Journal of Polish CIMAC
Gdansk University of Technology
The Faculty of Ocean Engineering and Ship Technology

NEW, ENERGY SAVING ROTOR SOLUTION OF BEATER GRINDER FOR CORN GRAIN

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Abstract

The permanent rice of consumption and price of meet products over the world have created necessity of looking for every possibility decrease cost of feed production, in this range, first of all, process machines.

15 mln ton corn grains was milled for feet every year by beater grinder. This part of machines characterize substantial energy consumption from 36 to 72 kJ/kg [1,2].

Analysis of literature and own investigation over grinders proved, that modernization of working unit may be reason to importance of energy saving in the process. To put into changes of beaters geometric, which consideration the structure of grain grinding. The verify of test the new rotor solution show advantage energetic compare to traditional one about 24%.

Keywords*: beater, grinder, corn grain, rotor, modernization, energy saving*

1. Introduction

Grain's grinding is the main technological operation in mixed feed production. It is achieved with the help of beater grinder (Fig. 1), which are commonly used owing to their all-purpose employment as far as the feeding stuff row material is concerned, their simple structure and service. The essential fault of these machines is height energy consumption [1, 2].

The technological process in the grinder is as follows, a weighed and placed in tank sample of the raw material is delivered to hammer mill encharging hopper at uniform rate through feeder. Next, it is transported gravitionally to the operation chamber where it is subjected to the percussive action of hammers. The kinetic energy of particles is used for their division, their collisions among them on the screen. The differen between grinders and grain must being 42 m/s – it is condition of shock defragmentation. Succesive division of the particle take place until its size is equal to the diameters of holes in the screen. Such particles leave the hammer mill, next they are transported by the air stream through special short channel to aerocyclone where they are separated from the air. In order to increase the efficiency of separation, the aerocyclone is provided with fibrous filter. The ground particles fall to product tank.

For example, grinding barley using screen 4 mm needed from 8 to 12 collision with beaters. The time of one contact being $10 \cdot 10^{-5}$ s. Great value of unit energy consumption (about 60 kJ/kg) is causes too long time of staying grains in working chamber. This phenomenon cause of produce too much fraction of dust (particle less than 0,5 mm) what is physiologically undesireable quality of feed is lower [3].

Continuous development of beater grinders don't solve problem of high energy consumption in this machines.

Betterment of working parameters take place with modernization. Changes of beater grinder dedicated to corn grains is a complex scientific problem, who contain three factors: corn grain (feed material), process of fragmentation and build of the machine.

General may be accept, that the structure of corn grains is inhomogeneous and have two parts: fibrous cover with high strength and unregulary interior represent fragile mass. Optimal way of grinding this material would be connecting of two methods: cutting for covered and beat for interior.

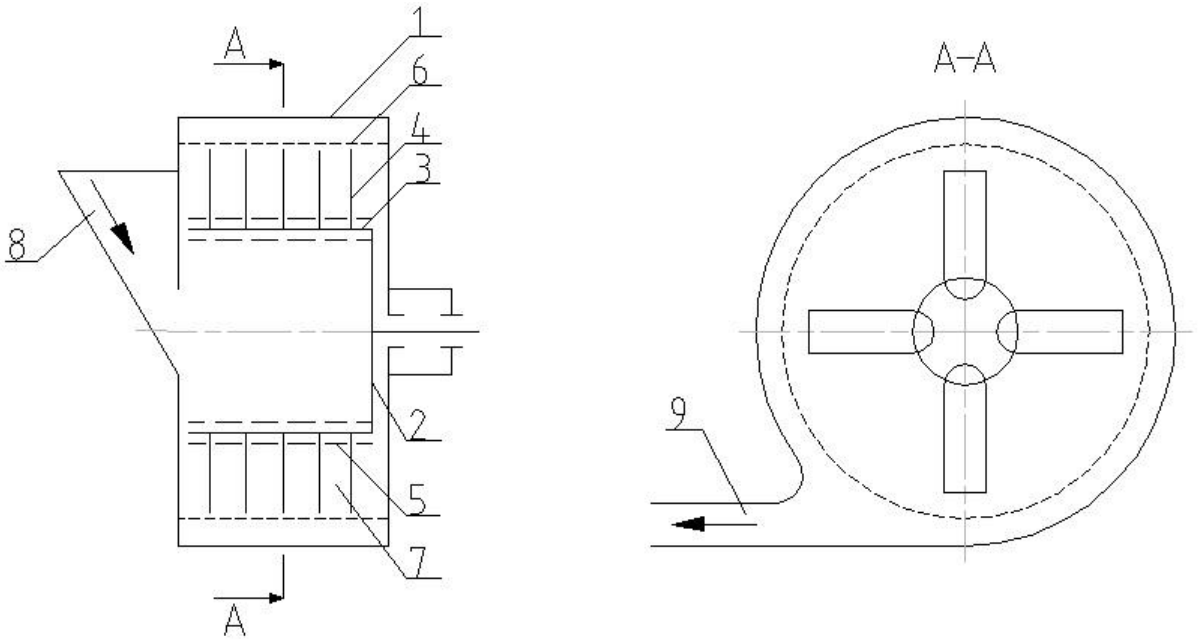

Fig. 1. Scheme of beater grinder :1 – housing, 2 – rotor, 3 – bolt, 4 – beater, 5 – sleeve, 6 – screen, 7 – working chamber, 8 – charge, 9 – outlet [1]

The second reason of high energy consumption by grinder is low efficiency of collisions in grinding chamber. It has been observed, that there grains take rotates motion. The consequence of this phenomenon is that not all collisions lead to fragmentation of particles. Compare to author of this article using in grinder rotor beater with different length: longer, which take place at outside of chambers and short one at the middle of working area. That solution generation speed gradient of particle to central part of chamber – braking circulation of collection grain. Consequential, quantity of efficiency collisions increase.

2. Object and methods

Description of grinder construction modernization, generates to the following research problems:

a) does application of the thin and thick beaters in grinder rotor, lead to reduction of energy consumption? The supposition is that the thin beater, can intense cutting cover of grain, while this beaters make collision process in grain interior area more effective.
b) does application of the long and short beaters in grinder rotor lead to less energy consumption? The supposition is that makes axis vector of particle speed, what provoke higher speed of collision.

Veryfication of this problems have needed experiment. The physical model of traditional and modernization grinder was made, next special system and measure instruments were installed. Barley was used like test material. Traditional beaters was perpendicular plate begin 4 mm- thickness and 80 mm- length.

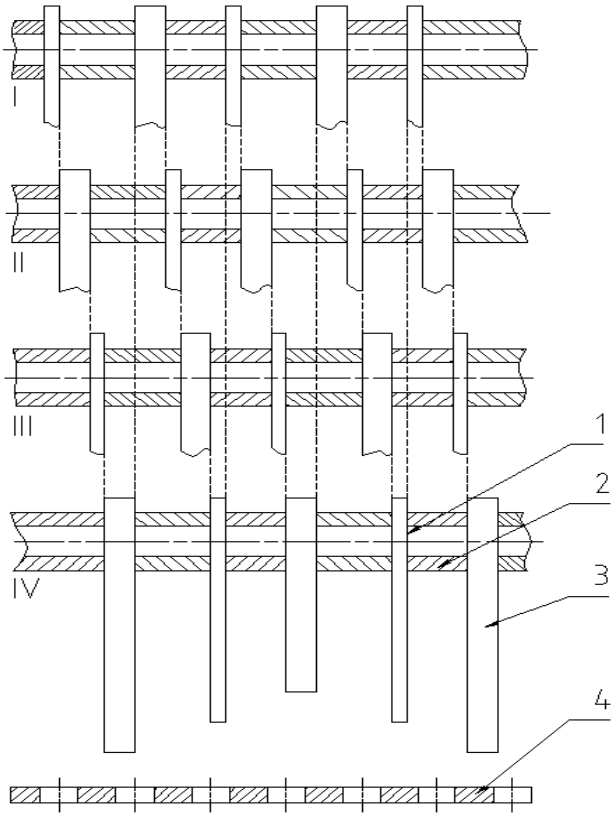

Fig. 2. Scheme of working set of grinding rotor, after modernization (unfold version): 1 – bolt, 2 – sleeve, 3 – beater, 4 – screen

Idea of the improved rotor with modified beaters is presented in Fig. 2,. Beaters is separated by special sleeve, which are fixed on the bolts I – IV. The following changes have been done according to traditional solution:

a) application "cutting" beater being 2mm,, and "shock" beaters being 4mm – divide of working process on two ways – cutting cover and defragmentation inside area by shock.
b) locate by turns five piece of beaters at four bolds with special sleeve, which make the next principle – one full turn of rotor determine that maximum area of chamber take place in process,
c) use the beaters having variable length and location the with principles – the shorter one put in the middle of the working chamber. The end points of beaters create parabolic line at one belt.

Laboratory grinder with change of constructional elements was build and installed in system consest – fedder, grinder and collect unit. Special solution make possible fast change of elements – rotors and screens. Screen who surround chamber has 3, 4, 5, 6 mm wholes diameter (according to norms). This parameters contains variable not-dependent in experiment.

In the test put to trial following function:

$$E = \frac{P_c - P_j}{Q_m} = f(g, l, d), \tag{1}$$

where:
E – unit energy consumption kJ/kg,
P_c – summary power in the process, W,
P_j – power of idle running, W,
Q_m – mass output, kg/n
g – thickness of beaters, mm,
l – length of beaters, mm,
d – diameter of holes screen, mm

The unit energy consumption was defined as the quantity of energy necessary to obtain a unit of the ground product mass. It was calculated from the ratio of power consumption to the hammer mill efficiency. The power was determined by an indirect method by means of the moment measured and the rotational speed of the hammer mill shaft.

3. Results and conclusions

Obtained results are presented in Fig. 3. Four curves show relations for various rotors. The first is base for compare investigations. Next numbers two and three show results individual solution of rotor and last – four is summary function for new construction of rotor at all.

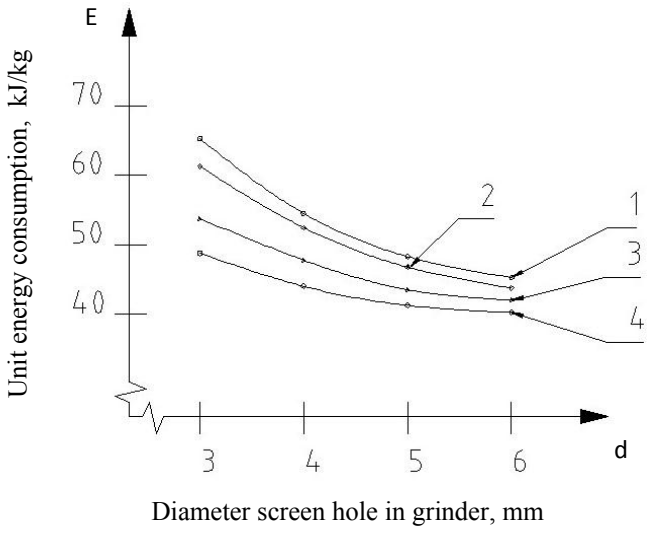

Fig. 3. Relationship between energy consumption E and diameter screen hole in grinder d for various rotor solution

Carried out experiment and analyses of curves in Fig. 3 entitle to formulate the following conclusions:

a) the independent variable in examination has proved essential influence on energy consumption of grinding process,
b) test results positive verify investigation problems in this experiment,
c) cpplication beaters which various length leads to reduction of energy consumption from 11 – 14%,
d) application beaters with various thickness leads to reduction of energy consumption up to 18%. The reduction is largest for inside diameter of screen being 3mm,
e) the largest row of grinding energetic is observed for completely redesigned rotor. The observed reduction is not as sum of applications, that is result of interaction between independent variables. Maximum reduction of energy consumption comparing with traditional solution is about 24%
f) the problems need optimization test.

References

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