THE USING OF BIOMASS FOR A GRATE DRIER
POUŽITIE BIOMASY PRE ROŠTOVÚ SUŠIAREŇ

Ivan Vitázek, Ján Tirol

Abstract

Gourd seeds are easy damageable. These seeds contain oil and healing substances. For drying of the gourd seeds very delicate handling needs. For this reasons a chamber grate dryer is proposed. For the heating of drying-medium air-heater was used. The air-heater used as fuel the mineral oil. The mineral oils emission is significant source of pollution of air. By burning of mineral oil very high value of CO_2 emission is produced that is meaning reason of greenhouse effect. Thereat air-heater for burning of wood splinters is successfully used for drying-medium heating. In paper basic calculations necessary for application of the air-heater for biomass burning are described and some service characteristics of drier. A chamber grate dryer with grate area of 7 x 4,5 m with seed bed depth of 0,2 m is proposed. A air-heater for wood splinters with heat performance of 87 kW is used for heating the drying medium. Chamber grate dryer dry 5040 kg gourd seeds per period (21 h). Consumption of timber is for one period approximately 633 kg.

Key words: gourd seeds, chamber grate drier, biomass

Introduction

Gourd is a commonly grown vegetable in our country. Table gourd has got a spherical form and rough pulp. We can stock gourd two-four months after harvesting. Apart from its pulp, gourd seeds are also highly evaluated. These seeds, which contain oil and healing substances, are harvested at the time of full maturity of gourds. Farming business in Kolíňany solved problem of processing of gourd seeds after harvesting. Chamber grate drier was proposed and source of heat the air-heater for biomass burning. The biomass has got a some advantages. Burning of biomass results in a low emission of CO_2, because CO_2 is produced just merely plant absorbs during vegetation. The mineral oil is the fossil fuel. Price of fossil fuel increase, thereat biomass suggests favour lower price and better availability. Consumption of mineral oil per drying period was 187,11kg.

Material and method

The gourd seeds are dried from humidity $\varphi = 40\%$ to $\varphi = 8\%$. The wet material has got density $\rho = 800\ kg.m^{-3}$.

Entry data

Chamber grate drier:

- surface of grate 7 x 4,5 m,
- depth of seed bed 0,2 m.

Air-heater:

- furnace for solid fuel with power 87 kW,
- drying medium 1,47 $m^3.s^{-1}$,
- heating from 10 °C to 70 °C.

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Dried material

The gourd seeds – data of sorption facilities are not available. We used data for other similar plant. Then is valid:

- sector of steady velocity of drying is between $w = 40 \div 20$ %,
- sector of decreasing velocity of drying is between $w = 20 \div 8$ %,

All account are established for $m_{M1} = 800$ kg.m^{-3}.

- sector of steady velocity $w_1 = 40$ %, $w_2 = 20$ %, $\varphi = 1{,}0$. Mass of outlet water:

$$m_V = m_{M1}\frac{w_1 - w_2}{100 - w_2} = 800\frac{40 - 20}{100 - 20} = 200 \quad \text{kg.m}^{-3} \quad (1)$$

- sector of decreasing velocity of drying by drying to is:

$w_2 = 14$ % $\quad m_V = m_{M1}\frac{w_1 - w_2}{100 - w_2} = 800\frac{40 - 14}{100 - 14} = 241{,}86$ kg.m^{-3}

$w_2 = 12$ % $\quad m_V = m_{M1}\frac{w_1 - w_2}{100 - w_2} = 800\frac{40 - 12}{100 - 12} = 254{,}55$ kg.m^{-3}

$w_2 = 10$ % $\quad m_V = m_{M1}\frac{w_1 - w_2}{100 - w_2} = 800\frac{40 - 10}{100 - 10} = 266{,}67$ kg.m^{-3}

$w_2 = 8$ % $\quad m_V = m_{M1}\frac{w_1 - w_2}{100 - w_2} = 800\frac{40 - 8}{100 - 8} = 278{,}26$ kg.m^{-3}

The density of dried material is:

$$r_2 = r_1 - m_V = 800 - 278{,}26 = 521{,}74 \quad \text{kg.m}^{-3} \quad (2)$$

The mass of wet material on start of drying is:

$$M_{M1} = V_m \,.\, r_1 = 7.4{,}5.0{,}2.800 = 5040 \quad \text{kg} \quad (3)$$

The mass of dried material on the end of drying is:

$$M_{M2} = V_m \,.\, r_2 = 7.4{,}5.0{,}2.521{,}74 = 3286{,}96 \quad \text{kg} \quad (4)$$

The mass of evaporation water by drying:

$$M_V = M_{M1} - M_{M2} = 5040 - 3286{,}9 = 1753 \quad \text{kg} \quad (5)$$

The drying medium:

Than the drying medium is used heating atmospheric air. During the drying enthalpy of air is not changed, thereat enthalpy is $i_2 = i_1$.

The process of drying two sector create.

Sector of steady velocity of drying. From dried material move up saturate air with $j = 1$, $x_2 = \text{const.}$, $t_2 = \text{const.}$

Sector of decreasing velocity of drying. From dried material move up drying medium in equilibrium state with dried material, that is $\varphi < 1$ and with decreasing of w the medium is decreasing, $x < x_2$ is decreasing with decreasing w. $t > t_2$ is increasing with decreasing w. We show course of change of heating medium in i-x diagram of wet air (figure 1).

Results

Atmospheric air, point 0.
We reason with t_0 = 10 °C, φ_0 = 0,8, p = 100 kPa.
In i-x diagram of wet air we deduct: x_0 = 6,2 g.kg^{-1}, i_0 = 25,8 kJ.kg^{-1}

The heating air, point 1.
We reason about heating in exchanger of heat, thereat $x_1 = x_0$, t_0 = 70 °C.
From this we calculate enthalpy:

$$i_1 = 1{,}004 t_1 + x_1 (2499 + 1{,}884 t_1) \quad (6)$$

$$i_1 = 1{,}004.70 + 0{,}0062 (2499 + 1{,}884.70)$$

$$i_1 = 86{,}6 \text{ kJ.kg}^{-1}$$

The mass flow of drying medium
Heat rate of air-heater P = 87 kW.
Difference of enthalpies of drying medium before and after heating:

$$\Delta i = i_1 - i_0 = 86{,}6 - 25{,}8 = 60{,}8 \text{ kJ.kg}^{-1} \quad (7)$$

The mass flow of drying medium:

$$P = m_{LS} . \Delta i \Rightarrow m_{LS} = \frac{P}{\Delta i} = \frac{87}{60{,}8} = 1{,}43 \text{ kg.s}^{-1} \quad (8)$$

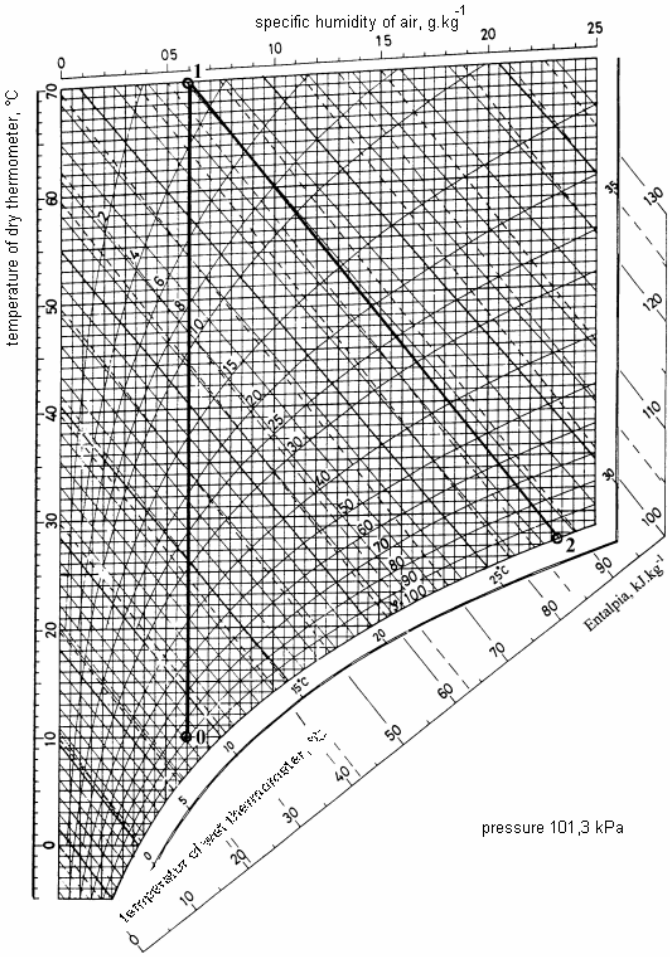

Figure 1. i-x diagram of wet air

Characteristics indexes

The mass of dried material per hour (w_1 = 40 %, w_2 = 8 %):

$$m_{M2} = M_{M2} / t = 3286{,}96 / 21{,}26 = 154{,}6 \quad \text{kg.h}^{-1} \quad (9)$$

Evaporation is the mass of evaporation water per hour:

$$m_V = M_V / t = 1753 / 21{,}26 = 82{,}46 \quad \text{kg.h}^{-1} \quad (10)$$

Specific evaporation is mass of evaporation (kg) on 1 m^2 effective surface per hour:

$$a = m_V / S_z = 82{,}46 / (7.4{,}5) = 2{,}62 \quad \text{kg.m}^{-2}\text{.h}^{-1} \quad (11)$$

Specific consumption of heat on *1* kg evaporation water:

$$q_Q = Q_T / m_V = P.3600 / m_V = 87.3600 / 82{,}46 = 3798{,}2 \quad \text{kJ.kg}^{-1} \quad (12)$$

Specific consumption of heat on 1 kg dried material:

$$q_Q = Q_T / m_{M2} = P.3600 / m_{M2} = 87.3600 / 154{,}6 = 2025{,}9 \quad \text{kJ.kg}^{-1} \quad (13)$$

Consumption of fuel

The air-heater use as a fuel the timber splinters. Caloric value q_p of timber is 13 MJ.

Mass of the fuel m_p necessary for one drier period t (21 h) is calculated from formula:

$$m_p = 3{,}6.P.t / q_p.0{,}8 = 3{,}6.87.21 / 13.0{,}8 = 632{,}42 \quad \text{kg} \quad (14)$$

Figure 2. Air-heater for heating of drying medium

Figure 3. Grate of chamber drier

Conclusion

The gourds seeds hold vitamins, proteins, quality oil, which is used also in pharmaceutical industry. Seeds are very meaning source of zinc. Essentials acids (EMK) reduce level of fat in blood. Seeds after harvest have to get to washing machine and next they have to dry to humidity 8%. For heating of drying medium was used mineral oil. Consumption of mineral oil was 187,11 kg per period. This was not respectable, thereat new air-heater for biomass burning is used now. Consumption of timber splinters is 632,42 kg per period. For consumption of mineral oil corresponding production of emission is 612,5 kg CO_2. This value is reduce trough using of biomass burning. Resolution of static of drying chamber grate drier helped realize of gourd seeds drying, synchronize power of harvester with power of drier and quality of seeds observe.

The paper is published thanks to carrying out grant project VEGA 1/3483/06 „Research in enhancing the effectivity of ecological aspects of operation of mobile and stationary technology in agriculture“.

Literature

1. HLAVÁČOVÁ, Z.: Sorptive Properties of Pea Seeds. In: PTEP Časopis za procesnu tehniku a energetiku u poljoprivredi, vol. 5, 2001, no. 3, p. 98-101.
2. CHYSKÝ, J.: Vlhký vzduch. Praha: SNTL, 1977. 160 s.
3. NIKITINA, L.M.: Tablicy rovnovesnogo udelnogo vlagosoderžanija i energii svjazi vlagi s materialama. Moskva: Gos. e. izdat., 1963. 176 s.
4. VITÁZEK, I.: Nový typ diagramu vlhkého vzduchu. In: Acta technologica agriculturae XXXIII. Nitra : ES VŠP, 1992, s. 269-276.
5. VITÁZEK, I. - HAVELKA, J.: Zdokonalenie teórie sušenia poľnohospodárskych materiálov. In: Zborník z medzinárodnej vedeckej konferencie „AGROTECH NITRA 2002“. Nitra : SPU, 2002, s. 345-350.
6. VITÁZEK, I.: Prenosové javy pri sušení - Krivky sušenia. Nitra: Vydavateľstvo SPU, 2004. 78 s. ISBN 80-8069-317-X
7. VITÁZEK, I.: Teplotechnika a hydrotechnika (Druhé vydanie). Nitra: SPU, 2008, 104 s.
8. VOZÁROVÁ, V. Termofyzikálne vlastnosti potravinárskych materiálov. In: Zborník z vedeckej konferencie „Výskumné a edukačné aktivity na katedrách fyziky technických univerzít na Slovensku. Bratislava : STU, 2004, s. 81-85.
9. STN 12 6000. Sušiarenstvo. Základné pojmy techniky sušenia. Názvoslovie.
10. STN 12 6013. Sušiarenstvo. Skúšanie poľnohospodárskych sušiarní.

Súhrn

Tekvicové semená sa ľahko poškodia. Tieto semená obsahujú olej a liečivé substancie. Pre sušenie tekvicových semien sa vyžaduje opatrné spracovanie. Z tohto dôvodu je navrhnutá komorová roštová sušiareň. Pre ohrev sušiaceho média bol použitý teplovzdušný ohrievač. Teplovzdušný ohrievač používal ako palivo naftu. Spaliny nafty sú významný zdroj znečistenia ovzdušia. Spaľovaním nafty je produkované veľké množstvo emisií CO_2, ktoré prispievajú k skleníkovému efektu a najmä toto palivo je ekonomicky neefektívne. Navrhnutý a úspešne odskúšaný bol ohrievač vzduchu pre spaľovanie drevnej štiepky pre ohrev sušiaceho prostredia. V príspevku sú popísané základné výpočty nutné pre použitie ohrievača spaľujúceho biomasu a vybrané prevádzkové charakteristiky sušiarne. Komorová roštová sušiareň je navrhnutá s plochou roštu 7 x 4,5 m a s výškou vrstvy semien 0,2 m. Použitý ohrievač vzduchu má výkon 87 kW a ako palivo slúžia dubové a bukové štvrtené siahovice. V navrhnutej sušiarni sa usuší 5040 kg tekvicových semien počas jedného sušiacho cyklu, ktorý trvá 21 hodín. Spotreba dreva na jeden sušiaci cyklus je cca 633 kg.

Kľúčové slová: tekvicové semená, roštová sušiareň, biomasa