

THE EFFECT OF SOME TECHNOLOGICAL FACTORS ON THE CONSUMPTION OF ENERGY AT MIXING GRANULAR MATERIALS

Józef Grochowicz, Sławomir Walczyński*

Agricultural University of Lublin, Poland

*Institute of Animal Science in Kraków, Poland

INTRODUCTION

Mixing loose materials is a very complex process. Its course is significantly affected by, apart from physical properties of the materials being mixed, also the conditions of in which it is being carried out, e.g. the share of individual constituents of the granular system, the level of filling the mixing apparatus, its rotational speed, etc. [2, 10].

The mixers used should ensure obtaining an optimum share of components in the shortest possible time, that is at the lowest input of energy. High effectiveness of the process may be received owing to the good choice of the mixer. It is especially important when mixing granular materials greatly non-homogenous concerning the measurements, specific or heaping density or else differing in other properties relevant in dynamic processes [2, 5, 6].

In the conducted so far tests on the exploitation of mixing power, standard meters of alternating current (ammeter, voltmeter, wattmeter) or torque meter were used. The calculated values are mean, not transient, parameters [3, 4, 8]. Moreover, first attempts at using computer techniques for direct reading of the measured values are undertaken [1, 7, 9].

OBJECTIVE AND RANGE OF THE STUDY

The objective of the studies was to determine the effect of the properties of the components as well as those of chosen technological factors on active energy consumption at the processes of mixing loose materials, and also to check the

measurement power of the stand, equipped with a power converter and computer set, for continuous data registration.

METHODOLOGY

Testing the course of the mixing process and its energy consumption was carried out using a level channel mixer with a band-blade stirrer. The mixer was powered by a three-phase motor of 3.0 kW, rotational speed 1415 rpm, $\cos \phi = 0.81$ and rated current $I_n = 5.6$ A. The stirrer was powered by a Motovario worm motoreducer, which provides constant rotational speed – 24 rpm.

According to the manufacturer, the mixer ought to ensure mixing of the components in 3-5 min, at the homogeneity of 1:100 000.

Energy consumption of the mixing process was determined by registering the changes in active power absorbed by the engine of the mixer. The system (Fig. 1) consisted of a three-phase power converter (measurement range 0-10 kW; constant voltage signal +10 V), an analogue – digital converter transmitting the signal directly to the computer and the tested apparatus.

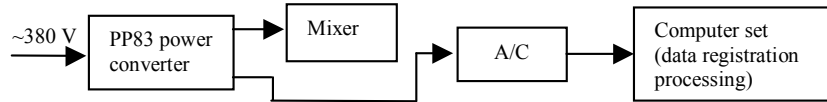


Fig. 1. Block diagram of the measurement stand

The used software enabled the observation, on the monitor screen, of the undergoing changes as an inspecting diagram. The frequency of sampling ranged from 1 to 1,000 Hz. After having completed the measurement, the registered data were further processed. An adequate scale on the X,Y axis was chosen and after having marked edge points, the program calculated the used active energy after the formula:

$$E = \int_{t_1}^{t_2} P dt \quad (1)$$

where:

- E – used energy [Wh],
- P – instantaneous power [W],
- t_1, t_2 – beginning and end of mixing [s].

The studies on energy consumption were carried out on barley cake as stock material.

The following variables were assumed:

- the weight of the stock 40, 80, 120 [kg] (the level of loading the mixer chamber was – 24, 48, 72, 96/%, respectively),
- mixing time 1, 2, 3, 4, 5, 6 [min].

All measurements were performed in five replications. The obtained results were described with statistical methods in order to get the basis for correct conclusions.

RESULTS AND DISCUSSION

The effect of the conducted studies was the received series of results characterising the processes of mixing in the tested apparatus, considering the energy consumption.

PROPERTIES OF RAW MATERIAL

Basic physical properties of the raw material used for the studies are presented in table 1.

Table 1. Basic physical properties of raw material used in the studies

Raw material	Humidity	Heaping density	Pouring angle	Heaping angle	Mean size of particle
-	%	kg/m	deg	deg	mm
Barley Class > 2.0 mm	12.8	655	17.5	20.5	2.7

TESTING ENERGY CONSUMPTION OF MIXING GRANULAR COMPONENTS IN MPP-200 INDUSTRIAL MIXER

The results of the tests carried out on an industrial MPP-200 band-blade mixer; Fig. 2-7. The engine of the mixer was powered directly from a three-phase power network. At the moment of the start-up, an intensive increase in the received instantaneous power occurred (of 4-5 times higher value than the stabilised power of the further work). However, such a state lasted for a very short while, about 0.39-0.54 s, then the system stabilised (Fig. 2, Tab. 2). The use of active energy at start-up was minimal and it ranged from 441.02×10 kWh (24% mixer load) to 618.63×10 kWh (96% mixer load) (Fig. 5).

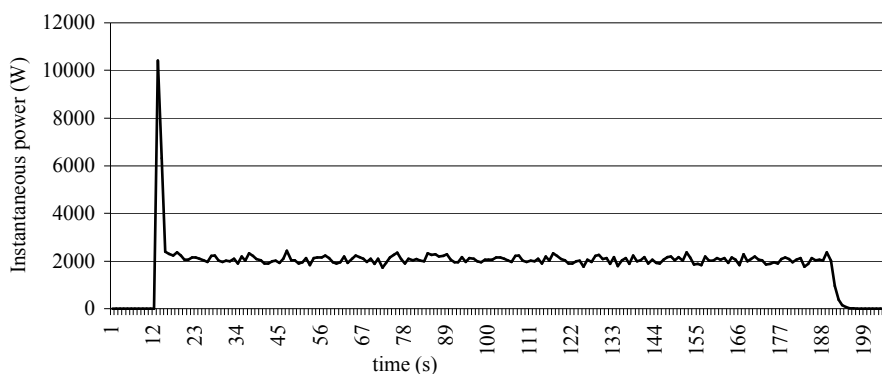


Fig. 2. Exemplary course of mixing process – mixer load 72%

Table 2. Active energy consumption at start-up of the mixer's transmission's system

Level of mixerload V	Time of start-up Mean value t_r	Standard aberration σ_{n-1}	Maximum power – instantaneous mean value P	Standard aberration σ_{n-1}	Energy used at start-up – mean value E_r	Standard aberration σ_{n-1}
%	s	s	W	W	kWh	kWh
0	0,392	0,067	7530	658	331×10^{-6}	$35,0 \times 10^{-6}$
24	0,402	0,069	8976	642	414×10^{-6}	$33,5 \times 10^{-6}$
48	0,420	0,053	10115	715	480×10^{-6}	$49,2 \times 10^{-6}$
72	0,454	0,075	9624	1529	488×10^{-6}	$67,8 \times 10^{-6}$
96	0,543	0,051	10855	971	618×10^{-6}	$67,3 \times 10^{-6}$

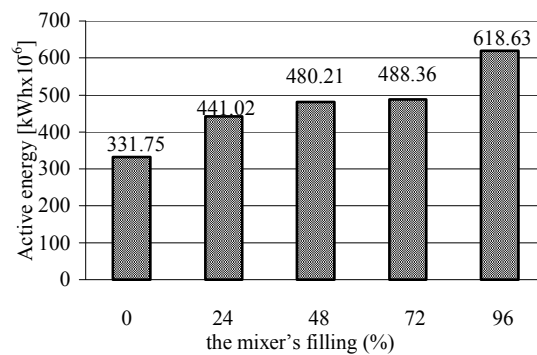


Fig. 3. Active energy consumption at start-up, at various levels of the mixer's filling

At the time of mixer work, the power taken in ranged from 10.8% (no stock) to 5.65% (96% of mixer load) – in relation to mean load; the variations decreased as the load of the engine decreased and were lower as in the case of the laboratory mixer.

Exemplary courses of the taken-in instantaneous power depending on the level of the mixer load are presented in Fig. 4.

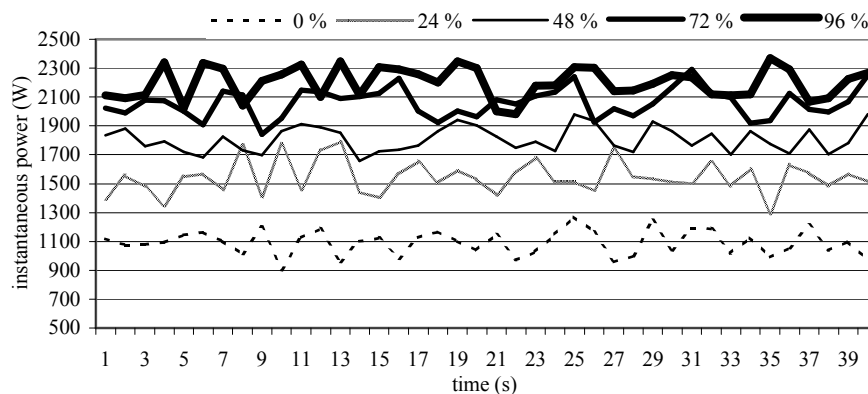


Fig. 4. Intake of instantaneous power at mixer work depending on the load level

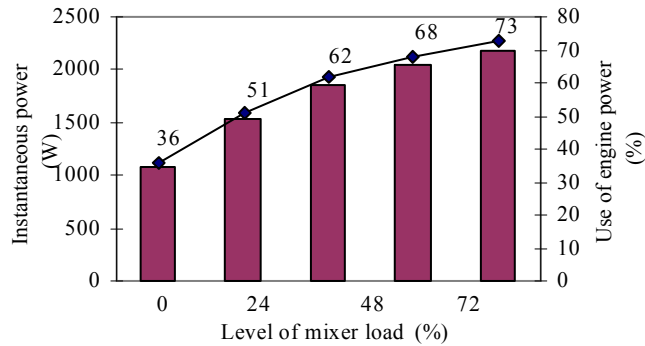


Fig. 5. Relation of instantaneous power taken i and the level of the mixer load

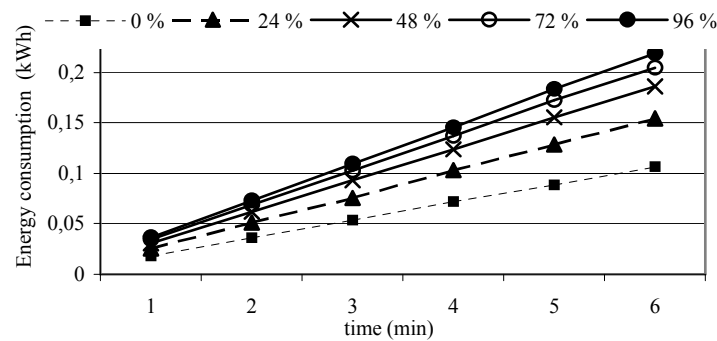


Fig. 6. Active energy consumption in the mixer engine depending on the load

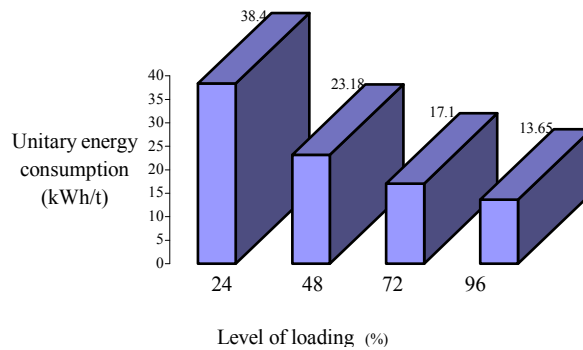


Fig. 7. Unitary energy consumption in relation to the mixer load

Increasing the level of loading the mixer from 24% to 96% resulted in the heightening the instantaneous power taken in by 42.6% (Fig. 5). On the basis of the studies it may be stated that the most effective, considering its energy consumption, is the variant, in which the level of mixer chamber load is maximum and equals 96% (Fig. 6). Unitary energy consumption (Fig. 7) for the constant mixing time of 1 minute drops then from 38.4 kWh/t (24% load) to 13.65 kWh/t (96% load).

CONCLUSIONS

1. Measurement system used in the studies was characterised by high accuracy and repetitiveness of the results. The determined coefficient of the variability at the mean load of 1.851 kW was 0.70%, and for 2.181 kW 0.60%; it decreased as the load of the driving engine heightened.

2. The stand for continuous registering of the taken-in active power is a universal measurement instrument, by means of which it is possible to observe the changes undergoing in the system. It enables receiving numerous data in a short time, which is ensured by the frequency of sampling in the range from 1 to 1,000 Hz. Their further processing is performed by means of using simple computer programmes.

3. In order to determine the optimum mixing time as well as the weight of the load for a particular mixer, for each group of raw materials of mean physical properties (e.g. mean dimension of particles, pouring density) the tests on the mixing effectiveness ought to be conducted. Every extra minute of mixing may be essential for an average feeds plant.

REFERENCES

1. **Bieliński K., Flizikowski J.:** System monitorowania środowiska energetycznego w zakładzie przetwórczym, VII Ogólnopolskie Seminarium Mieszanie, Koszalin 1996, 5 – 10.
2. **Boss J.:** Mieszanie materiałów ziarnistych, PWN, Warszawa/ Wrocław 1987.
3. **Boss J., Węgrzyn M.:** Moc mieszania materiałów ziarnistych, VIII Konferencja Naukowo-Techniczna MUPS, Białystok/Białowieża, Materiały konferencyjne, 1998, 49-58.
4. **Boss J. Węgrzyn M.:** Ocena wpływu geometrii mieszadła na moc mieszania materiałów ziarnistych, Zesz.Nauk.Politech.Łódź. Inż.Chem. i Proc. Z. 27, 2000, 39-45.
5. **Grochowicz J.:** Zaawansowane techniki wytwarzania przemysłowych mieszanek paszowych, Wyd. Pagros, Lublin 1998.
6. **Mc Ellhiney R.R.:** Feed Manufacturing Technology IV, AFMA, Arlington, 1994.
7. **Laskowski J., Łysiak G.:** Stanowisko do badań procesu rozdrabniania surowców biologicznych, Postępy Techniki Przetwórstwa Spożywczego, nr 1-2, 1997, 55-58.
8. **Pankowski Z.:** Pełne badania kwalifikacyjne prototypu mieszalnika pasz suchych typu H-742. Maszynopis, Poznań 1991.
9. **Rielly C.D., Smith D.L.O., Lindley J.A., Niranjan K., Philips V.R.:** Mixing Processes For Agricultural And Food Materials: Part 4. Assessment And Monitoring Of Mixing Systems. J.Agric.Eng.Res., 59, 1994, 1-18.
10. **Strępek F.:** Mieszanie i mieszalniki, WNT, Warszawa 1981.

SUMMARY

The work presents the results of the studies on the effect of the properties of the selected technological components on the active energy consumption at mixing processes. In the tests, an industrial band-blade mixer was used. Measurement capacity for continuous data registration of the stand equipped in a power converter and a computer was tested. The determined coefficients of variability for the applied loading of the system ranged from 0.6 to 0.7%; the system was characterised by high measurement accuracy.