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**THEORETICAL STUDY OF ENERGY CHARACTERISTICS WITH JUSTIFICATION TECHNICAL DATA MIXERS OF CONTINUOUS ACTION**  
PhD, Project and Program Management, Alatoon Mohammad Fayiz Ahmad

KROK University, Ukraine, Kiev

*Improving the efficiency of the process of mixing of feed for the sheep and goats can be achieved by applying the mixing of the working body able to qualitatively move groups of different sizes of particles from one position to another. In addition, effective mixer should provide a continuous process with minimal cost of energy and labour. Calculation of power parameters fodder mixing process is crucial when choosing the design parameters and it has a decisive significance is also important to take into account the fact that the quality ration can be obtained only from the ground components, the dimensions of which correspond to the veterinary technical requirements.*

*The results of theoretical studies provide a basis for the study of the basic design parameters of the working bodies of feed mixer. It was found that the feed particles oscillate in the variable radius with a simultaneous axial movement, which is achieved by a non-cylindrical shape of the hopper. The simplest non-cylindrical design of the hopper, from the standpoint of manufacturing in the production, is a truncated cone. Determine the total power expended on the work and power, the need to idle the rotor, thus reducing the value of the considered transport capacity.*

*Keywords: adhesion, cohesion, bunker, energy intensity, cone shape, feed mixture, the coefficient of friction, livestock requirements*

**Introduction.** Practice shows that this failure load is not enough to ensure a constant separation of the particles, so to ensure this effect, with the help of the working bodies of the mixer, you must create an additional breaking force. It follows from the above that effective mixing succulent fodder with coarse and concentrated feed mixer, in the process, must overcome the force of the adhesive connection. Need dissipate full power expended on the work and power, the need to idle the rotor, and should take into account the amount of reduction in transport capacity. Improving the efficiency of feed mixing process for the sheep and goats can be achieved through the application of scientifically based design parameters of the mixer and mixing the working body [1 - 5, 7].

To realize this goal of better understanding of the energy of the process of mixing multicomponent feed mixtures, as well as ways to reduce energy and material. A cornerstone in this process is the lack of methods for calculating the design parameters of the mixer based on Raseta energy

parameters of the process. It follows from the above that during operation must overcome the force of adhesion of the compound as a specific breaking load is not sufficient to separate particles that have relevance in the feed production process. That is why the development of a methodology for calculating the mixer parameters that can qualitatively move groups of different sizes of particles from one position to another, it must be recognized to date.

## **2. Analysis of the published data and the formulation of the problem**

In [1, 6, 7-16] revealed the main provisions of the theory of blending, systematization and refinement of design parameters of mixers.

The calculation of the parameters of mixers provides the definition of power, the need for its drive, as well as the main design parameters: the size of the container, the size and speed of working bodies. Analysis [3, 4] indicates the practical lesser usefulness of the proposed method of calculation and the need for clarification.

An indicator of the efficiency of the mixer is not only the quality of the mix (the degree of homogeneity of the mixture), and the specific energy consumption of the process of mixing and determining the parameters by means of laser systems [18, 19]. These equations relate the basic structural and kinematic parameters of the rotating cone with physical and mechanical properties of the material moving. Unfortunately, profiles section blades are investigated insufficiently and do not allow to unify the system of payments.

Analysis of published data shows [7, 8, 14], that the most appropriate mixing process to explore the theoretical - experimental way, but it is necessary to theoretically justify the design parameters of the working body of the mixer, which comprises mixing components will effectively move, alternately changing its position in the array [8, 11, 16], but this is not done.

Rationale for design parameters is advantageously carried out using the following techniques.

## **3. The purpose and objectives of the study**

The aim is to study the theoretical energy performance with the support of the main design parameters of the working bodies of the mixer feeds a continuous continuous.

To achieve this goal it is necessary to solve the following tasks:

- To carry out theoretical studies of the energy performance of the mixer works and determine the total power consumed by its efficient operation;
- A scientific foundation for the design parameters of the mixer roughage.

## **4. The results of theoretical research feed mixer parameters**

Full power expended on the work of the proposed mixer can be determined by the formula [2, 9, 15, 17]:

$$N_{CP} = K_i \cdot (N_{X-X} + N_O) / \eta \text{ кВт}, \quad (1)$$

where  $K_i$  - coefficient overcome inertia at the start,  $K_i = 1.2 - 2.5$  [6, 19];  
 $N_{X-X}$  - the power requirements for the movement and mixing, kW;;  
 $N_O$  - the power requirements for the movement and mixing, kW;  
 $\eta$  - Efficiency a drive mechanism for the V-belt transmission  $\eta = 0,95$ ; reducer for  $\eta = 0,96$ ; to transfer circuit-star  $\eta = 0,92$ ; for roller bearings,  $\eta = 0,92$  [2, 20, 22].

Power, the need to idle the rotor can be determined from the expression proposed by VP Goryachkin [1, 6, 10, 21]:

$$N_{X-X} = A \cdot \omega e + B \omega e^3, \text{ kW}, \quad (2)$$

где  $\omega e$  - the angular velocity of the rotor,  $s^{-1}$ ;

$A \cdot \omega e$  - power required to overcome the friction in the bearings, kW;

$B \omega e^3$  - the power needed to overcome air resistance, kW.

Given that the frictional resistance in bearings and resistance to wind is much less than the total resistance to movement of the mixture on the basis of the data presented in [2, 6, 12, 15], we will:  $A = 0,4 \cdot 10^{-3}$ ,  $B = 0,91 \cdot 10^{-6}$ . (It is necessary to consider that the proposed mixer 4 poles).

The power requirements for the movement and mixing:

$$N_O = N_P + N_C, \text{ кВт}, \quad (3)$$

where  $N_P$  - power, the need to move, kW;

$N_C$  - power requirements for the mixing kW.

The power requirements for the movement of [2, 6, 11]:

$$N_P = \pm \frac{Q_{com} \psi H}{360} + c_o \psi \frac{Q_{com} \psi L_T}{360}, \text{ кВт}, \quad (4)$$

where  $Q_{com}$  - performance mixer, t / h;

$H$  - height of the raising or lowering of the mixed material, m;

$c_o$  - coefficient of the material movement, which includes the wet ingredients,  $w = 8 - 18$  [3 - 6];

$L_T$  - transportation length, m.

It is necessary to take into account the decrease in the value of the considered earlier  $W_i$  transport capacity due to the use of curved blades.

$$N_P = \pm \frac{Q_{com} \psi H}{360} + c_o \psi \frac{Q_{com} \psi L_T}{360}, \text{ кВт}, \quad (5)$$

The power requirements for the mix:

$$N_C = \mu_i \psi \frac{Q_{com} \psi L_T}{360}, \text{ кВт}, \quad (6)$$

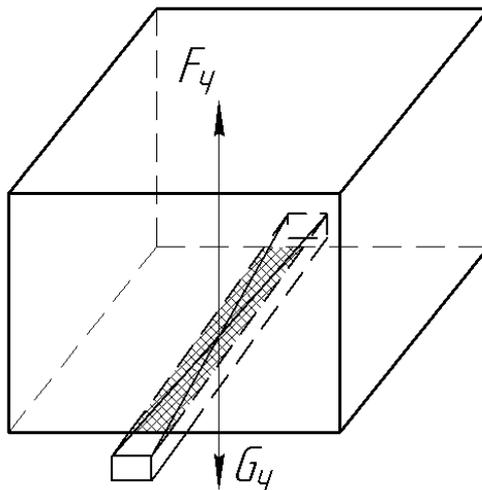
where  $\mu_i$  - drag coefficient mix.

By combining (4, 5 and 6), we obtain:

$$N_O = \pm N_O = \pm \frac{Q_{com} \chi_H}{360} + \frac{c_0}{W_i} \chi \frac{Q_{com} \chi_{L_T}}{360} + \mu_i \chi \frac{Q_{com} \chi_{L_T}}{360}, \text{ кВТ}, \quad (7)$$

In practice, the mixing of the drag coefficient is determined empirically, but in the case of mixing chip succulent fodder and dry coarse and concentrated feed moisture redistribution will not allow to obtain adequate experimental data. Based on the foregoing, there is a need in the determination of the coefficient theoretically. To determine the coefficient of resistance is necessary to simulate one of the situations that arise in the process of mixing.

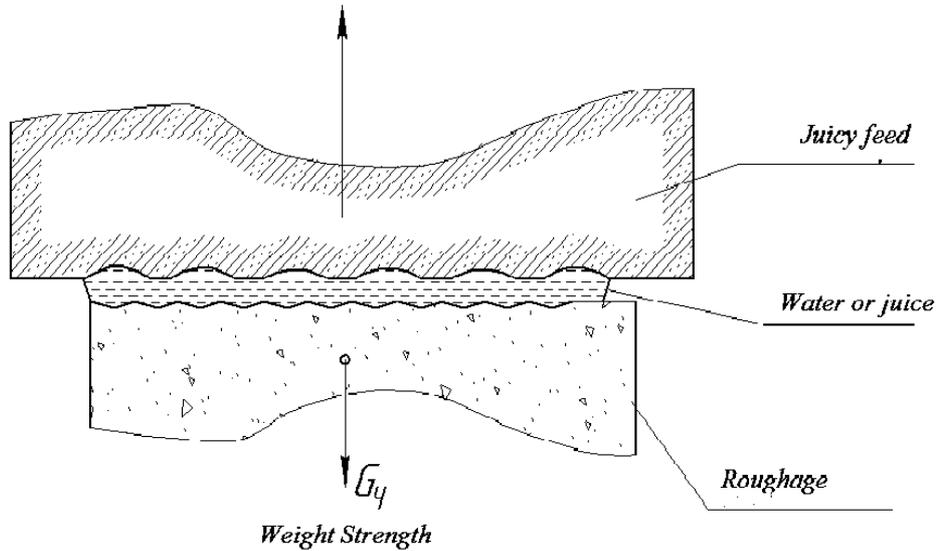
According to the conventional prescription feeding, root account for 45% of the weight of the mixture. The proposed mixer, in the process, is a certain mass of shredded root vegetables. This consists of a mass of individual particles. Suppose that in a ternary mixture of root vegetable chips is the size of the cubes faces 10 mm, which is entirely consistent with the requirements of zootechnical. The surface area of the cube 600 mm<sup>2</sup>. The total area of the outer surface of the crushed root crops 600  $n_K$ . The  $n_K$  in this case - is the number of particles in the total mass of crushed roots. A particle of root and wet it with the force of  $F_{CH}$  adhered particles of coarse and concentrated feeds. If we consider the case where a single particle of root stuck one particle of another kind of food, you will see that this gluing force counteracts the force of the weight of the particles  $G_{CH}$  (Fig. 1). Molecules of the liquid surface layer (in this case root juice) have the ability to wet the surface of coarse and concentrated feeds. This well-known phenomenon called wetting - surface phenomenon that occurs at the boundary between the phases, one of which is a rigid body, a different - liquid.



**Fig. 1. Determination of the resistance coefficient mix.**

Wetting is shown in a partial or complete spreading of the liquid on the solid surface, impregnating the porous bodies and powders [11, 15]. Wetting depends on the ratio between the forces of adhesion of the liquid molecules with molecules (or atoms) wettable bodies (adhesion) and mutual adhesion

forces fluid molecules (cohesion) [15-19]. This clutch has durability. Adhesive Strength - force required to break the adhesive bond, referred to adhesive contact area  $[\tau_A] = \text{N} / \text{m}^2$  [15, p. 8] (see Fig. 1



**Fig. 2. Scheme of adhesive bonding and juicy roughage.**

With the destruction of the adhesive compound is determined FRi force necessary for pulling (or pushing) the fibers of the layer of adhesive and adhesive area  $S_{Ri}$  connection. The adhesion strength was calculated by the formula [11]:

$$\tau_A = \frac{F_{Pi}}{S_{Pi}}, \text{ H/M}^2. \quad (8)$$

Weight Strength creates specific  $\tau_{RU}$  breaking load  $\text{N} / \text{m}^2$  ( $\text{m}^2$  weight of one component of the mixture in a single particle thickness).

Practice shows that this failure load is not enough to ensure a constant separation of the particles, so to ensure this effect, with the help of the working bodies of the mixer, you must create an additional breaking force. From the foregoing, it follows that for effective mixing succulent fodder with coarse and concentrated feed mixer, in the process, must overcome the force of adhesion compounds as specific breaking load not sufficient to separate particles. The ratio of adhesion strength and a specific breaking load generated by the weight force, is one measure that shows how many times the additional breaking force must be greater than the force of weight.

Consequently:

$$\mu_i = \frac{\tau_A}{\tau_{PY}}. \quad (9)$$

Then the total capacity, taking into account all the components can be expressed as a mathematical relationship:

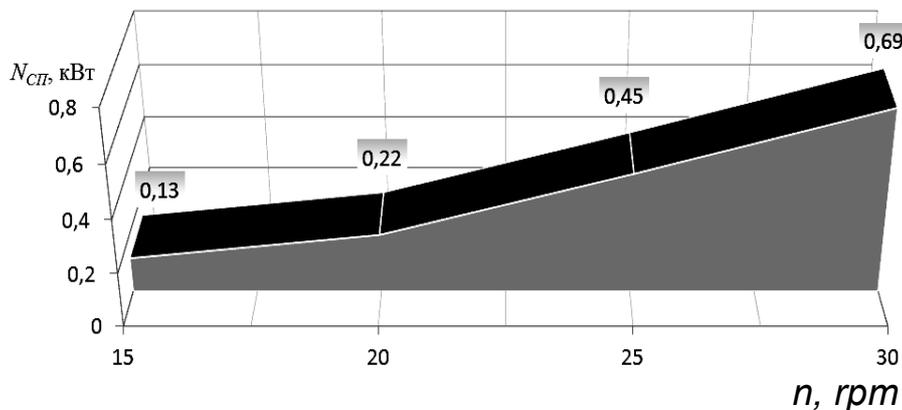
$$N_{CH} = \frac{K_H}{\eta} \cdot \left( A \cdot \omega_e + B \cdot \omega_e^3 \pm \frac{Q_{OБЩ} \cdot H}{360} + \frac{c_0}{W_i} \cdot \frac{Q_{OБЩ} \cdot L_T}{360} + \frac{\tau_A}{\tau_{PY}} \cdot \frac{Q_{OБЩ} \cdot L_T}{360} \right), \text{ кВт.} \quad (10)$$

As for the mixer drive uses a DC motor controlled using the controller, which includes a transformer and a diode bridge, so it is necessary in the expression (10) take into account the loss of power to the control devices.

$$N_{Cp} = \frac{K_i}{\eta} \psi K_y \psi \left( A \psi \omega_e + B \psi \omega_e^3 \pm \frac{Q_{com} \psi H}{360} + \frac{c_0}{W_i} \psi \frac{Q_{com} \psi L_T}{360} + \frac{\tau_A}{\tau_{PY}} \psi \frac{Q_{com} \psi L_T}{360} \right), \quad \text{кВт,} \quad (11)$$

where  $K_y$  - coefficient taking into account the power loss in the control devices.

From (10) we plot the theoretical dependence of the power costs for the mixing speed of the drum (Fig. 3).



**Fig. 3. Theoretical dependence of the power costs for mixer operation of the speed of the hopper.**

The specific energy consumption of feed mixing process was determined by the well-known formula [1, 2-9]:

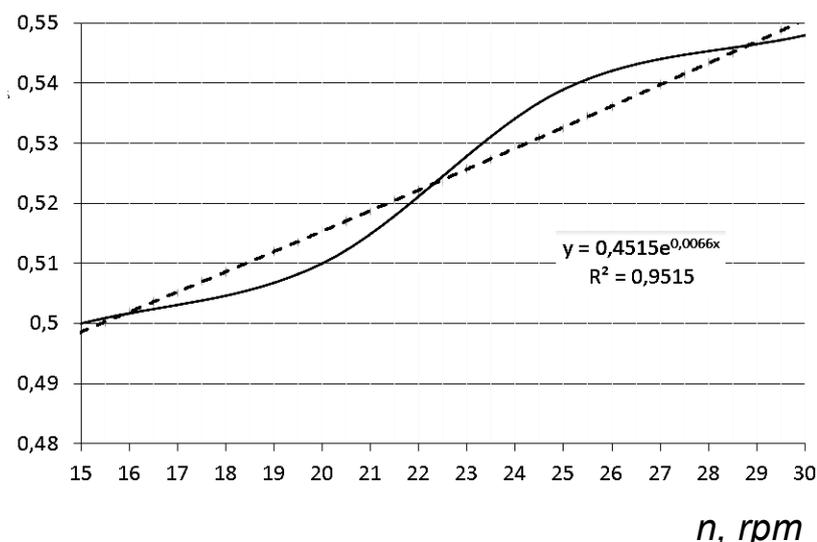
$$E_y = \frac{N_{Cp}}{Q_{com}}, \text{ кВт h/т,} \quad (12)$$

$N_{Cp}$  – the cost of power, the need to mix, kW;

$Q_{com}$  - performance mixer t / h;

Based on the data presented in Fig. 2 and 3 constructed a graph of the energy intensity of the mixing process of the drum speed.

$E$ , kW h/m



**Fig. 4. The graphic dependence of the energy intensity of the mixing process from the silo speed.**

Analysis of plots and mathematical models leads to the following conclusions:

- ratio chip adhesive bond strength to root crop straw and chaff specific breaking load generated by the weight force of the chopped straw is 3: 1;

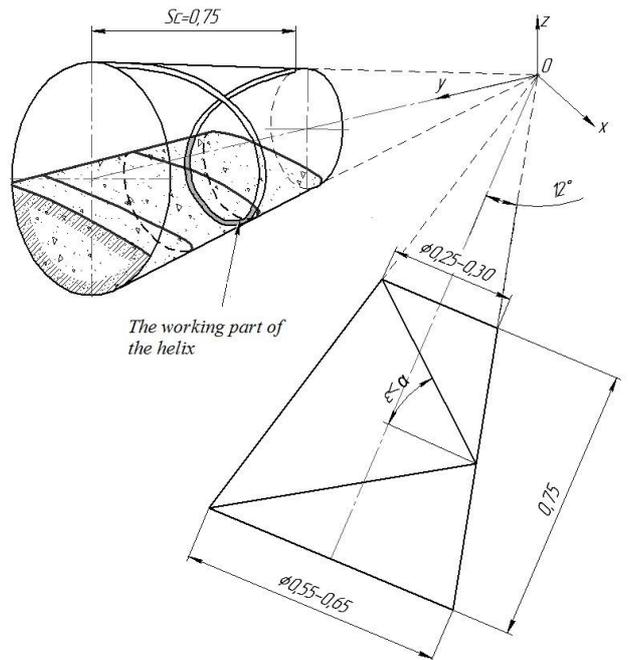
- hopper speed at 20 rev / min. Power costs mixing amount of 0,22 kW;

- when working on this a rational bunker speed theoretical power consumption of the mixing process will be 0.5 kWh / t;

- a graph theoretical energy intensity mixing process from the drum rotation speed is approximated by an exponential function with a squared magnitude of more than 95%.

Driving mixer feeds a continuous shown in Fig. 5.

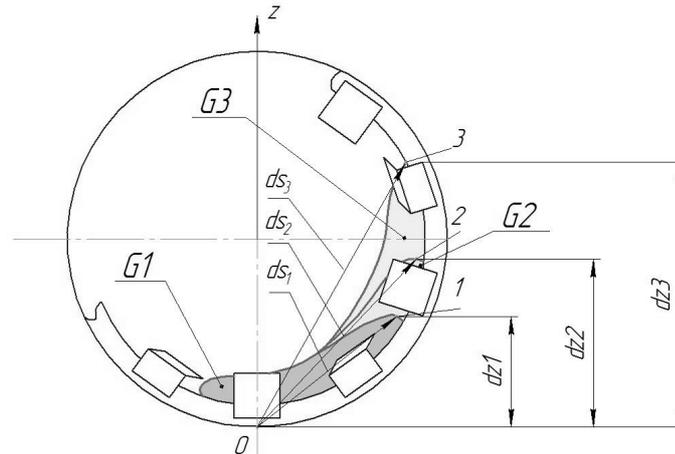
The analysis of existing scientific information and made theoretical studies provide the basis for the justification of the main design parameters of the working bodies of feed mixer. food particles oscillate in the variable radius with a simultaneous axial movement, which is achieved by a non-cylindrical shape of the hopper. The simplest non-cylindrical design of the hopper, from the standpoint of manufacturing in the production, is a truncated cone. A truncated cone is characterized by height and diameter of the base.



**Fig. 5. On the justification of the design parameters of the mixer hopper.**

It is important to lower the base, because it can be completely filled with the material, the movement of which in the spacer connecting the cones will only spiral wound, and the transport capacity cones lead to overflow the mixer hopper.

Since half of the cone apex angle,  $\varphi$  must be 12 degrees, knowing the diameter of the smaller base of the cone and the silo conveying path length  $L_T$  can calculate the diameter of the greater base of which is 0,55-0,6 m. The height of the truncated cone is determined from the operating conditions. In our case it is 0,75 m. The height of the cone, and the helical pitch angle  $sc$  hopper tilt determine the overall length  $l_{OS}$  spiral and the length of the working part of the spiral  $l_{RS}$ . Since the transport must be carried out with constant stirring layers that achieved the highest possible oversleeping, winding step can be taken as the height of the cone. Step winding cone equal to the height of 0,75 mm provides the following condition. helix angle  $\epsilon$  smaller than the angle of repose of the mixture of  $\beta$ . This spiral will effectively capture part of the mix, and raise it to the height at which the weight force will overcome the internal friction and the mixture begins to pour through the spiral. This condition determines the height of the helix. Raising the mixture to a certain height (Fig. 6), wrapped with blades will cause gravity to do the work.



**Fig. 6. Driving to the definition of the work force of gravity.**

Location on 0-1 [20, c. 67]:

$$A = \int_0^1 G_1 dz = m_1 g (z_1 - z_0), \text{ Дж}, \quad (13)$$

Location on 1-2 [20, c. 67]:

$$A = \int_1^2 G_2 dz = m_2 g (z_2 - z_1), \text{ Дж}, \quad (14)$$

Location on 2-3 [20, c. 67]:

$$A = \int_2^3 G_3 dz = m_3 g (z_3 - z_2), \text{ Дж}. \quad (15)$$

where  $dz$  — increment of coordinates  $z$  (see Figure 6.);

$m_1$  - mass of the mixture, raise the wound, kg;

$m_2$  - mass of the mixture, raise the extension winding, kg;

$m^3$  - mass of the mixture, raise the shoulder blade, kg.

On this basis, the total work amount to [15-17]:

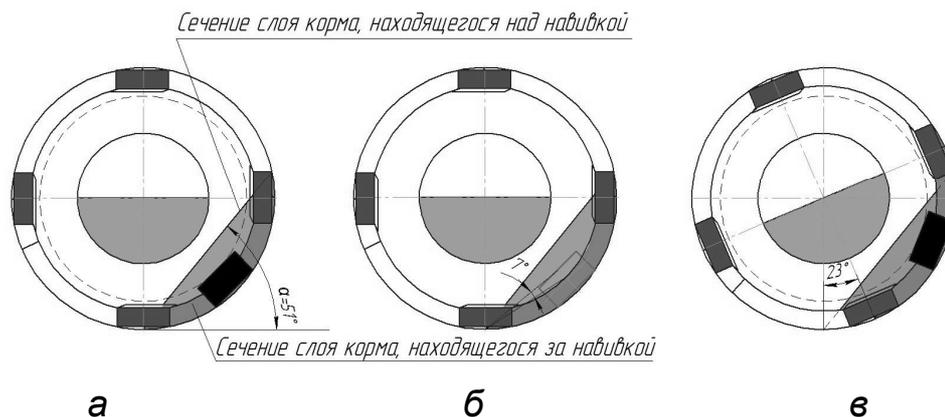
$$\sum_{i=1}^3 A = \int_0^1 G_1 dz + \int_1^2 G_2 dz + \int_2^3 G_3 dz = m_1 g (z_1 - z_0) + m_2 g (z_2 - z_1) + m_3 g (z_3 - z_2), \text{ Дж}. \quad (16)$$

Because  $dz$  is inherently scalar product of the unit vector  $ds$  on the vertical axis  $z$ , the [15-17]:

$$\sum_{i=1}^3 A = \int_0^1 G_1 ds + \int_1^2 G_2 ds + \int_2^3 G_3 ds, \text{ Дж}. \quad (17)$$

Blades offset scheme during the rotation of the mixer is shown in Figure 7.

Therefore, knowing the operating conditions of the mixer, as defined above, by changing the number of blades and extensions winding can control the amount of material in each section pour  $dz$ . The number of blades and extensions of winding, as well as their shape, combined with operating modes, must not allow a full rotation of the lifted material.



**Рис. 7. Схема смещения лопаток при вращении смесителя.**

Knowing the calculated value  $Sp$  and the diameter of the larger base of the cone can be determined that section 0,5 of the layer will be placed over the wound at her height of 35-40 mm, which is consistent with previously accepted value of the winding height. By rotating the feed mixer will rise to a height of  $dz_1$  (Fig. 6), which achieves an angle of repose, and the part of the feed, which is above the wound, it begins to pour.

Extension allows a part of the feed mixture to rise to the height of the  $dz_2$ , which is due to the large angle of rotation of the mixer, which is determined according to the scheme shown in Fig. 7 b. For the received extension to the size of 100x50 mm, height  $dz_2$  will be achieved when the angle between the horizon and  $ds_2$  (Fig. 6) equal to  $51 + 7 = 58$  degrees. This will feed into a power strip oversleeping. The curved blade allows portability her stern sleep only when it is completely out of the movable layer. This condition (Fig. 7 c) is achieved when the angle between the horizon and  $ds_3$  (see. Fig. 6) equal to  $251 + 23 = 74$  degrees.

Number of blades and extensions of winding is caused by the degree of homogeneity of the mixture and the mechanical and technological parameters of fodder components. Knowing the weight of the mixture, raise the wound, extension and scapula, and the length  $ds$  is possible to calculate the appropriate values of work.

Dividing the appropriate values of work at the time of oversleeping can get the values of power expended in the process that allows you to check the adequacy of the expression (6)

### Conclusions.

continuous feed mixer constructively should be a rotating hopper, consisting of two truncated cones joined by a smaller base. On the inner surface of the hopper is fixed spiral wrapped, complete with curved blades and rectangular extensions. Blades and extenders, in turn, to be installed at a distance that allows the feed mixture to raise to different heights and thus intensify the mixing process.

From the standpoint of mixing the bulk material layers must move wrapped with blades and the cone should contribute to movement, providing sliding and rolling of the particles, which is performed when the hopper rotational speed 20 rev / min.

At this frequency hopper rotational power costs for mixing feed amount of 0,22 kW, and the theoretical energy consumption of the mixing process is 0,5 KWh / ton.

The theoretical calculations of the following design parameters laid:

the length of the cone 0,75 m;

maximum and minimum diameter of the cone of 0,55 and 0,25 m, respectively;

the helical pitch of 0,75 m.

height 35 mm winding.

Graphic dependence of the theoretical energy consumption of the mixing process from the drum rotation speed is approximated by an exponential function with a squared magnitude of more than 95%.

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