ARPN Journal of Engineering and Applied Sciences

ENGINEERING METHODS OF TECHNOLOGICAL CALCULATION OF MEAT GRINDERS

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ABSTRACT

The construction and grinding operating principle of meat grinders should have minimal effect to meat losses. This paper presents the engineering calculation of the cutting process of meat grinder. The experimental grinder consists of a frame, screw, gearbox, electric motor, V-belt transmission, casing, lock and hopper. The calculation algorithm of grinding process includes determination of the coefficient of use of the area of plates, cutting capacity and required power of the equipment. The operator scheme of mechanical processing of meat consists of the subsystem of preliminary grinding of meat and subsystem of mechanical processing of minced meat.

Keywords: meat grinder, cutting mechanism, calculation, power, mechanical processing.

INTRODUCTION

Intensification of technological processes is one of the main directions of technological progress in the meat industry. Along with a significant increase in the volume of meat products, the meat industry is faced with the task of improving the quality and range of products with the most complete and rational use of raw materials [1].

In the production of sausages and semi-finished products cutting processes are widely used, which significantly affect the quality of raw materials and finished products. One of the main types of technological equipment designed for grinding meat are grinders. The kinetics of the process of grinding raw meat is different due to the complexity of changes in the processes occurring in the spaces between the elements of the transporting and cutting mechanisms. Improvement of the grinding process is based on the study of changes in the structural and mechanical characteristics of the processed raw materials and technological parameters of the process [2, 3].

Grinders are designed for grinding both frozen and non-frozen meat and other food products. For the main characteristic of the grinders the diameter of the plate of 180 mm is taken; the number of revolutions of the screw per minute 230 for low-speed, 200-300 for medium, and more than 300 for high-speed machines [4].

The main part of the household grinders is the cutting mechanism. The productivity of the grinders is determined by the capacity of the cutting mechanism. The most common cutting mechanism is of knives and plate. Plates have holes with the diameter of 5, 8, 12, 16 mm, which determine the speed of the passing product and the degree of grinding; lattices, being a part of the cutting pair, provide cutting of the connective tissue of meat. It is required to strive for greater utilization of the plate area of the holes, but retaining the desired strength at the maximum of its allowable wear [5, 6].

The goal of this paper is to develop the structural scheme and the technological calculation of the meat grinder.

MATERIALS AND METHODS

The experimental grinder consists of a frame, screw, gearbox, electric motor, V-belt transmission, casing, lock and hopper. The main executive body of the grinder is a grinding device, which is a set of matrices and grinders alternating in a certain order: a matrix with large triangular holes, a grinder, a matrix with small triangular holes, a matrix with round holes. Matrices are installed in the nozzle and fixed with stoppers. Choppers are fixed on the front end of the screw. Pieces of raw materials up to 40 mm are loaded into the hopper, these are picked up by a screw and moved to the grinding device. Grinding of raw materials is carried out by stationary matrices and rotating grinders. The screw is driven by an electric motor through a V-belt drive and a reducer [7].

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1 - frame; 2 - cutting tool; 3 - hopper

Figure-1. Experimental meat grinder.

In order to move the product forward in the working chamber, feeding it to the knives and pushing through the cutting plate a rotating screw with uniform pitch of thread is used. The peculiarity of the screw is the pre-grinding of raw meat and the creation of pressure sufficient to move the product through the cutting mechanism without squeezing contained liquid phase therein. Screws are divided into cylindrical and conical; with constant or variable pitch; the number of turns; the number of threads of the screw; thread count, the profile of the thread; with or without trimming. The cutting tool of the grinder consists of fixed plates and rotating knives. Fixed cutting plates are made in the form of discs with round holes and are paired to cutting parts with rotating knives.

RESULTS AND DISCUSSIONS

Structural analysis of grinders and ways to improve the cutting mechanism

In the production of semi-finished meat products, in the preparation of minced meat in the sausage and canning production, grinding of meat raw materials is used. Structural-mechanical and technological characteristics of the grinded raw materials, and, consequently, the quality and yield of the finished product depends on the design and dynamic parameters of the cutting and transporting mechanisms [8, 9].

It should be noted that the two-dimensional block diagram is a scheme of the grinder with a separate drive, and one one-dimensional block diagram is a structural scheme of the grinder with a combined drive of the screw feeder and the knife shaft [10]. However, the multidimensional systems are technically difficult to implement and cross-connections can occur in them with a high degree of probability. Therefore, it is proposed to divide the two-dimensional system into two one-dimensional and construct structural schemes that are relatively easy to be technically implemented and do not have cross-linkages.

Structural analysis of grinders allows to systematize significant deficiencies and determine the adjustable parameters that influence the process and quality of grinding. The block diagram of the grinder is shown in Figure-2, where each structural element is selected by a separate block.

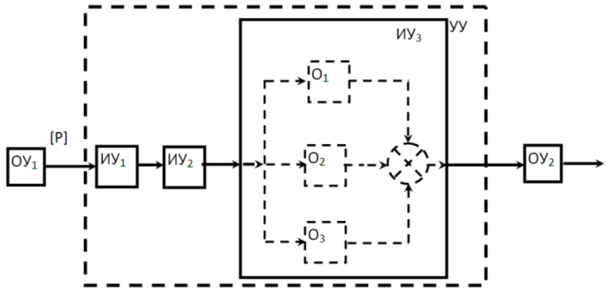

Figure-2. Structural scheme of meat grinder.

This structural scheme involves the study of the work of grinder that includes the following structural elements: AM (actuation mechanism) screw - AM_1, the knife and the modified knife AM_2 modified cutting plate - AM_3 that make up a complex control unit - CU, which in turn affects CE (control elements): CE_1 - raw meat, CE_2 - minced meat and allows to determine the optimal design of the actuation mechanisms.

Statement of the problem

Produce technical design of the grinder, if the number of grids in the cutting mechanism s=2, the outer diameter of the grid D=0,180 m, the number of blades of knife K=4, the number of revolutions of the knives n_H =230 rpm, the coefficient of use of the cutting ability of the mechanism φ_0=0,7, the specific energy consumption for products cutting $\alpha_p=3\cdot10^3$ j/m^2, the coefficient of sliding friction of the knife on the plate in the presence of a grinding product μ=0,1, specific pressure to the major surface of the knife and plates P =2.106 N/m^2, the width of the plane of contact of the knife blades with the plate=0,003 m, the number of cutting planes in the mechanism z=4, the external diameter of the knife d_H =0,165 m, the inner diameter of the knife d_H =0,032 m, the density ρ=1015 kg/m^3, coefficient that takes into account the energy loss due to friction of the product when moving it in the cylinder of the grinder α_T=0.8 , and the utilization ratio of the screw of the grinder α_s=0.35, number of revolutions of the screw n_s =230 rpm, pitch of the screw t_s =0,036 m, acceleration of gravity g=9,81 m/s^2, the outer diameter of the screw D_s =0.16 m, the diameter of the worm shaft d_s =0,075 m, resistance coefficient during transportation of products on feeder k_o=4, screw length L=0,735 m, efficiency coefficient of transmission from the motor to the worm shaft of the screw η=0,80 , the number of holes in plates n_o=3; 132 , the diameter of the holes of the plates d_o =0,04; 0,008 m, specific surface area when grinding per unit weight of products F_1=0,6; 1,2, shearing

VOL. 14, NO. 22, NOVEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

stress that creates conditions for indentation of grinding products in the holes of the grids $\tau=3\cdot10^3$; $4\cdot10^3$ N/m^2.

Calculation algorithm

For technological calculation of the grinder following equation is recommended [11, 12]:

when determining the coefficient of use of the area of plates:

$$\varphi = n_0 \cdot d_0^2 / D_p^2; \tag{1}$$

when determining the cutting capacity of the mechanism, m^2 /h:

$$F = 15 \cdot n_H \cdot \pi \cdot D_p^2 \cdot \sum k \cdot \varphi, \tag{2}$$

in determining the performance of the cutting capacity (kg/h):

$$M = \varphi_0 \cdot F / F\ , \tag{3}$$

in determining the power required for product grinding (kW):

$$N_1 = \alpha_p \cdot F_1 \cdot M / (3600 \cdot 1000); \tag{4}$$

when determining the power required to overcome friction in the details of the cutting mechanism, kW:

$$N_2 = M_0 \cdot P \cdot b \cdot k \cdot z \cdot \pi \cdot (D_H - d_H)/(30 \cdot 1000), \tag{5}$$

when determining the pressure force on the product, N/m^2:

$$P_1 = 4 \cdot \tau \cdot d_0, \tag{6}$$

when determining the volumetric capacity of the grinder, m^3/s:

$$M_0 = M / \rho, \tag{7}$$

when determining the power required for the operation of the screw, kW:

$$N_3 = P_0 \cdot M_0 \cdot (0 + \alpha)/(3600 \cdot 1000), \tag{8}$$

when determining the productivity of the grinder by carrying capacity, kg/h:

$$Q = 15 \cdot \alpha_ш \cdot \pi \cdot n_ш \cdot t_ш \cdot \rho \cdot (D_ш^2 - d_ш^2), \tag{9}$$

when determining the power required for the operation of devices feeding the meat into the cylinder of the grinder, kW:

$$N_4 = k_0 \cdot M_1 \cdot L \cdot \rho \cdot g \cdot (3600 \cdot 1000), \tag{10}$$

when determining the power of the grinder, kW:

$$N = (N_1 + N_2 + N_3 + N_4)/\eta, \tag{11}$$

Development of operator scheme of mechanical processing of raw meat

During the implementation of the initiative research work, a new operator scheme of mechanical processing of meat is proposed, in the form of a set of several typical process operators. In this scheme, the recycling technological connection is characterized by the presence of a closed process flow, which connects the grinding, mixing and molding zones with each other.

On the basis of this operator scheme, a new technological scheme for the production of cooked sausages, shown in Figure-3, was designed. For production of sausages raw materials of healthy animals without signs of microbial spoilage and rancidity of fat are used. Before entering on cutting they are checked by veterinarians, fouled surfaces are washed with water and skin stamps applied with inedible paint are cut off. The meat is then weighed on a floor scale and passed on for further processing.

After butchering the boning and trimming processes are held. During trimming the meat from the bone is carefully separated, it is permitted to leave only a slight redness on the surface of the complex profile of bones. After boning, trimming is carried out: the separation of connective tissue, blood and lymph vessels, cartilages, small bones, bruises and dirt. The meat is then grinded on an experimental spinning grinder through the plate with holes with a diameter of $3\cdot10^{-3}$ m. In the grinder meat is subjected to cutting, wrinkling and tearing. The minced meat is fed to a cutter or a cutter stirrer where it is machined. Then the minced meat is stuffed into the sausage casing on the syringe. After binding, the sausage loaves are hung on the frames and sent to the settling, at which they are aged up to 4 hours. When roasting, sausage loaves are processed with smoke fume at 323÷393ºK for 1÷3 hours. Then loaves are cooked in a boiling pot at 323÷393ºKfor 1÷3 hours. Next, the loaves are cooled within 4÷8 hours. Ready-made sausage loaves are stored at 281ºK for 48 to 72 hours.

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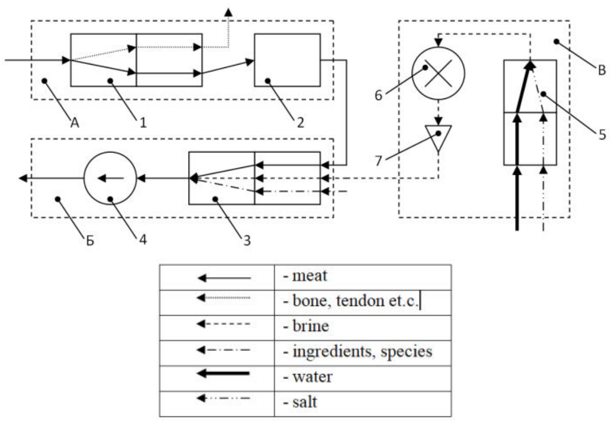

A - subsystem of preliminary grinding of meat, operators: 1 - boning and trimming, 2 - grinding; B - subsystem of mechanical processing of minced meat, operators: 3 - fine grinding and mixing, 4 - molding; B - subsystem of brine preparation, operators: 5 - mixing, 6 - cooling, 7 - dosing

Figure-3. Operator scheme of mechanical processing of meat.

CONCLUSIONS

The engineering method of technological calculation of a grinder realized in the form of algorithm and the program on the PC is developed. The geometrical parameters of the cutting mechanism and technological parameters of the grinder are determined. The operator scheme of mechanical processing of raw meat and technological scheme of production of cooked sausages is developed. The obtained analytical expressions characterizing the parameters of the process of grinding raw meat materials can be included in the engineering method of technological calculation of grinders and the method of calculation of screws.

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