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EFFICIENCY OF SOLAR COLLECTORS FOR DRYING WHEAT

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Abstract

In the article is analysis about of possibility of using solar collectors in the conditions of the Krasnodar region. Due to the current economic situation in Russian Federation, the cost of wheat in recent years has increased by 40% due to rising prices for fertilizers, plant protection products and fuels and lubricants. In turn, the increase in the cost of grain led to a decrease in the profitability of production, which required the farmers to introduce additional measures for reducing cost of production. One of the energy-consuming parts of high-quality wheat production is drying. Amount of energy resources for post-harvest drying of grain can reach 30% of all production costs. Therefore, by increasing the energy efficiency of the drying process, it is possible to reduce the cost of grain and increase the profitability of production. Currently, direct or indirect heat diesel generators are widely used for grain drying. In view of the high demand for thermal energy for drying process of grain, it is logical to assume that it is possible to use solar collectors to reduce the consumption of fossil fuels in the production of heat, and, therefore, to increase the environmental friendliness of the drying process. In consideration of increasing of prices for fuels and lubricants and environmental issues, it is advisable to assess the possibility of using solar collectors. It is concluded that there is a fundamental energy possibility of using solar collectors for drying wheat in the territory of the Krasnodar region.

Keywords: Solar collectors, grain drying.

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1. Introduction

The most important task of agriculture is to provide the population with high quality food with acceptable cost. It requires constant optimization of production in a market economy in order to maintain a balance of economic interests between the producer of the product and it's consumer. All this requires accelerating the pace of agricultural development, which is inextricably linked with an increase in labor productivity. In turn, it is impossible to increase the efficiency of agricultural production and reduce production costs without introducing the achievements of scientific and technological progress (Mikhailushkin & Barannikov, 2013).

2. Problem Statement

Crop production is the most important branch of agricultural production. This sector accounts for about 3% of the total gross domestic product and about 6 million people are employed in this sector of the economy (Belessiotis & Delyannis, 2011). Due to the current economic situation, the cost of grain increased over the past year by 40%. Reasons are rising prices for fertilizers, pesticides and fuel and lubricants. In turn, increase in the cost of grain production led to a decrease in the profitability of production, which requires from farmers to introduce additional means for reducing cost of grain production.

3. Research Questions

One of ways to increase the profitability of production is the processing of raw grain, which allows not only to affect the quality of products, but also its added value. In the same time environmental issues of modern production are really important (El Hage, Herez, Ramadan, Bazzi, & Khaled, 2018). Various devices for the utilization of renewable energy sources, in particular solar collectors, are being introduced in industry. In view of the high demand for thermal energy when drying grain, it is logical to assume that it is possible to use solar collectors to reduce the consumption of fossil fuels in the production of heat, and therefore to increase the environmental friendliness of the drying process (Radajewski, Jolly, & Abawi, 1987).

4. Purpose of the Study

In the greater territory of the Russian Federation, freshly harvested grain under normal weather conditions has a moisture content of 18 ... 20%, under adverse weather conditions it reaches 25 ... 35%. Standard requirements for the quality of wheat are in a range to 13.5-14 5% (State standard specification P 52554 – 2006, 2006.). At the same time, grain drying is one of the most energy-intensive processes of post-harvest processing. Thus, energy costs for post-harvest drying of grain can reach 30% of all production costs (Moroz, 1986). Therefore, by increasing the energy efficiency of the drying process, it is possible to reduce the cost of grain and increase the profitability of production (Farkas, 2013). Currently, dryers with direct or indirect heating heat generators operating on diesel fuel are widely used. This drying technology is relatively simple, but, like any technology, can either be replaced by more energy-efficient or improved.

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5. Research Methods

When evaluating the efficiency of using air solar collectors for grain drying, we used the data from the farms of "Kuban Rice LLC" (Poltavskaya stanitsa, Krasnodar Krai) from 2016 to 2017 (Table 01). The main economic activity is the cultivation of grain crops.

Table 01. Wheat production and drying at "Kuban Rice LLC"

	2015	2016	2017
Volume of produced grain, thousand tons	24,6	23,9	25,1
Volume of grain for drying, thousand tons	1,8	3,3	4,4
Moisture content of grain before drying, %	16,5-18,0	16,5-18,0	16,5-18,0
Moisture content of grain after drying, %	13,5-14,0	13,5-14,0	13,5-14,0
Cost of wheat production , roubles/kg	3,7	3,4	3,6
Cost of diesel fuel, roubles/kg	29,5	32,1	33,5
Cost of electricity, roubles/kW	5,3	5,4	5,6
Release price, roubles/kg	6,8	7,1	7,5

Drying process lasted an average of 30 days (25-35 days) and was carried out from September 10 to October 15 with three stationary Agrex PRT250/FE-SC dryers with heat exchangers (table 02) with a capacity of 75 tons/day, 22 hours per day with a 13,2 hours period of active ventilation.

Table 02. Agrex PRT250/FE-SC technical specifications

Supply voltage, V	400
Installed electric power, kW	42,5
Power of the main electric motor, kW	300
Air consumption, m^3/hour	53000
Thermal power of the dryer, kcal/hour	$9 \cdot 10^5$

Volume of fuel spent on drying is 2.2 liters (1,89 kg) of diesel fuel per 1 ton with the removal of 1% moisture. Dryers are served by an operator with a salary of 42,000 rubles/month. Maintenance of three dryers are daily and costs 3500 rubles/month. In addition, service company performed maintenance of three dryers at a cost of 80 000 rubles/year three times a year. So, cost per unit of drying is 290-330 rubles/ton with the removal of 3% moisture content of the grain, depending on the volume of grain.

When assessing the effectiveness of used and analyzed drying process, it makes sense to switch to energy units, which will allow us to get away from the cost of solar collectors at this stage of the analysis and evaluate the efficiency of their use from an energy point of view. Therefore, with a specific heat of combustion of diesel of 43 MJ/kg used in dryers, indicator of the total specific heat consumption for evaporation of 1 kg of moisture is $\Sigma_q = 240$ kJ/kg for wheat with a removal of 3% moisture at an air flow rate of 53,000 m^3/hour.

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6. Findings

Analysis of the technical characteristics of world-class solar collectors (Grammer Solar, BUSO, Valliant) shows that from an energy point of view, up to 27 MJ/hour (TwinSolar 10, TwinSolar 12.55) can be obtained from 10 m2 of solar collector with a flow of 350 m3/h of heated air (table 03). With an average day longitude of 12 hours, taking into account weather conditions (see the figure 01), the energy yield will be no more than 280 MJ/day.

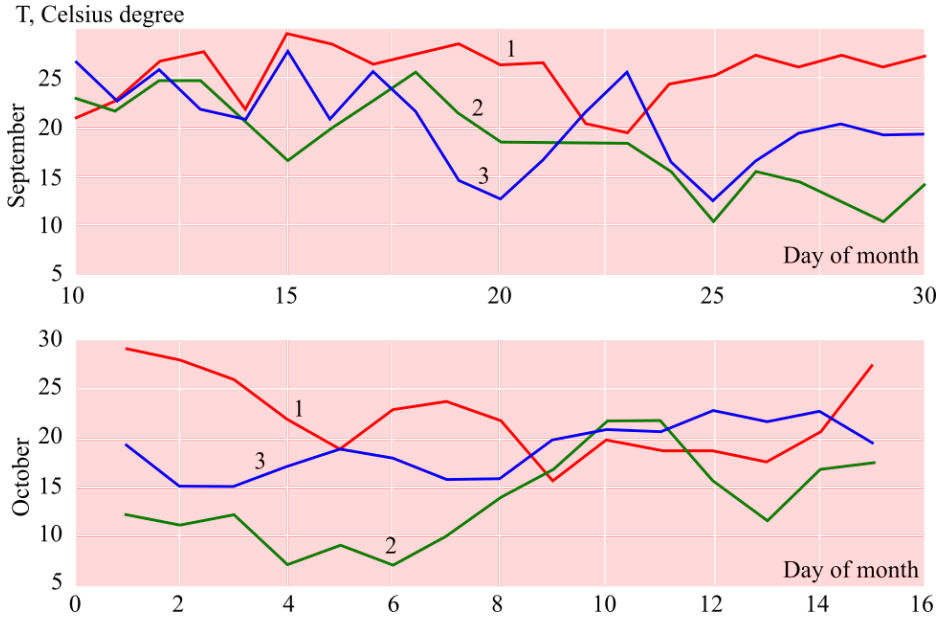

Figure 01. Graphic of environment's temperature in 2015 (1), 2016 (2), 2017 (3)

Table 03. Technical characteristics of solar collectors

	TwinSolar 10,0	TwinSolar 12,55	Agrex PRT250/FE-SC
Collector area, m^2	10	12,55	
Peak thermal performance, MJ/hour	21,6	27	3700
Air supply, m^3/hour	350	350	53000

Taking into account above mentioned data, we obtain the daily heat demand for drying (table 04).

Table 04. Wheat production and drying at "Kuban Rice LLC"

	2015	2016	2017
Volume of grain for drying, thousand tons	1,8	3,3	4,4
Daily volume for drying, tons	60	110	145
Daily volume of heat demand, MJ	13800	25300	33350
Daily productivity of solar collectors (TwinSolar 10,0), MJ	280	280	280
Required collector area, m^2	490	900	1190

7. Conclusion

Analysis shows that there is a fundamental energy possibility of using solar collectors for drying grain in the territory of the Krasnodar Territory. Moreover, collectors can be both the only sources of heat, and work as part of traditional drying technologies. Efficiency depends on the following conditions:

- the availability of free space for arrangement of solar collectors;

- the enterprise should be located in an area with a high density of solar flux on the surface of the collectors.

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