POWER CONSUMPTION AT INERTIAL THRESHING OF SESAME

КОНСУМАЦИЯ МОЩНОСТИ ИНЕРЦИОННОЙ МОЛОТЬБЫ КУНЖУТА

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Abstract: *The power consumption of a flow fruit detacher and classic thresher with equal nominal throughput at sesame threshing has been determined. The results show that the total power consumed by the detacher is 4.81 times smaller than by the conventional thresher. This result is due to inertial threshing which does not require destruction of capsules and deformation of stems for detaching of seeds.*
***Keywords**: SESAME HARVESTING, MECHANICAL THRESHING, POWER CONSUMPTION*

1. Introduction

An experimental unit of a flow detacher with non-symmetric angular oscillations has been developed at the Agricultural University - Plovdiv, BULGARIA (Ishpekov S. et al., 2015a). It is designed for detaching of fruits and seeds from plants through inertial way. The detacher achieves the best indicators about degree of threshing, portion of impurities in the threshed mixture and mechanical damage of the seed (Ishpekov S. et al., 2016). Moreover, it threshes sesame without destruction and deformation of its capsules and stems, which is the significant difference with the classic thresher (Ishpekov S., 2013, Ishpekov S. et al., 2015b). The various ways of threshing cause a difference between their power consumption.

The aim of the study is to determine the power consumption of the flow detacher at inertial threshing of sesame and its comparison with that of the conventional thresher.

2. Experimental method

The power consumption of the detacher has been determined experimentally through the magnitude of current consumed by the drive motor. The measurement of the AC is conducted with an experimental installation presented in figure 1. It is composed of the detacher (6, 7, 8, 9), electric motor 4, frequency inverter - 3 and ammeter - 2. The detacher is driven by three-phase asynchronous motor - 4 with a nominal power of 750 *W*. It is connected under the scheme "star", which supplies 3 phases of 220 *V* to the coils, and not as a normal - three phases of 380 *V*. Therefore, the engine develops $\sqrt{3}$ times less power, i.e. 433 *W*. The speed of the electric motor is controlled by frequency inverter Schneider Electric - ATV12HU22M2 - 3 (http://www.schneider-electric.com/ww/en/).

Power consumption of the electric motor - P_k, [*W*] is calculated by the formula

$$P_k = U.I.\eta_м \cos\varphi \qquad (1)$$

where:

U is the voltage supplied to the motor, [*V*];

I - the current consumed by the three phases, [*A*];

$cos\varphi$ - the power factor of the used electric motor ($\cos\varphi$=0,74);

$\eta_м$ - the mechanical efficiency of the system. Is calculated by reference (Trubilin E., 2010);

The power consumption of the detacher is determined for three operating modes that are typical for the thresher of grain harvester:

- In acceleration mode without loading with stems;
- In idling mode with constant rotation frequency of the central wheel of the pulse mechanism - 7;
- In mode with loading with stems.

An experiment according to design B_2 (Mitkov At., 1993) with three replications has been conducted for each of the three operating modes with the following controllable factors:

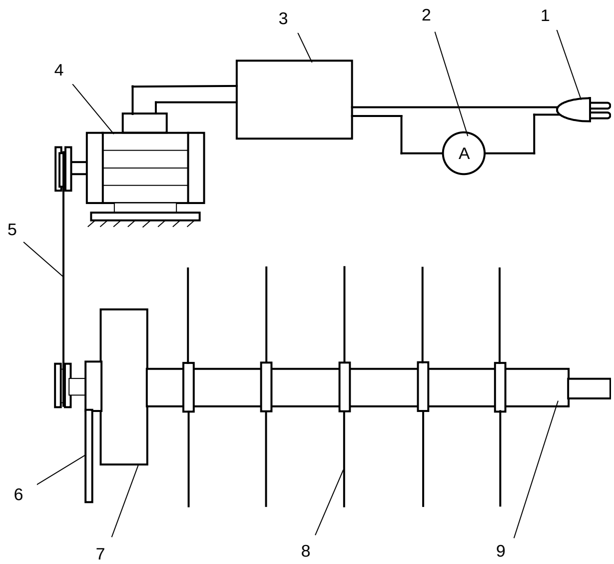

***Figure 1.** Scheme of experimental installation*
1 - power supply, 2 - ammeter, 3 - frequency inverter, 4 - three-phase electric motor, 5 - belt drive, 6 - one-way clutch, 7 - pulse Chalmers mechanism, 8 - fingers, 9 - shaft.

- The rotation frequency of the central wheel of the pulse mechanism - *n*, [min^{-1}];
- Initial elastic momentum of the clutch - $M_{el\,0}$, [*N.m*].

The natural and coded values of controllable factors are presented in table 1.

The current consumed by the drive motor - *I* has been meazured and by formula 1 is calculated the power consumption of the detacher - P_k.

The power consumption of the frequency inverter has been measured and reduced from this of the electric motor in all experiments.

Table 1. Natural and coded values of controllable factors

code	*n*	$M_{el\ 0}$
	min^{-1}	*N.m*
-1	120	0
0	420	1,28
+1	720	2,56

The power consumption of the conventional thresher is analytically determined by the following relations (Ishpekov S., 2013):

$$P_0 = A\omega + B\omega^3 \qquad (2)$$

where:

$A\omega$ is the power to overcome friction in the bearings, [*W*];

$B\omega^3$ - the power to overcome air resistance, [*W*];

P_0 - the power idling, [W];

The coefficients A and B have been taken from reference book. (Ishpekov S., 2013).

$$P_{o\text{в}} = \frac{q.v_{\text{б}}^2}{1-f} \qquad (3)$$

where:

q is the productivity of the conventional thresher, [kg/s];

$v_{\text{б}}$ - the peripheral speed of the drum, [m/s];

f - the coefficient for accounting the resistance of the concave (for rim thresher f =0,65÷0,75);

$P_{o\text{в}}$ - the power for threshing, [W];

$$P = P_0 + P_{o\text{в}} \qquad (4)$$

where P it the total power consumption of the conventional thresher, [W].

The resulting power consumption translates to one kilogram threshing stems. The results are used to compare the two devices and the two working methods of threshing.

3. RESULTS

The power consumption of the detacher and of the threshing apparatus of the plot combine harvester Wintersteiger - classic (www.wintersteiger.com) have been determined and compared. The main technical data for the two devices are presented in table 2. Both have the same nominal productivity, but operate on different principles. The detacher releases sesame seeds on inertia way and threshing apparatus of the combine harvester - by rubbing and strokes.

The measured power consumption of the inverter at a constant mode is 16,3 W and at acceleration reaches 95,4 W. During acceleration up to speed of the central wheel shown in table 1 is seen an increase of power consumed by the detacher from 138,4 W to 488,4 W. At an acceleration up to n=720 min^{-1} the power consumption reaches 112,8 % compared to the nominal, which in this case is 433 W. The electric motor works with an overload of 12,8 %, which is acceptable for a short time.

In idle mode the power consumption is changed from 137,3 W to 241,5 W, which is from 31,7 % to 55,8 % of the rated (Fig. 2). The remaining power may be used for the technological process in the detacher.

Table 2. *Technical data of the investigated devices*

Parameter	Dimension	Detacher	Threshing apparatus of Wintersteiger - classic
Diameter of the drum	*m*	0,48	0,35
Width of the drum	*m*	1,3	0,785
Peripheral speed of the drum	*m/s*	1,45 - 3,05	15
Frequency of angular oscillations of the drum	*Hz*	12	-
Rated productivity	*kg/s*	1	1
Principle of threshing	-	inertial	rubbing and strokes

In mode with loading with stems, which mass is 0,87 kg for the power consumption P_k of the detacher is obtained the following regression equation -

$$P_k = 131,8415 + 0,0373n - 12,5068M_{el\_0} + 0,0002n^2 + 3,2570M_{el\_0}^2$$

with coefficient of determination R^2=0,99, Fisher criterion $F_{4,22}$=558,15, and probability $p(F)$=0,00001.

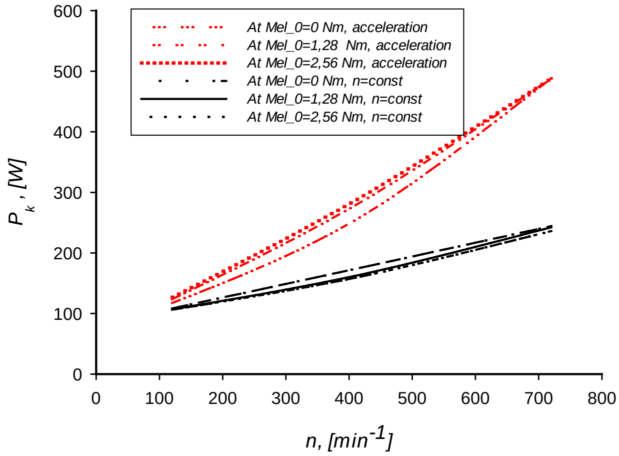

Figure 2. *Power consumption P_k of the detacher depending on the speed of the central wheel n and the initial elastic moment M_{el_0} in mode without loading with stems.*

Equal level lines for power consumption P_k in mode with loading of the detacher with stems are presented in figure 3. The power consumption is from 174,2 W to 258,8 W, which is an increase compared to idling from 36,9 W (26,6 %) to 17,3 W (7,2 %). This increase is less at high speed of the central wheel, because then the inertial forces are increased, but the proportion of torque for vibrations and movement of the stems - decreases.

The results obtained demonstrate two important facts:

- In load mode the detacher has a large supply of power to overcome temporary overloads;

- The initial elastic moment the clutch M_{el_0}, which is resistance type, has no significant impact on the power consumption of the detacher in idling and loading modes (Fig. 3). It increases the power consumed in acceleration mode only.

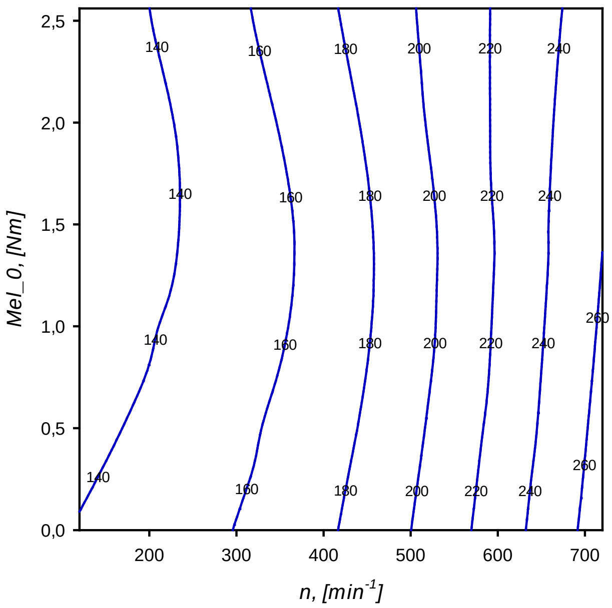

Figure 3. Equal level lines for power consumption P_k of the detacher depending on speed of the central wheel n and initial elastic moment M_{el_0} in loading mode with stems which mass is 0,87 kg.

The power consumption of both devices at threshing equal amount of stems is presented in table 3. Apparently, the detacher consumes 2,04 times less power at idle due to lack fan effect. It consumes 43,35 times less power for threshing, because it does not deform stems and capsules for removing seeds, while in classic thresher this is inevitable. Total specific power consumption of the detacher is 4,81 times smaller than of the conventional thresher with the same productivity.

Table 3. *Specific power consumption by the investigated devices [W/kg] at threshing stems with a mass 0,87 kg.*

Parameter	Detacher	Thresher of Wintersteiger - classic	Difference (times)
Specific power consumption in idling mode	277,6	567,3	2,04
Specific power consumption for threshing	19,9	862,1	43,35
Total specific power consumption	297,5	1429,4	4,81

It should take into account that the power consumption of the detacher has been determined experimentally and of the conventional thresher - analytically. Besides that, it is presumed an equality of both resistance coefficients of the concave at threshing of wheat and sesame. The value of this coefficient for sesame threshing is unknown, but probably is greater than that for wheat threshing. Therefore, it is possible the actual power for sesame threshing $P_{ов}$ by conventional thresher to be greater than analytically obtained. For this reason, it can be expected that the actual differences between power consumption of inertial and classical threshing to be larger than those obtained in this study. Those assumptions may lead to experimental error of the first kind, which does not lead in bad consequences of the results (Mitkov At., 1989).

4. CONCLUSION

The initial elastic moment of the clutch has no significant impact on the power consumption of the detacher in constant mode of operation. In idling the detacher consumes up to 48,3 % of the power that is consumed in acceleration mode. Power consumption for threshing of the detacher is up to 7,6 % in comparison with the power for its acceleration. The total power consumed by the detacher is 4.81 times smaller than by the conventional thresher with the same productivity.

5. References

Ishpekov S., (2013). Harvesting machines - I part. Book, Agricultural University - Plovdiv, ISBN 978-954-517-188-8, (Bg).

Ishpekov S., P. Petrov, D. Ruschev, R. Zaykov, 2015 a. Flow rotational fruit detacher with non-symmetric angular vibrations. Patent Application 3143 of 05.11.2015, Bulgarian Patent Office.

Ishpekov S., R. Zajkov, (2015 b). Inertial detachment of sesame seeds from non-squander genotypes, Agric Eng Int: 17, (3), p 83 - 91, (En).

Ishpekov S., R. Zajkov, P. Petrov, D. Ruschev, (2016). Indices of flow fruit detacher with angular vibrations at inertial threshing of sesame. Agric Eng Int: 18 (2):94-10;

Mitkov At., D. Minkov, 1993. Statistical methods for investigation and optimization of agricultural machinery. Zemizdat, Sofia, p 366, (Bg).

Trubilin E., V. Ablikov. Harvesters. Krasnodar, 2010 (Ru). Трубилин Е. И., В А Абликов., 2010. Машины для уборки сельскохозяйственных култур. Краснодар, 325 стр.

www.wintersteiger.com

http://www.schneider-electric.com/ww/en/