TEKA Kom. Mot. Energ. Roln. – OL PAN, 2008, 8, 241–246

ENERGY-CONSUMPTION AT SWEET CORN THRESHING

Mariusz Szymanek

Department of Theory of Agricultural Machines, Faculty of Production Engineering,
20-612 Lublin, Głęboka 28, ph. 081 445 61 28, e-mail: mariusz.szymanek@ar.lublin.pl

Summary. The paper considers an influence of the angular speed of threshing drum on power consumption during the threshing of sweet corn variety Candle. The sweet corn cobs were blanched and frozen prior to threshing. The changes of angular speed of threshing drum varied from 100 to 180 rad·s^{-1} , which affected an increase of power consumption in the range from 2.29 to 2.44 kW (t·h^{-1}) , about 7%.

Key words: sweet corn, frozen, threshing, power consumption.

INTRODUCTION

Corn has a lasting place in our agriculture thanks to research on growing and cultivation technology, which assures the supply of new varieties of higher ability to potential crop. The achievement of a farmer and agricultural engineer have made it possible to increase the growing area and yield of corn in the last years [7]. Most clearly, there has been an increase of the growing area of sweet corn for consumption. Nowadays the growing area of sweet corn is about 5-6 tys. ha [21].

The kernels of sweetcorn for consumption are harvested at milk stage of maturity. In this period the moisture of kernels is in the range of 70 do 78% [13, 20]. The corn is characterized by a high level of moisture at this stage. The immature, soft and semi-liquid pulp of kernel cannot be directly separated with the threshing method, as in the threshing of corn which reached a physiological stage of maturity [8].

The applied classical methods of gaining kernel for consumption by cutting lead to large quantitative and qualitative losses of kernels [1, 17, 18] as well as the high expenditure of energy, which resulted from the contact of a knife with hard corn core [12]. So there is a need for the searching of other methods leading to reduction of kernel losses. The threshing methods can be applied for removal the kernels from a frozen cob. Nowadays in Polish and foreign literature this kind of study is scarce. Therefore, special attention should be paid to the research on energy-consumption in the process. On the other hand, the problems connected with traditional threshing and energy aspect were considered by many authors [2, 3, 4, 5, 6, 9, 10, 11, 15, 16,19].

An effect of angular speed of threshing drum on power consumption was the objective of this article.

MATERIALS AND METHODS

The Candle variety of sweet corn used in the present study was obtained from a crop grown, as representative of commercial processing, during 2007 in the zone of Warsaw. When the corn attained the optimum processing maturity (monitored by moisture content and juice consistency of kernels), the harvesting was begun. At harvest ears were randomly picked from plantation. The corn ears selected for study were healthy, of straight shape, high degree of kernel filling and similar geometrical properties. The characteristics of sweet corn are presented in Table 1.

Table 1. The characteristics of sweet corn

Contest	Mean (SD)
Cob weight*, g	334.3 (21.1)
Cob length, cm	23.1(2.6)
Max. cob diameter, cm	4.8(0.8)
Number of kernels per row, pcs.	26 (1.3)
Number of kernel rows, pcs.	14 (1.5)
Kernel moisture,** %	74.3 (1.6)

* husked, ** before frozen

To determine an average size of sweet corn, a sample of 100 ears was randomly selected. The moisture content was determined according to standard methods (PN-ISO 6540, 1994). The linear dimensions of the husked ears and kernels were measured using a caliper reading to 0.1 mm. The weight of husked ears was measured using a WPE 2000p balance with an accuracy of 0.1g.

Before the threshing sweet corn was blanched and frozen. Blanching was carried out in the water of about 80-90°C. The blanching time was about 2 minutes. After taking out the cobs from the water they were cooled down in an ambient temperature (about 22° C), then they were dried. Next, the corn cobs were being frozen in a stream of liquid nitrogen of minus ca. 40 °C for about 4 minutes. The conditions of blanching and freezing were determined on the basis of literature and initial experiments. The sweet corncobs were frozen in a container (thermos). The liquid nitrogen was supplied from applicators of Dewar flask. The frozen cobs were moved to threshing. A finger threshing unit with axial flow was applied (Fig. 1).

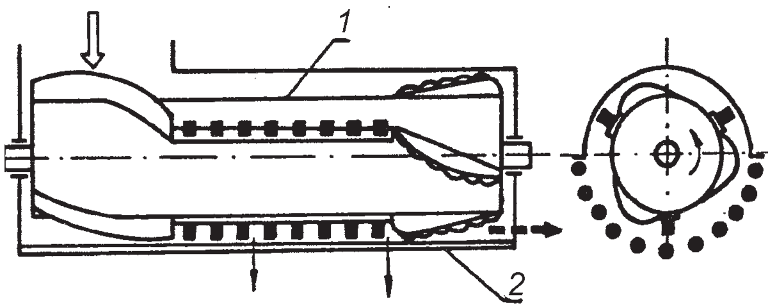


Fig. 1. Scheme of a threshing unit with axial flow of material: 1 – drum, 2 – floor

The technical parameters of the threshing unit are presented in Table 2.

Table 2. Technical parameters of the threshing unit

Angle of drum belting, rad	π
Working gap, mm: – inlet – outlet	 30 15
Drum length, mm	1200
Drum diameter, mm	240
Engine power, kW	3.5

The energy-consumption of threshing was investigated on a laboratory stand equipped with a threshing unit (Fig. 1), by a system of electric power measurement Lumel PP83 at sampling 1 s and frequency transducers Telemecanique ATV 18V. The measurements were realized in 3 replications for each threshing drum speed on the sample of 10 cobs. The cobs were fed for the threshing unit till it was full. The power of threshing was measured after the threshing drum achieved a stable speed.

The optimum consumption of power (*N*) was determined according to formula:

$$N = N_c - N_{bj}, \tag{1}$$

where:
N_c – power consumption at threshing, kW
N_{bj} – power consumption at neutral gear, kW

On the basis of initial studies the square function to describe the energy-consumption was taken.

$$N = a \cdot \omega^2 + b \cdot \omega + c, \tag{2}$$

where:
a, *b*, *c* – real constants;
ω – angular speed of threshing drum, rad·s^{-1}.

The measurements of power consumption were realized in the function of four angular speeds of threshing drum: 100, 120, 140, 180 rad·s^{-1}. A range of applied speed was set on the basis of initial studies. Frequency transducers, by taking into account the gear ratio, were used to changing the threshing drum speed. The drum speed was controlled with an optical tachometer Prova RM -1000 with accuracy 0.01%.

An estimation of results was realized on the basis of an analysis of variance and multiple regression. Comparison of means was conducted with the Tukey's least significant difference (LSD) test, at a significance level p = 0.05. In addition, the standard deviations for mean values were given.

Analyses of errors were realized to set a probable error *r* according to the formula given by Pabis [14].

$$r = 0.6745\sqrt{\frac{\sum_{i=1}^{n}(x_1 - x_m)^2}{n-1}}, \tag{3}$$

where:
x_1 – measurement value,
x_m – arithmetical mean,
n – number of measurements.

In a case when the measurement error exceeded fivefold admissible value of probable error:

$$r > 4.9r, \quad (4)$$

the measurement was rejected.

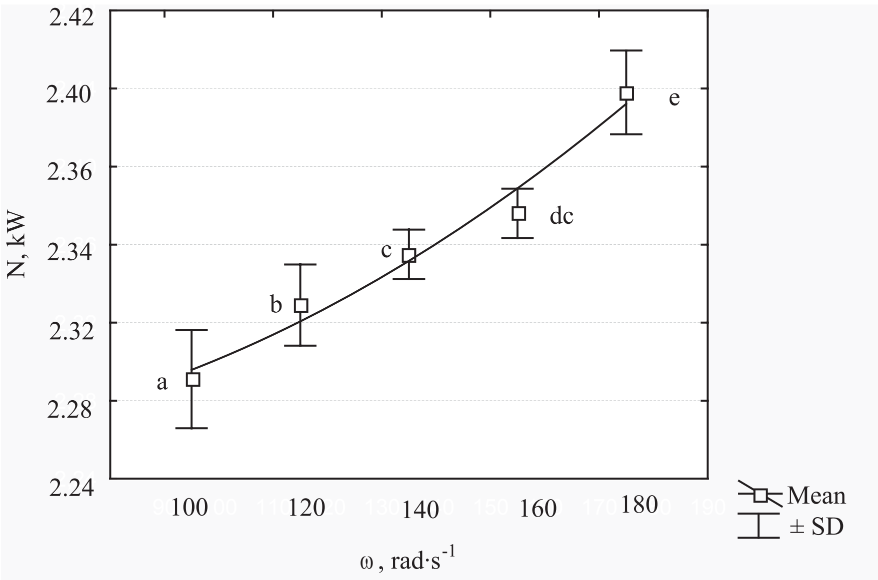
RESULTS AND DISCUSSION

Analyses of variance (Table 2) showed that the angular speed of threshing drum at $\alpha = 0.05$ had a statistically significant influence on power consumption during the threshing of frozen sweet corn.

Table 2. Analysis of variance for

Specification	Sum of square	Degree of freedom	Mean square	Test F	Significant level
N	0.26	4	0.07	75.36	0.0001

Tukey test (Fig. 2) showed an insignificant difference in mean values of power between speed of 140 and 160 rad·s^{-1}.



Numbers in the same letter are insignificantly different at p<0.05.
Fig. 2. Power consumption (*N*) in dependence of angular speed (*ω*)

A curve of dependence power consumption of angular speed is illustrated with the equation:

$$N = 7.68 \cdot 10^{-6} \omega^2 + 0.4 \cdot 10^{-3} \omega + 2.26 \ (r = 92\%).$$

The mean values of power in the range from 100 to 180 rad·s^{-1} vary from 2.29 to 2.44 kW. The mean values of power consumption were relevant (counted) to the efficiency of ton per hour.

CONCLUSIONS

The investigation of power consumption in dependence of angular speed of threshing drum was carried out. An increase of speed has an influence on the growth of mean values of power consumption. The change of power in dependence of speed was showed by means of a square function.

In the range from 100 to 180 rad·s^{-1} the power consumption varied from 2.29 to 2.44 kW (t·h^{-1}), about 7%.

REFERENCES

Brecht J. K. 1998: Fresh cut sweet corn kernels. Citrus and Vegetable Magazine, 63 (7), 36-37.

Bulgakov, V., Shpokas, L. Petkavicius, S. 2006: Исследование уборки кукурузы на зерно. Motorization and powerindustry in agriculture. ISSN 1730-8658. Lublin, Vol. 8, p. 58–68.

Domin M., Kluza F. 2005: Decreasing the temperature of pop corn cobs as a process reducing the losses of mechanical seeding. Electronic Journal of Polish Agricultural, Agricultural Engineering, Volume 8, Issue 4.

Dreszer K.A., Suseł I. 1994: Stan badań nad czynnikami wpływającymi na energochłonność procesu omłotu. Postępy Nauk Rolniczych, 3, 75-90.

Goć K. 1974: Wpływ prędkości zasilania zespołu młócącego na proces omłotu zbóż. Biuletyn Prac Naukowo-Badawczych, 10. IBMER Warszawa.

Goriaczkin W.P. 1936: Teoria barabana. Teoria konstrukcja i proizwodstwo sielskochoziajstwiennych maszyn. Sbornik Trudow, 4, 134-172.

Heimann H., Janiak W., Siódemak J. 2007: Kukurydza, 110-120. Gacek E. S., Lista opisowa Odmian. Rośliny rolnicze, cz. 1, COBORU, Słupia Wielka.

Jamieson P.D., Gillespie R.N. 1998: Predicting sweet corn maturity for factory processing in Canterbury, Proceedings of the 9th Australian Agronomy Conference,Wagga wagga

Kanafojski Cz. 1980: Teoria i konstrukcja maszyn rolniczych, t. 2, cz. I, PWRiL Warszawa.

Kugler K. 1976: Leistung und techniszcher Aufwand von Mahdrescher mit Mehrtrommel-drescherwerk. Agrartechnik, 12, 573-576.

Kutzbach, H. D. 2003: Mähdrescher-Combine harvesters, Jahrbuch Agrartechnik-Yearbook Agricultural Engineering, Band 15, VDMA Landtechnik, VDI-MEG, KTBL, Frankfurt, pp. 147-154.

Niedziółka I., Szymanek M., Rybczyński R. 2002: Energochłonność procesu cięcia ziarna kukurydzy cukrowej. Inżynieria Rolnicza, 6, 347-351.

Ortiz de Bertorelli L, De Venanzi F, Alfonzo B, Camacho C. 2002: Super sweet corn hybrid sh2 adaptability for industrial canning process. Archivos Latinoamericanos de Nutrición, 52(4), 381-386.

Pabis S. 1994: Rachunek błędów w badaniach procesu suszenia. Cz. I. Wybrane zagadnienia rachunku błędów. Zeszyty Problemowe Postępów Nauk Rolniczych, 415, 23-33.

Ratschow J.P. 1975: Charakterisierung der Dreschleistung von Mähdreschern. Landtechnik, 5, 248-251.

Shpokas L., Bulgakov W., Petkjawychus S. 2005: Eksperimentalnoje issledowonije technologicheskogo processa uborki kukuruzy na zerno. Naukowyj wisnyk NAU. Kyiw, u. 2 (80). s. 184–193.

Szymanek M. 2006: Wpływ terminu zbioru kolb kukurydzy cukrowej na straty masy odcinanego ziarna , Journal of research and applications in agricultural engineering, vol. 51(3), 47-50.

Szymanek M., Niedziółka I. 2006: Ocena nakładów energetycznych w procesie zbioru i odcinania ziarna kukurydzy cukrowej, Teka Komisji Motoryzacji i Energetyki Rolnictwa PAN, 6, 94-101.

Wacker P. 1988: Einflusse auf die Dreschleistung von Mähdreschern, Landtechnik, 6, 273-277.

Waligóra H. 2001: Aktualny stan produkcji i wykorzystania kukurydzy cukrowej w Polsce. Kukurydza 2(18): 49-50.

Warzecha R., Nosecka B. 2007: Kukurydza cukrowa, 36-37. Kukurydza nowe możliwości. Agro Serwis, wyd. IV. Biznes Press, Warszawa.