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OAT DRYING USING MOBILE AIR HEATING SOLAR COLLECTOR

AVIŽŲ DŽIOVINIMAS NAUDOJANT MOBILŲ ORO ŠILDYMO SAULĖS KOLEKTORIŲ

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The aim of this research was to determine the effectiveness of oat grain drying using air heating solar collector's heated atmospheric air. The experiment took place in Spring. The obtained results and their analysis confirms and proves air heating solar collector application effectiveness and efficiency of agricultural products drying. Oats grain drying using air heating solar collector heat up the air with an average temperature 33°C provide 5,1 g/100g water removal after 6.5 hours of drying. At the initial grain moisture 25.85% after 8 hours of drying using solar air heating collector with heating air temperature 33°C 5 cm thick grain layer moisture reaches 14.4%. Oat grain layers temperatures and moistures changes depending on the drying time are given.

Oat, drying, solar collector.

Introduction

Preservation of agricultural production is a very important problem to be solved producer of this product. One of the way of the preservation of products is drying. Drying process is the use of products with low water activity, thereby inhibiting the production of microbial reproduction and enzyme activity, and can give the flavor of a good product to achieve long-term storage, easy to transport, easy to consumer spending. During drying, heat is supplied and the volatile component, mainly water, is eliminated from the material mixture.

Many studies were done to process cereals, carrot, apples and etc. drying by small heated air. The researches have been investigate the influence of some process parameters (temperature, sample thickness, layer thickness, air flow rate, etc).

On the other hand the solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. This is devise that absorbs the incoming solar radiation, convert it into heat, and transfers the heat to a fluid (usually water, air or heat transfer oil) flowing through the collector.

In general, solar air heaters are flat-plate collectors (FPCs), consisting of an absorber, a transparent cover, and backward insulation. The performance of solar air heaters is mainly influenced by meteorological parameters (direct and diffuse radiation, ambient temperature and wind speed), design parameters (type of collector, collector materials) and flow parameters (air flow rate, mode of flow). The principal requirements of these designs are a large contact area between the absorbing surface and air (Kalogirou, 2009).

The air heating collectors can be used in two main directions- for production drying and room heating (ventilation). Production issues through drying in the sun-warmed air are discussed a lot in works (Mulet et al., 1993, Ratti & Mujumdar 1997, Andoh et al., 2010; Aboltins & Upitis, 2011, 2012).

Over the past years in the Latvia growing oats sown area. This means that an increasing interest in oat drying and storage. Drying costs are high, so try to use alternative energy sources, such as. solar energy. Based on Latvia University of Agriculture obtained LV patent N°14310 is made air heating solar collector. This collector was used for heating ambient air and drying wet oats.

The aim of the study is to investigate oat drying possibilities using air heating solar collector.

Materials and Methods

The mobile air heating solar collector technical solution is based on three key elements (Fig.1) – carts with hydraulic lifting platform at an angle from 0 to 40 degrees, the two modules foldable flat-plate solar collector (2 modules (120 cm x 80 cm x 12 cm) in total surface area of 1,92 m²) and fan (capacity 290 m³/h and power consumption of N = 58 W) (Fig.1).

Fig.1. Drying equipment with mobile air heating solar collector: 1 - modular solar collector with variable angle setting; 2 – fan; 3 – air inlet; 4 – drying equipment; 5 – scales.

1 pav. Džiovinimo įrenginys su mobiliu oro kaitinimo saulės kolektoriumi: 1 – modulinis keičiamo posvyrio kampo saulės kolektorius; 2 – ventiliatorius; 3 – oro kanalas; 4 – džiovykla; 5 – svarstyklės.

Moisture-resistant plywood panels of 8 mm thick used as body material. 6 mm thick clear polycarbonate sheet of cells is used as a covering material, which is mechanically and atmospherically resistant, as well as be effective from the thermal point of view. Prefabricated modular solar collector panel for increased surface area and capacity and provides easy handling and safe storage in compact state. Absorber was made of 0,5 mm thick sheet metal plate coated with black matte paint. Absorber was placed in the middle of the collector. For the studies made cylindrical experimental ventilation equipment (4) (with volume 200 liters) located on the scales (5) and connected with isolated air supply (3) to the solar fan (1). (Fig. 1)

Fig. 2. Grain temperature measurement sensor location
2 pav. Grūdų temperatūros matavimo jutiklių išdėstymas

Fig. 3. Humidity measurement in grain layer
3 pav. Grūdų masės drėgmės matavimas

Experiment used 25,7% wet oats. Air heating was performed using a mobile air heating solar collectors. Beginning of drying atmospheric temperature was 14 °C.

Results and Discussions

Oats drying experiment took place at 01.05.2013 during the time from 11:30 to 18:00. Experiment investigated the air-heating efficiency of mobile air heating

collector (Fig. 4). Solar collector efficiency is characterized by its ability to raise the flowing air temperature which depending on the solar radiation. The experiment showed that the given collector at solar radiation between 700 W/m^2 to 850 W/m^2 heat the atmospheric air by an average of 25 °C. At solar radiation between 300 W/m^2 and 500 W/m^2 air was warmed by 8-10 °C. The ambient air average temperature during experiment was 15,1 °C.

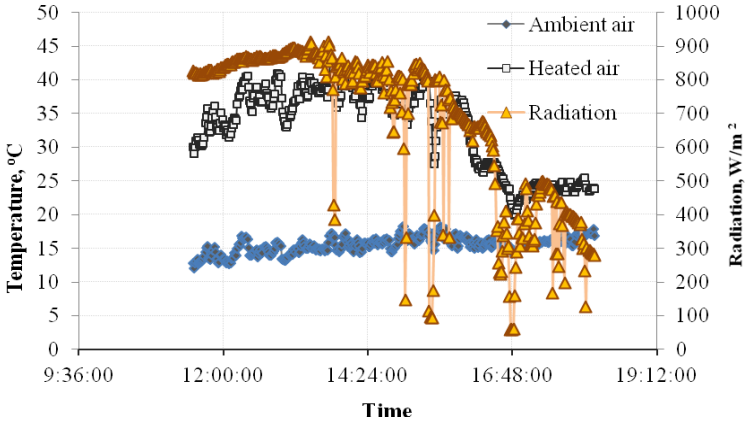

Fig. 4. Heated and ambient air temperature changes depending on the solar radiation
4 pav. Kaitinamo ir aplinkos oro temperatūros kitimas priklausomai nuo saulės spinduliavimo stiprio

Solar heated air was passed to drying equipment which is filled with oat grains (Fig. 1). Grain temperature dynamics in oat layers shows air heating solar collector heated air effects on grain temperatures (Fig. 5).

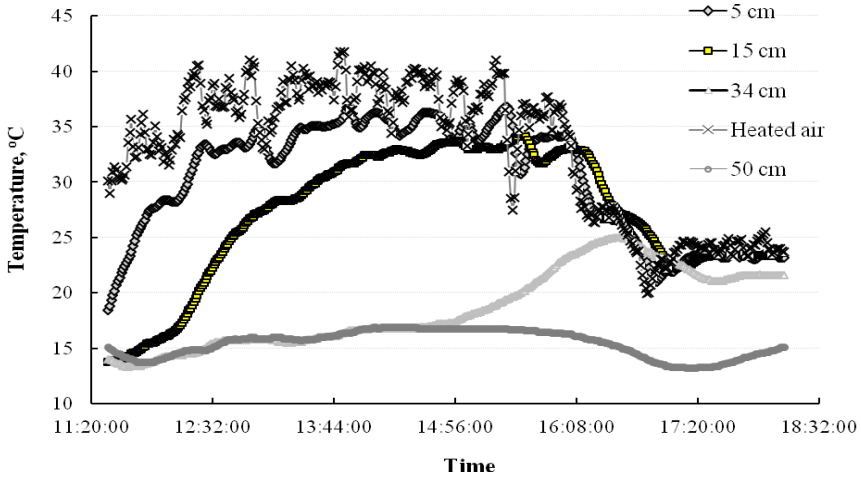

Fig. 5. Oat grain layer temperature changes depending on the drying time
5 pav. Avižų sluoksnio temperatūros kitimas prikalusomai nuo džiovinimo laiko

Grain temperature increases is gradually in the grain layer from the input of warmed air it is 5, 15, 35 and 50 cm thick layer. Visible the deviation of time for temperature increase, depending on the layer thickness. This can explain with the drying front movement and drying is connected with water removal, which requires energy. All drying time oat grain temperature at 50 cm depth insignificant changes. At 35 cm depth temperature starts to increase rapidly after 3,5 hours. Grain temperature changes is similar, only it is different from the layer thickness (Fig. 5).

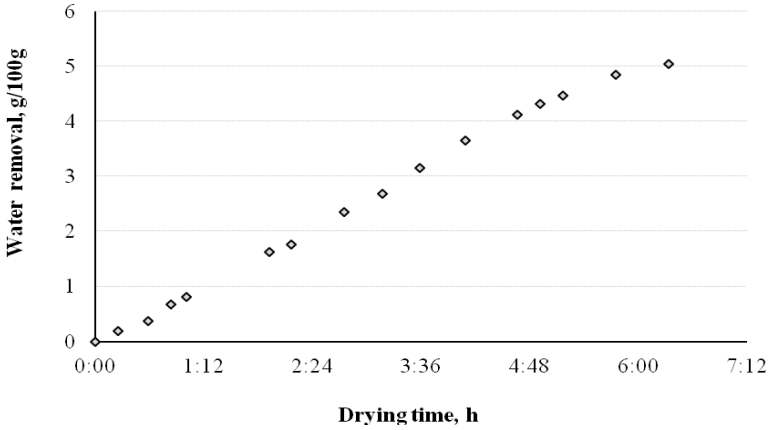

Fig. 6. Moisture removal from wet oat layer dependence from drying time
6 pav. Drėgmės pašalinimo iš drėgnojo avižų sluoksnio priklausomybė nuo džiovinimo laiko

The total water removal from oat shown at Fig. 6. At the first 4 hours of drying at average warmed air temperature 36,7 °C water removal at 1 hour was 0,9-1,0 g/100 g drying grain. Decrease of solar radiation reduce the collector-heat temperatures as a result of the moisture removal decreased to 0,4-0,5 g/100 g. This can be explained by the fact that in the afternoon increased relative humidity of air and drying rate decreases.

Dried material moisture reduction depends not only on the grain thickness of the layer but also the drying time (Table 1).

Table 1. Oat moisture changes in layer depending on the drying time
1 lentelė. Drėgmės avižų sluoksnyje pasikeitimas priklausomai nuo džiovinimo laiko

Thickness of oat layer	Oat humidity, %				
	At beginning	After 2 h	After 4 h	After 6 h	After 8 h
5 cm	25,8	24,3	22,9	17	14,4
25 cm	25,9	25,5	24,9	23,9	19,3
45 cm	25,9	25,9	25	24,9	21,6
65 cm	25,8	25	22,8	20,3	19,4

At the initial grain moisture 25,85% after 8 hours of drying using solar air heating collector 5 cm thick grain layer moisture reaches 14,4%. This means that the continued drying, the lower layer of grain over dried, which is not desirable. There is a need to solve the removal of the dried grain from drying equipment. Drying zone moves from the bottom layer to the top, it means that the air wetted at bottom layer intake less moisture from upper grain layers. Studies have shown as illogical moisture reduction after 2 hours drying in 65 cm layer comparing with 45 cm thick. This is due to the fact that the upper layer of oats shone upon the sun, warmed it and wind addition dried it.

Conclusions

1. Oats grain drying using air heating solar collector heat up the air with an average temperature 33 °C provide 5,1 g/100 g water removal after 6,5 hours of drying.
2. Cereal harvest period in July-August, when the solar radiation and ambient air temperature is high drying efficiency of the solar air heating collector only increase.
3. Research shows solar collector efficiency, but does not solve the dried grain handling from this drying equipment

References

1. Kalogirou, S. 2009. Solar energy engineering: processes and systems. (1st ed), Academic Press Elsevier Inc., USA.
2. Mulet, A.; Berna, A.; Rosello, S.; Canellas, J. 1993. Analysis of open sun drying experiments. *Drying Technology*, 11, 6, pp.1385-1400.
3. Ratti, C.; Mujumdar, A.S. 1997. Solar drying of foods. Modelling and numerical simulation. *Solar Energy*, 60 3-4, pp.151-157.
4. Andoh, H.Y.; Gbaha, P.; Koua, B.K.; Koffi, P.M.E.; Toure, S. 2010. Thermal performance study of a solar collector using a natural vegetable fiber, coconut coir, as heat insulation. *Energy for Sustainable Development*, vol. 14, pp. 297-301.
5. Aboltins A., Upitis A. 2011. The mathematical model of carrot slices drying. *Poljoprivredna tehnika* XXXIV (2), pp. 69-75.
6. Aboltins, A.; Upitis, A. 2012. Experimental and theoretical investigation of agricultural material drying process. *11th International Scientific Conference „Engineering for Rural Development"*, vol.11, Jelgava, p. 93-98.
7. Palabinskis, J.; Aboltins, A.; Kunkulis, A. LR Patent No 14310 „Transformable, mobile air heating solar collector" (2011).

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AVIŽŲ DŽIOVINIMAS NAUDOJANT MOBILŲ ORO ŠILDYMO SAULĖS KOLEKTORIŲ

Šio tyrimo tikslas buvo nustatyti avižų grūdų džiovinimo efektyvumą naudojant saulės kolektoriuje šildomą atmosferos orą. Eksperimentas atliktas pavasarį. Gauti rezultatai ir jų analizė patvirtina ir įrodo oro šildymo saulės kolektoriuje ir saulės kolektoriaus taikymo žemės ūkio produktams džiovinti efektyvumą. Saulės kolektoriuje oras sušildomas vidutiniškai iki 33 °C temperatūros, dėl to po 6,5 valandų džiovinimo iš avižų sluoksnio pašalinama 5,1 g/100 g drėgmės. Esant pradinei 25,85 % grūdų drėgmei, po 8 valandų džiovinimo, sušildant orą saulės kolektoriumi iki 33 °C laipsnių, 5 cm storio grūdų sluoksnio drėgmė sumažėja iki 14,4 %. Avižų grūdų sluoksnio temperatūros ir drėgmės pokyčių priklausomybės nuo džiovinimo laiko grafikai yra pateikti straipsnyje.

Avižos, džiovinimas, saulės kolektorius.

Айварс Аболтинс, Янис Палабинскис

СУШКА ОВСА ПУТЕМ НАГРЕВА ВОЗДУХА МОБИЛЬНЫМ СОЛНЕЧНЫМ КОЛЛЕКТОРОМ

Целью данного исследования было определение эффективности сушки овса атмосферным воздухом, нагретым солнечным коллектором. Эксперимент проведен весной. Полученные результаты и их анализ подтверждают и доказывают как эффективность нагрева воздуха коллектором, так и эффективность его применения для сушки сельскохозяйственной продукции. В солнечном коллекторе воздух нагревается до средней температуры 33°C, что обеспечивает удаление из слоя овсяного зерна 5,1 г/100г влаги после 6,5 часов сушки. При начальной влажности зерна 25,85 %, после 8 часов сушки, с использованием воздуха, нагретого солнечным коллектором до 33°C, в слое зерна толщиной 5 см уровень влаги достигает 14,4 %. Графики изменений температуры и влаги слоя овсяного зерна в зависимости от времени сушки приведены в статье.

Овес, сушка, солнечный коллектор.