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GROUNDING STRUCTURAL PARAMETERS OF MACHINE FOR APPLE SLICING

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Abstract. The project of a low-powered slicing machine, shredder for fruits and vegetables was presented. After the investigations on material cutting, the design and components of the machine as well as its operating mode were particularly considered. The technical characteristics of constructional scheme system was developed and future optimizing research directions proposed.

Key words: constructional scheme, cutting, fruits slicing

INTRODUCTION

Lately, a wide range of new food products has appeared at the domestic market, chips is a good example of them. It was marketed only some time ago but have become very popular and still are being very nutritious and valuable food.

Such dried fruits as dried apples, pears, plums and others are not only food products but rather simple and not too energy wasteful, that's why it is effective method of raw material canning based on antibioses principles.

One of the most important technological operations in the technology of dried fruits production is the fruit cutting practice (apples, pears) into the same slices. Under the conditions of small processing enterprises, it is often manual cutting operation because small businesses cannot afford a high productive but power consuming and expensive shredder.

Low cost and but effective fruit shredder is necessary for small processing firms, farm or private agricultural enterprises. Therefore, the aim of the present work is to ground the constructional scheme and calculate low-powered apple shredder gear for fruit slicing in the technological process of dried fruit production.

The tasks of the project is to ground the shredder constructional scheme, to determine necessary efforts for apples slice cutting and to calculate shredder gear.

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GROUNDING OF THE CONSTRUCTIONAL SCHEME

To design the constructional scheme of the machine for apple slice cutting in the technological process of dried fruit production, we have considered the following initial conditions:

– low productivity of shredder – 100–150 kg·hour^{-1};
– wide application – for apples, pears, potatoes, beat and other products;
– low specific waste of power – 2–5 Wh·kg^{-1};
– necessary degree and evenness of cutting – slice thickness 1.5–5.0 mm;
– high ultimate product output – production losses 2.0–2.5%;
– construction simplicity and work guarantee;
– small size and weight.

The design of shredder constructional scheme is based on the technical idea of reciprocating motion of the piston in working cylinder with plain knives. During the idle motion of piston (from low to upper dead point), fruit is taken from vibrating bin to plate-like stationary knives fixed in cylinder knives. During its power stroke (from upper to low dead point) the piston transfers its gear efforts on the fruit. The theoretical curve of the dependence of deformation value and fruit shift as the result of pressure is presented in figure 1 [Pisarenko 1993].

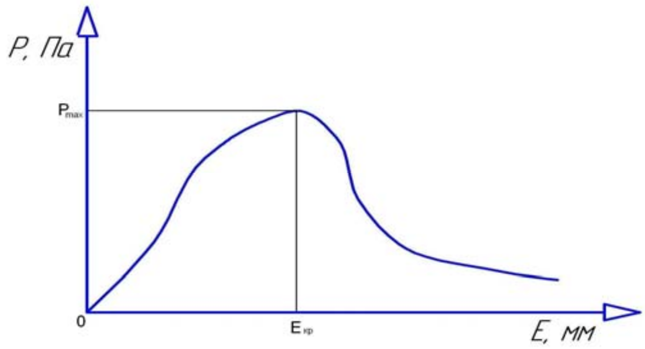

Fig. 1. Theoretical dependence curve of fruit deformation E and pressure P: Pmax – maximum pressure in the process of fruit cutting, Pa; Ekr – crucial deformation of shift and fruit slicing, mm.

Rys. 1. Teoretyczna krzywa zależności ciśnienia P od odkształcenia E owoców: Pmax – maksymalna wartość naprężeń w procesie cięcia owocu, Pa; Ekr – krytyczna zmiana odkształcenia, mm.

Piston efforts should be sufficient for initial fruit peeling, the following deformation of fruit surface layer, and finally – shifting and slicing (slices of even and given thickness).

The increasing piston pressure over the fruit causes its full cutting. On the basis of this idea, we propose the next constructional scheme of apples shredder into slices which is shown in figure 2.

The shredder consists of electromotor (8), and its rotation moment is transferred by gear comprising belt gear (7), reducer (6) and chain gear onto crank (4). Crank (4) transforms rotation moment from electromotor (8) into reciprocating motion of the piston (3) moving in working cylinder (1). Under the pressure developed by piston (3), apple or other fruit is pressed to the knife cassette (2) composed of several stationary vertically fixed plate – like knives.

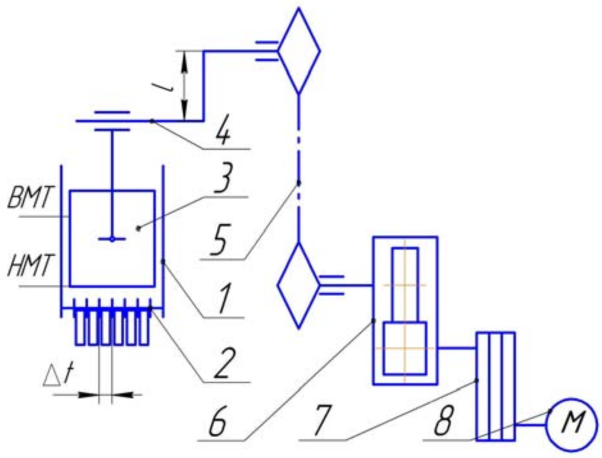

Fig. 2. Constructional scheme of apple shredder into slices: 1 – working cylinder, 2 – plate-like stationary knives, 3 – piston, 4 – crank, 5 – chain gear, 6 – reducer, 7 – belt gear, 8 – electromotor, 9 – BMT – piston upper dead point, 10 – HMT – piston low dead point
Rys. 2. Projekt konstrukcyjny plasterkownicy do jabłek: 1 – cylinder roboczy, 2 – stacjonarne noże płytowe, 3 – tłok, 4 – korba, 5 – przekładnia łańcuchowa, 6 – reduktor, 7 – przekładnia pasowa, 8 – silnik elektryczny, 9 – BMT – górne martwe położenie tłoka, 10 – HMT – dolne martwe położenie tłoka

During the piston power stroke, from the upper to low dead point, under the compression efforts, fruit passes through knives forming slices.

The thickness of fruit slices δ equals to:

$$\delta = \Delta t - \Delta_t \qquad (1)$$

where, Δt – distance between plate-like knives, mm;
Δ_t – value of residual deformation of fruit slice, mm.

STUDY ON THE SHEAR FORCE REQUIRED FOR APPLE CUTTING INTO SLICES

To define the maximum shear force for apple cutting into slices, we have designed the laboratory equipment (fig. 3).

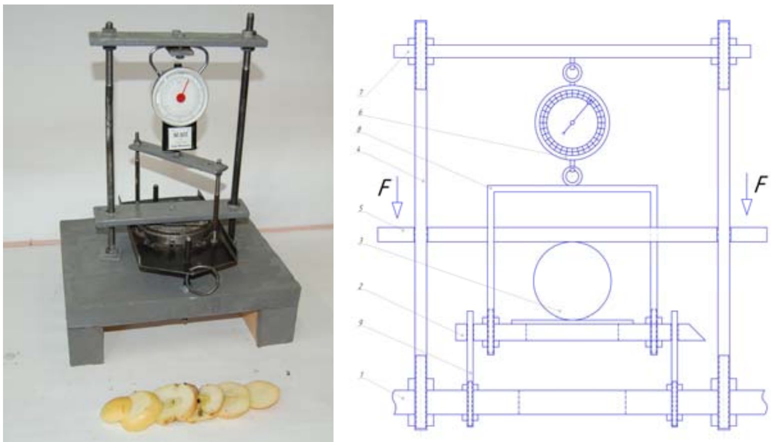

Fig. 3. Laboratory equipment for estimation of maximum efforts of apples cutting on slices at the moment of testing

Rys. 3. Sprzęt laboratoryjny do określania maksymalnej siły cięcia jabłek krojonych na plasterki podczas badania

Laboratory testing equipment for apple cutting consists of the plate, where knife cassette (2) with changeable block of plate-like knives is fixed (1), two main directed rods (4), press plate (5), digital dynamometer (6) with measure points 0.01 kg and bearing plate (7).

Laboratory equipment operation starts with the press plate (5), it presses the apple (3) clamping it to the knife cassette (2) up to the moment of apple cut into on slices. The knife cassette (2) assisted by the plug (8) attached to dynamometer (6) is attached to the stationary bearing plate (7) from the other side. Under the load, the knife cassette (2) induces plate-parallel motion through the auxiliary direction rods (9). Thus, the force which affects the press plate (5) through knife cassette (2) and plug (8) and is transmitted to the dynamometer (6) fixing maximum force at apple or other fruit slicing.

During the test performed on the prepared laboratory equipment, we determined the maximum force F necessary for apple slicing. There were applied different varieties of apples for testing – 45 fruits of varying size. As a result, it was found that the maximum figure $F = 157$ N is characteristic of the winter variety “Snow Calvin”, whose fruits are most solid and hard. On the grounds of research results, specific load through razor length q calculated by formula was defined [Malashchenko and Yankiv 2004, Tokarskiy and Yankiv 2008]:

$$q = \frac{4 \cdot F}{3 \cdot \sum_{i=1}^{n} l_i \cdot n_{л}} \qquad (2)$$

where: F – maximum force applied to the press plate, N;
l_i – working length of the i-rasor, m;
n – quantity of i-rasors.

According to our calculations F = 157 N, a $\sum_{i=1}^{n} l_i \cdot n_{ё}$ = 0.52 m. Thus,

$$q = \frac{4 \cdot 157}{3 \cdot 0,52} = 402.6 \text{ N·m}^{-1}.$$

SHREDDER GEAR DESIGNING

Shredder gear design was based on the electromotor choice and the calculation of reducer, belt and chain gears.

The standard methods of machine details were applied for electromotor choice. Necessary calculating electromotor power is equal to 41.9 W. From the electric equipment catalogues it was chosen the closest by power from parametrical raw standard electric engine 41.9 W. With such the parameters of technical characteristics [Kalayda 1998]

– power P = 120 W;
– synchronic rotary frequency n = 1500 min^{-1};
– synchronic rotary frequency n = 1380 min^{-1};
– coefficient of efficiency – 0.63;
– weight – 3.5 kg.

The calculation of parameters of reducer, belts and chain gears was performed using software program on operation system basis Kompas 2D SHAFT developed by the department of machine building of LNAU.

DESCRIPTION OF CONSTRUCTIONAL AND OPERATION PRINCIPLES OF THE SHREDDER

Fruit slicing shredder consists of (fig. 4): base (1), fixed member (9) and working desk (16) where all the units and details are installed. Electromotor is installed on base (1). Using the belt gear, the rotary moment is transferred from electromotor to single-stage cylindrical reducer (5), and then to crank (11) with help of chain gear.

Electromotor works as follows: electromotor produces and transfers rotary moment through belt gear to reducer, and next, with the help of chain gear on shaft with crank. Crank is connected with piston completing reciprocating strokes in working cylinder. The fruits are provided from the vibrating bin into this cylinder through supply hole. During the idle piston stroke, the fruit is taken on knife cassette, and during the working stroke of piston and under its pressure, it is cut into slices of required thickness in the changeable knife cassette. Finally, the slices pass into container.

Slices thickness is determined by the distance between unchangeable and strictly vertically fixed plate-like knives with ribbed razor in the knife cassette. To obtain the desired thickness of slices, the shredder must be fitted with a parametrical raw of knife cassettes ensuring different thickness of slices of a cut fruit.

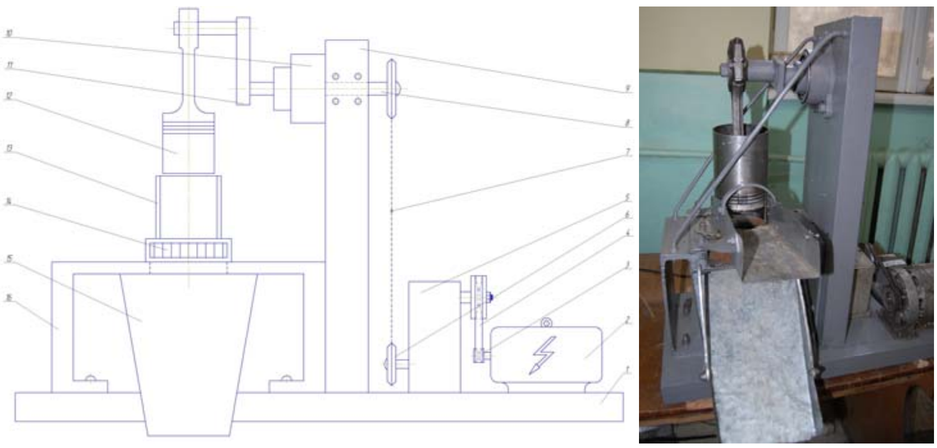

Fig. 4. Drawing and general view of fruit slices shredder: 1 – base, 2 – electromotor, 3 – drive pulley of belt gear, 4 – belt, 5 – cylindrical reducer, 6 – drive star, 7 – chain, 8 – shaft, 9 – fixed member, 10 – bearing unit, 11 – crank, 12 – piston, 13 – working cylinder, 14 – knife cassette, 15 – container, 16 – working desk

Rys. 4. Schemat i ogólny widok krajalnicy do owoców na plasterki: 1 – podstawa, 2 – silnik elektryczny, 3 – koło napędowe przekładni pasowej, 4 – pas, 5 – reduktor walcowy, 6 – gwiazda napędowa, 7 – łańcuch, 8 – wał, 9 – element mocujący, 10 – łożysko, 11 – korba, 12 – tłok, 13 – cylinder roboczy, 14 – skrzynka nożowa, 15 – zbiornik, 16 – płyta robocza

According to the results of the present work, there were presented two applications to receive the patents on the invention.

CONCLUSION

The engineering tasks of the work have been solved. The design of the shredder constructional scheme is based on the technical idea of the reciprocating stroke of the piston in working cylinder containing the plate-like knives in its base and the distance between the knives provides required slice thickness.

To determine the maximum shear force for apple cut into slices, we have produced the laboratory equipment. On the ground of the obtained research results, the shredder gear has been calculated. The essential constructional-designing documentation was prepared. Then, the experimental model of equipment for fruit cutting into slices to be implemented in the technological process of dried fruit production was developed in the research-mechanical workshop of student designing-technological unit of The Faculty of Mechanics and Power Engineering of LNAU.

Technical shredder characteristics:

– consuming power of electroenergy – 120 W;

– efficiency 90–120 $kg \cdot h^{-1}$;

– specific energy expenditure – $(1.0–1.3) \cdot 10^{-3}$ $kWh \cdot kg^{-1}$;

– overall dimensions – 0.82 × 0.38 × 0.74 m;

– weight 37 kg.

The study perspectives:

– grounding of parametrical raw of knife cassettes for various thickness slices;

– designing of knife cassette for cubes cutting;

– improvement of vibrating bin for fruit supply to working cylinder to reduce fruit deformation;

– gear change using the method of worm reducer .

REFERENCES

Equipment of enterprises of processing and food industry. Editor I.S. Gulogo. Winnitca 2001, pp. 576.

Flys I.M., 2004. Ground of the production programme of processing enterprise // Announcer LDAU: Agrarian Eng. Res. 8. Lviv, LDAU.

Kalayda V.V., 1998. Details of machines and basis of constructing. K.: the Publishing Center of NAU.

Malashchenko V.O., Yankiv V.V., 2004. Details of machines. Course planning. Lviv, New World.

Pisarenko G.S., 1993. Resistance of materials. K.: Higher School.

Sirotyuk S.V., 1999. Mechanization of cork and storage of products of plant-grower / Course of Lectures. Lviv, LDAU.

Tokarskiy Yu.M., Yankiv V.V., 2008. The mechanical transmissions, calculation and constructing / Navch. Posib. Lviv, New World.

Tokarskiy Yu.M., Yankiv V.V., Siryk Z.M., Goshko M.O., Kosenko I.E., 2003. Calculation of mechanical transmissions on computer /Navch. Posib. Lviv, LDAU.

PODSTAWOWE STRUKTURALNE PARAMETRY MASZYNY DO KROJENIA JABŁEK NA PLASTRY

Streszczenie. W pracy przedstawiono konstrukcję urządzenia do cięcia na plastry owoców i warzyw. Po przeprowadzeniu badań eksperymentalnych nad siłą cięcia produktów dokonano analizy pod kątem konstrukcyjnym urządzenia i jego podzespołów, jak również oceniono jego działanie. Wykonano techniczną charakterystykę systemu oraz zasugerowano kierunki badań optymalizujących na przyszłość.

Słowa kluczowe: projekt konstrukcyjny, cięcie, krojenie owoców na plasterki

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