

Key words: *power-saving complex, technical-technological parameters of drying, biofuel, quality of seeds.*
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Introduction. Drying is the most responsible technological operation in the process of post-harvest processing of high quality corn seeds. From this process, the decrease in the moisture content of corn grain to a safe dry condition, preservation of its quality, energy consumption [1, 2].

The main parameters of the current (regulated) method of drying of seed corn cobs in the typical chamber grain dryer SKP are: temperature regime of 35-50 ° C depending on the moisture content of the grain, successive or parallel incorporation of chambers into work, cyclical drying schedule, reversal, ie, change in the direction of blowing of chambers, which provides more uniform drying of the cobs along the entire height of the embankment [3, 4]. But this method is quite energy-consuming due to the current performance conditions. Therefore, there is a need to search and create new methods of drying with a significant reduction in energy costs.

Today various technical and technological operations are known, which contribute to the reduction of energy consumption in the process of drying maize, are two-stage drying of cobs with pre-drying in grain, pulsed drying mode with alternation of heating and cooling, drying at maximum allowable temperatures [5-8]. Tricks that contribute to lowering energy consumption include sealing of dryers, maximum loading of drying chambers, removal of self-crushing (grain) from the mass of caches.

All known energy-saving technologies are based on the modernization of chamber corn dryers without replacing the type of fuel. A fundamentally another method of energy saving is drying using heat generators and receiving heat from combustion of plant fuels, in particular corn cobs [9]. To do this, create energy-saving complexes, which include typical chamber corn driers and heat generators. However, the technical and technological parameters of the operation of such complexes remain unknown.

The purpose of the research is to determine the technical and technological parameters of the energy saving complex, to conduct its production testing, to determine the effect of energy saving drying on the crop and yield properties of seeds of hybrids of corn and their parent components.

Methodology and methods of research.

The methodology included conducting experimental studies of energy-saving complex consisting of chamber corn duster and a new heat-generator with a heat output of 2.5 MW for burning corn cobs. Experiments were

conducted in the conditions of the State Enterprise "Dnipro" and "Agrosphere" Ltd. located in the Dnipropetrovsk region. The method of research was maintained in accordance with the recommendations, methodical instructions and methods for drying seeds of cereal crops [10-12]. The following basic parameters of the drying process were studied: temperature regime, volume of coolant, relative humidity of air and coolant. The temperature regime was determined using the M-16AN thermographs and temperature sensors. Temperature measurement on thermographs was carried out in accordance with the requirements of GOST 64-75.

The volume of the coolant was determined using lobed and cup anemometers at different operating modes of the ventilation compartment. Relative humidity of the working coolant was determined using hygrographs and a psychrometer.

The rate of drying of corn cobs (V,%/h) was determined taking into account the length of the process (τ, hour), the initial (W1,%) and final (W2,%) grain moisture content (Wz,%) and rods (Wc,%) for formula:

$$V = \frac{\left[(W_1^3 \cdot 0,75) + (W_1^c \cdot 0,25)\right] - \left[(W_2^3 \cdot 0,8) + (W_2^c \cdot 0,2)\right]}{\tau}$$

where: 0,75 and 0,25 - the ratio of grain and rods to drying; 0,8 and 0,2 - the ratio of grain and rods after drying.

Experimental studies were also accompanied by theoretical analysis and mathematical calculations in accordance with the theory of drying of thermally stable materials [3, 8].

Research results. For the first time, a new method of drying in an energy-saving complex was conducted, which included the chamber corn dryer SKP-10 with the heat generator TPG-1/25. The new heat generator worked in the mode of direct combustion of fuel - the corn cobs, therefore the efficiency is 90-95%. Corn dryer is equipped with a system of reversal (change of direction) of the coolant at certain intervals of time.

The temperature of the drying mode in the dryer fluctuated within the optimum temperatures - 38-43 ° C, depending on the humidity of the corn, namely decreasing at the beginning of drying, increased - in the end (Fig. 1). The temperature also varied according to the direction of blowing the chambers, it was higher at the inlets of the working coolant and lower at its output. The temperature difference between the upper and lower corridors of the dryer was recorded, it was in the range of 8-10 ° C at the beginning of drying and 2-3 ° C in the end.

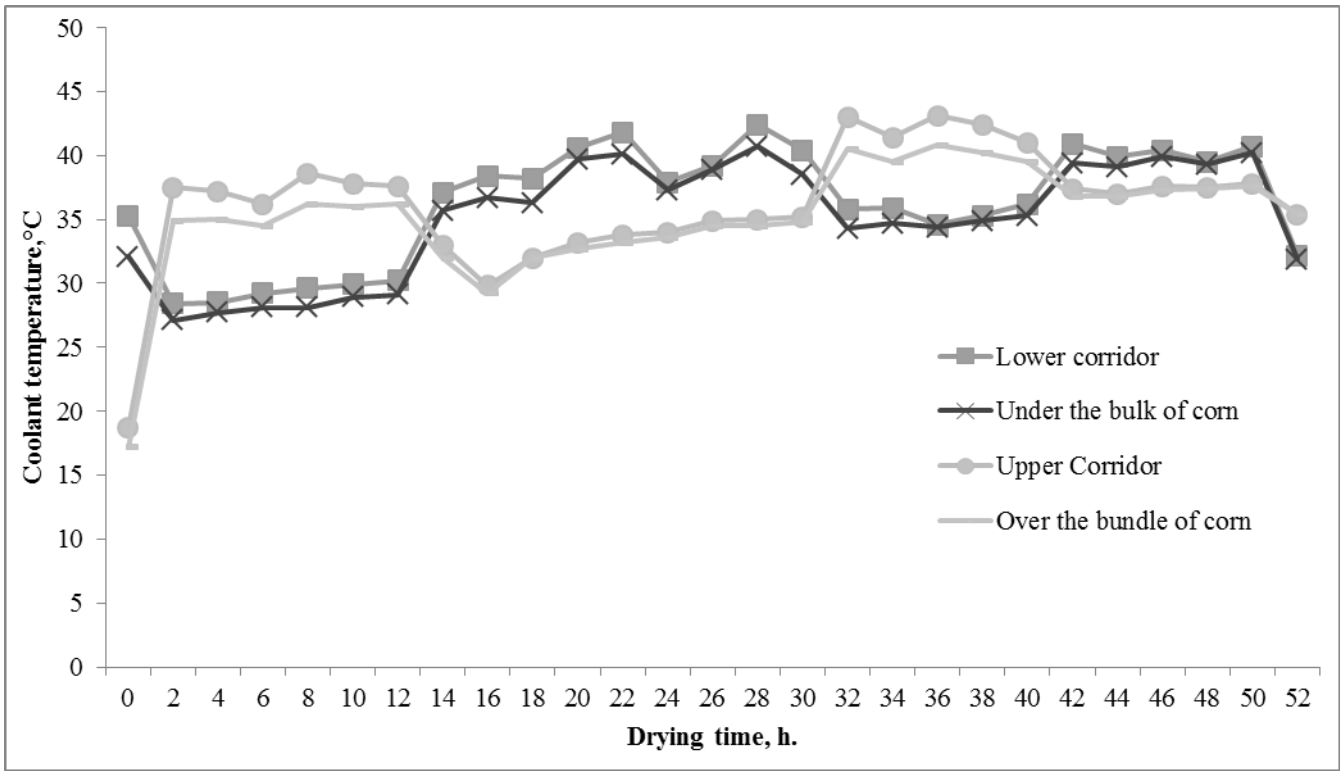

Figure 1. Fluctuations in the temperature of the coolant in the process of drying, depending on the direction of blowing the drying chambers.

In the process of drying are important indicators of relative humidity of the working and spent coolant, which depends on the rate of moisture content of the cobs. Perhaps that the relative humidity of the coolant also varies depending on the chemical composition of the fuel, its content of hydrogen, oxygen, carbon dioxide, sulfur, water vapor, and ash matter. In our experiments it was established that the relative humidity of the working coolant ranged from 10 to 12%, and spent - 44-20%, depending on the drying time (Table 1). The temperature of the working coolant was 36-41 ° C, the spent - 29-33 ° C at an ambient temperature within the range of 1.8-8.6 ° C.

1. Characteristics of the working and spent coolant in the process of drying corn cobs at the energy saving complex

Drying time, h	Working coolant		Exhaust coolant		Control - atmospheric air	
	relative humidity, %	temperature, °C	relative humidity, %	temperature, °C	relative humidity, %	temperature, °C
4,5	10	36,1	44	29,1	60	6,5
9	11	39,7	43	31,4	77	3,0
13,5	11	39,4	39	31,7	80	2,3
18	10	40	36	31,5	59	7
22,5	10	41	35	31,4	60	7,4
27	10	38,7	28	32,3	68	4,8
31,5	12	39,9	24	33,2	83	2,1
36	11	38,8	23	32,5	85	1,8
40,5	10	39	21	32,2	71	5,4
45	12	39,9	19	32,1	64	8,6
49,5	10	38,7	19	31,9	68	5,1
54	10	38,2	20	32,5	72	4,8

The ventilation regime, which consisted of corn dryers depending on the power of ventilation units, was also studied. The dryer has two ventilation units C-4-70, with a capacity of 70 thousand m^3/h each. The volume of the coolant in the drier was measured at the operation of both and each fan with different air access to the ventilation compartment (Table 2). Different air access was created by opening-closing hatches, shibres, which changed the air flow. With full access to air and the work of two fans, the specific volume of the coolant is 1393 m3/h per 1 t of corn cobs, which fully meets the standard set for hybrids and parent components (800 and 1000 m^3, respectively). With a single fan and full air access, the standard set for hybrids is maintained. With limited access, the rate is maintained for hybrids only under the condition of two fans.

2. General and specific delivery of coolant depending on the mode of the fuel and ventilation compartment of the dryer with the heat generator TPG-1/25

Air access mode	Two fans are involved		The fan is in use №1		The fan is in use №2	
	Total delivery, m^3/h	Specific consumption *, m^3/h per 1 t	Total delivery, m^3/h	Specific consumption *, m^3/h per 1 t	Total delivery, m^3/h	Specific consumption *, m^3/h per 1 t
Full	125400	1393	71812	798	53588	595
Limited	72520	806	38509	428	34011	377

Note: * - specific consumption in the calculation of 90 tons of caches

Technological efficiency of the energy-saving drying method was determined by separate parameters - drying rate, drying performance, quality of seeds. In the experiments, the drying rate fluctuated within the range of 0.16-0.39%/h the productivity was 1.2-6.0 t-%/h, depending on the weight of the cobs, their humidity and drying exposure (Table 3).

3. Technological and technological parameters of the energy-saving method of drying of corncobs in 2016-2018.

Hybrid/Line	Weight of the cobs, t	Moisture content, %		Exposure of drying, h	Drying rate,%/h	Productivity, t -%/h
		to drying	after drying			
Orzhycja 237 MV	6	21,8	11,0	28,0	0,33	2,3
DN Zorjana	18,4	26,9	11,2	54	0,25	5,3
DN Hortycja	14,3	24,1	10,6	74	0,16	2,6
DB Hotyn	13,5	33,6	13,9	88	0,21	3,0
DN Pyvyha	15,1	29,2	10,9	88	0,18	3,1
Kros 255 Mst	9,3	27,3	10,1	80,5	0,20	2,0
Kros 260 M	12,0	37,3	13,3	88	0,25	3,3
Kros 254 M	4,2	24,7	11,0	54	0,25	1,2
Kros 222 S	3,9	25,8	10,2	54	0,29	1,3
DK 744 ZM SV	4,2	27,2	10,9	36,5	0,39	1,8
DK 365 SV	11,4	32,2	12,1	61,5	0,30	6,0
DK 4163 MV	7,1	26,4	10,3	54	0,30	2,4

The low drying rate of corn hybrids in the experiments is due to increased exposure and as a result of low humidity at 10%. The speed was also influenced by the mass of corncobs in various drying chambers.

Studies have shown that as a result of the drying of corncobs, collected at a humidity of 20.3-29.5%, they received high quality seeds of hybrids of corn and their parent components. Laboratory similarity was conditioned, within the range of 95-98%. Field similarity was at the level of control, yields did not decrease compared to it (Table 4).

4. Effect of drying methods on sowing and yield properties of seeds of hybrids of corn, 2016-2018 gg.

Hybrid / Line	Drying humidity,%	Method of drying	Seed germination,%			Yield, t/ha
			laboratory	cold test	field	
Orzhycja 237 MV	20,3	Control *	98	90	80	5,50
		Control **	95	92	81	5,40
		Energy saving	95	93	84	6,03
		NIR $_{0,5}$			4,6	0,33
DN Akvozor	21,5	Control *	96	93	82	7,61
		Control **	97	95	84	7,80
		Energy saving	98	95	81	7,79
		NIR $_{0,5}$			4,6	0,30
DB Hotyn	29,5	Control *	99	90	76	7,25
		Control **	97	90	80	7,27
		Energy saving	97	92	80	7,21
		NIR $_{0,5}$			4,4	0,35
Kros 254 Mst	22,4	Control *	97	83	75	5,45
		Control **	98	79	73	5,44
		Energy saving	97	90	82	5,47
		NIR $_{0,5}$			4,2	0,53
Kros 255 Mst	25,2	Control *	99	90	88	5,81
		Control **	98	86	87	6,03
		Energy saving	95	89	85	5,99
		NIR $_{0,5}$			3,9	0,53

Note: Control * - natural drying (t = 20-24 ° C); Control ** - laboratory drying, t = 38 ° C corncobs

Due to drying in the energy-saving complex and the use of biofuels, they received a significant economic effect. The total cost of drying corncobs when using different types of fuel was as follows: diesel - 1145 UAH / t; gaseous - 665 UAH / t; corn corn - 250 UAH / t. Taking into account the cost of equipment, assembly-transport and commissioning works the payback period of the new energy saving complex is 1.5-3 years depending on

the volume of drying. In addition, full independence from the supply of traditional fuels and fluctuations in their prices is achieved.

Conclusions

The technical and technological indicators of the new energy-saving complex, which consists of a typical chamber corn dryer and a heat generator with thermal power of 2.5 MW, are determined and investigated. The temperature mode of the dryer corresponded to the regulatory requirements and fluctuated within 38-43 ° C. The ventilation regime depended on the mode of air access to the ventilation compartment and the number of fans. The full air access of two fans provided a specific volume of coolant at the level of 1393 m^3/h per 1 t of corncobs, which complies with the norm set for hybrids and corn lines 800-1000 m^3/h. Relative humidity of the working coolant during the entire drying process was 10-12%, and spent 44-20%.

The rate of drying of the corncobs fluctuated within the range of 0.16-0.39%/h, the performance of one chamber was 1,2-6,0 t-%/h. Drying in the energy-saving complex did not have a negative impact on the quality of corn seeds, the laboratory germination capacity was 95-98%. The yield of seeds dried in the energy-saving complex was at the control level (laboratory drying). The cost of drying in the energy saving complex was lower by 415-895 UAH/t compared with traditional fuels.

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