Innovative Equipment and Production Method for Mixed Fodder in the Conditions of Agricultural Enterprises

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Innovative Equipment and Production Method for Mixed Fodder in the Conditions of Agricultural Enterprises

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Abstract. It is recommended to feed the cattle and poultry with grain fodder in the form of feed mixture balanced according to the content. Feeding of grain fodder in the form of stock feed is inefficient and economically unreasonable. The article is devoted to actual problem – the preparation of mixed fodder in the conditions of agricultural enterprises. Review and critical analyses of mixed fodder assemblies and aggregates are given. Structural and technical schemes of small-size mixed fodder aggregate with intensified attachments of vibrating and percussive action for preparation of bulk feed mixture in the conditions of agricultural enterprises were developed. The mixed fodder aggregate for its preparation in the places of direct consumption from own grain fodder production and purchased protein and vitamin supplements is also suggested. Mixed fodder aggregate allows to get prepared mixed fodder of high uniformity at low cost of energy and price of production that is becoming profitable for livestock breeding. Model line-up of suggested mixed fodder aggregate with different productivity both for small and big agricultural enterprises is considered.

Introduction

The national project of Russia in the field of agriculture provides for intensive development of livestock breeding. In common production process livestock breeding spends more than half of cost for mixed fodder.

It is proved by scientific researches and practice that increasing productivity of cattle and poultry depends much upon the quality of mixed fodder. Feeding of grain fodder in the form of feed mixture is inefficient and economically unreasonable. Simple feed mixture from several kinds of grain fodder, balanced according to the content gives considerably greater effect than simple stock feed prepared from one crop [1].

Complete mixed fodder, balanced according to the main feed elements, microelements and vitamins are in 25-39% more effective than the cereal feeds [2]. Feed grain can be processed in mixed feed, developing home-grown mixed fodder production. It allows to reduce cost for purchases of raw material, its transportation, to use grain fodder and purchased expensive protein and vitamin mineral components more rationally and to provide continuously collective, peasant (farm) holdings with home-grown mixed fodder. That is why the production of mixed fodder in the places of direct consumption is becoming profitable for livestock breeding.

Objects and methods

At present many agricultural enterprises of different forms of property abandon from mixed fodder purchase on a big feed plants because of high prices and transportation expenses. That is why
one of the solution variants of this task in these conditions are to organize mixed fodder production on
the base home-grown grain raw material and purchased protein and vitamin supplements and premixes

During the preparation of mixed fodder in the conditions of agricultural enterprises usually use
equipment of production units of EMFPU type (equipment of mixed fodder production units) or
EPUMFPU (equipment of production units for mixed feed production). Such production units for mixed
fodder occupy big areas, require high investments and have high energy and metal consumption but do
not provide mixed fodder of high quality.

In connection with the above, many joint stock companies of our country need in rather cheap
and simple in construction and maintenance arrangements for mixed fodder production from home-
grown feed raw material. This problem is particular sensitive in connection with the development of
peasant and farm holding, where reliable and available in price technique for mixed fodder production
are required [3].

There are many type of equipments for such conditions of mixed fodder production. Although it
is difficult for commodity producers to see into effectiveness and applicability of usage these
equipments. Well-known and stock-produced mixed fodder aggregates and arrangements (UMK-F-2,
KA-4, mixed fodder production units of small size «Uralets», «ITAI» and others) have series of
disadvantages [4, 5, 6, 7, 8]. In these aggregates – finished operation of mixing is done by augers. As
you know, during the operation both horizontal and vertical auger rotates inside the cyldindrical section,
where there are some quantity of mixture (mixture of different components). It is necessary to apply
considerable effort for auger rotation during the mixing. It requires much energy but it doesn’t often
provide mixed fodder of high quality.

It is obvious that it is necessary new, innovative technologies and processes for mixed fodder
preparation, providing the growth of effectiveness of feed preparing equipment.

The review of modern machines condition of vibrating action in different branches of economy
shows the advantages of vibromethod from the standpoint of reduction of efforts and energy
consumption, increasing the productivity of equipment and quality fulfillment of technological
processes. Vibrating processes and machines are considered as technology of the future [10, 11]. All
these advantages open them wide perspectives for creation new mixed fodder technological processes.

Vast researches on development of vibrating and percussive - centrifugal feed preparing
machines are carried out in the Southern-Ural agrarian university headed by professor N.S. Sergeev
[8]. The vibropercussive technology of mixed fodder production is carried out by professor I.Ya.
Fedorenko in the Altaj SAU [6, 7]. Researches in this field showed practical reason and economic
effectiveness of usage of vibrating and percussive attachments for processing of feed materials.

All foregoing allows to make the conclusion that it is necessary to involve vibrating processes
and machines in technology of preparing bulk feed mixture. Also at present time the effective
technologies and technical equipments, intensified the process of preparing concentrated feeds for
cattle feeding in the conditions of agricultural enterprises are absent.

Specific of mixed fodder preparation technology in the conditions of agricultural enterprises
allows to examine formalized relations of process holding in working equipment (for separation,
chopping, dosing and mixing) with an account of vibrating and percussive influence on the bulk feed
(components of mixed fodder) and their physical- mechanical properties as well as influence of these
conformities to law on qualitative index of prepared mixed fodder.

Mixed fodder arrangement of small - size on the base of serial mixed fodder aggregate UMK-F-2
deserves great attention [3, 9]. Feature of suggested construction of mixed fodder arrangement of
small - size is that it is provided with vibrating mixer with step mixing elements in the form of semi-
spheres, set after crush chamber. The diameters of mixing elements of vibrating mixer are increased
from the foundation to the edge of teeth according to the arithmetic progression law and established
according to chess order. Increasing the homogeneity degree of mixture during simultaneous reduction of energy consumption and duration of mixed fodder preparation process are provided due to it.
Investigation results

Technology of mixed fodder preparation consists of several operations. Expenses of energy consumption take the chopping and mixing processes. They became important in technological lines on processing of plant raw material. Another operations (for example separation and dosing) are auxiliary. The main functions provide efficiency of all object but auxiliary ones characterize the means of achievements of the main functions and promote their realization.

According to the rates of standards and normative-technical documents, used in mixed fodder preparation in the conditions of agricultural enterprises, technical solutions must provide some requirements: increasing the productivity and division of grain lots; increasing the uniformity of granulometric grinding product content; increasing the effectiveness of dosing and mixing of fodder components. That is why criterions attracting qualitative and quantitative indexes of preparation: increasing the quality and reduction of energy consumption of mixed fodder preparation process are chosen for estimation of effective functioning of technical equipments for mixed fodder preparation.

To achieve high quality of technical equipment operation due to intensification of mixed fodder preparation processes they must provide the maintenance of all requirements. Such functions as external impact, conditions of mixed fodder preparation equipment and technical impact on quality are influenced during the operation of each mixed fodder preparation aggregate.

Technological process of mixed fodder preparation in the conditions of agricultural enterprises is complex multiparametrical system where the scheme of functioning has hierarchical structure, including subsystem presented the models of some processes (separation, chopping, dosing and mixing), phenomenon and their relationship.

Suggested mixed fodder preparation processes may be considered as multidimensional dynamic system with many input and output parameters, which operates in the conditions of continuously changed external influences. Each type of operation in suggested technology of mixed fodder preparation is subsystem and carried out in specific sequence. The result of their work is increasing the quality and reduction of energy consumption of mixed fodder preparation process.

![Diagram of mixed fodder preparation process](image-url)
The structural scheme of technological process of mixed fodder preparation process is suggested taking into account of functional system of mixed fodder machines and peculiarities of action of each separate operation using intensified attachments of vibrating and percussive action (fig.1).

On the basis of structural scheme (fig. 1) the function of technological process of mixed fodder preparation is written as follows:

\[ E = f(X, Z, U), \]  
(1)

where \( E \) – vector-function, parameters defined productive indexes of technology of mixed fodder preparation in the conditions of agricultural enterprises (\( E_1, E_2 \)); \( X \) – vector-function of external influences on grain cleaning machine \( X_{sep} \), chopper of percussive principle of action \( X_{chop} \), vibromixer \( X_{mix} \) (physico-mechanical properties of mixed fodder components and conditions of external environment); \( Z \) – vector-function of technical means conditions, intensifying technological process of mixed fodder preparation (internal unregulated parameters of feed preparing machines); \( U \) – vector-function influences technical means for mixed fodder preparation in the conditions of agricultural enterprises (internal regulated parameters of feed preparing machines).

\[
X = (X_{sep}, X_{chop}, X_{dos}, X_{mix})  \\
Z = (Z_{sep}, Z_{chop}, Z_{dos}, Z_{mix})  \\
U = (U_{sep}, U_{chop}, U_{dos}, U_{mix}).
\]

After solution of the tasks on determination of parameters vector – function external influences regulated and unregulated parameters of technical means of operations fulfillment on mixed fodder preparation for function building \( f(X, Z, U) \) productive indexes of operation are defined:

- grain cleaning machine:
  \[ Y_{sep} = f_{sep}(X_{sep}, Z_{sep}, U_{sep}). \]
- chopper of percussive principle of action:
  \[ Y_{chop} = f_{chop}(X_{sep}, Z_{chop}, U_{chop}). \]
- vibromixer:
  \[ Y_{mix} = f_{mix}(X_{dos}, Z_{mix}, U_{mix}). \]
- vibrodoser:
  \[ Y_{dos} = f_{dos}(X_{sep}, Z_{dos}, U_{dos}). \]

Consequently, the total function of technology for mixed fodder preparation in the conditions of agricultural enterprises using intensified attachments of vibrating and percussive principle of action is written as follows

\[ E = f_{mix}(f_{dos}(f_{sep}(X_{sep}, Z_{sep}, U_{sep}), Z_{chop}, U_{chop}), Z_{dos}, U_{dos}) Z_{mix}, U_{mix}). \]

Change of resulting indexes both separate feed preparing machines and whole feed preparing process will take place in the result of changing of external influences regulated and unregulated parameters.

In grain cleaning machine for separation (cleaning) of grain material (grain fodder) input parameters \( G \) (specific grain load kg/sm\(^2\)) and \( E_1 \) (initial quality of grain fodder with impurities (\( Z \), % and moisture (\( W \)),%) influence on the plane screen with oblong openings set at an angle, output indexes (variable) are \( q \) quantity of treated grain fodder on screen of grain cleaning machine depending upon completeness of separation (\( \varepsilon \)), productivity (\( Q \)), estimated through the ratio of usage screen length (\( n \)) and probability of grain passage through the holes (\( P \)), its quality \( E_{1_{sep}} \) and specific energy consumption \( N_{sep} \) (or \( E_{2_{sep}} \)).

Under the influence on the chopper of percussive principle of action of two variables \( q_{sep} \) and \( E_{1_{sep}} \) output parameters are specific energy consumption \( N_{chop} \) (or \( E_{2_{chop}} \)), quantity (\( Q_{chop} \)) chopped particles of grain material and its quality (\( E_{1_{chop}} \)) as output effect, defined the alignment granulometric content (\( \lambda, M \)), depending upon angles jamming \( \chi_1 \) and \( \chi_2 \) of chopping stages. Value \( E_{1_{chop}} \) and \( E_{2_{chop}} \) are input parameters for vibrodoser.

Along with quantity (\( Q_{dos} \)) of dosing grain material according to recipe of mixed fodder preparation and specific energy consumption \( N_{dos} \) (or \( E_{2_{dos}} \)) for vibrodoser which includes unevenness of ingredients dosing estimating by the ratio variation \( C_v \), meeting the zootechnical requirements and reflecting quality of each dosing mixed fodder ingredients \( E_{1_{dos}} \).
All above mentioned output indexes variables of vibrodoser \(E_{\text{dos}}\) and \(E_{\text{dos}}\) are parameters input parameters –amplitude \((A)\) and frequency oscillations \((\omega)\) of vibromixer attachment, tilt angle of trough \((\alpha)\) to the horizon and quantity of mixing elements \((n)\) of conical form.

Output parameters of vibromixer and whole technological line of mixed fodder preparation in the conditions of agricultural enterprises are quantity (productivity \(Q\)), quality of mixed fodder \(E_{\text{1 mix}}\) expressed through uniformity of mixed fodder \(\theta\), power consumption of mixing process \(E_{\text{2 mix}}\) and the whole technological line of mixed fodder preparation \(E_{\text{2}}\).

It should be noted that power consumption of mixed fodder preparation process in the conditions of agricultural enterprises makes:

\[
E_{\text{2}} = E_{\text{2 sep}} + E_{\text{2 chop}} + E_{\text{2 dos}} + E_{\text{2 mix}}
\]  

In the result of analyses of scheme model of mixed fodder preparation follows that controlled output parameters under the influence of two input sizes \(G\) and \(E_{\text{1}}\) is \(E_{\text{1}}\) \((\text{or } \theta)\) and \(E_{\text{2}}\). These parameters characterize output indexes of whole technological line of mixed fodder preparation in the conditions of agricultural enterprises.

In order to increase the quality and to reduce power consumption of mixed fodder preparation in the conditions of agricultural enterprises we used method of casual search according to transition from previous stage \(E_{n-1}\) to next the step is taken \(j \cdot \xi\), where \(\xi\) – single vector, indicated the direction of changing parameters intensified attachments of feed preparing machines; \(j\) – size of the step.

Proceeded from the requirements of increasing the quality and reduction of power consumption of technology of mixed fodder preparation in the conditions of agricultural enterprises using intensified attachments of vibrating and percussive principle of action, mixed fodder technological process will be carried out according to the interactive scheme;

\[
E_{n} = E_{n-1} \begin{cases} 
  j \cdot \xi_{n}, & \text{if } J \cdot (E_{n-1} - j \cdot \xi_{n}) < J \cdot (E_{n-1}) \\
  0, & \text{if } J \cdot (E_{n-1} - j \cdot \xi_{n}) \geq J \cdot (E_{n-1})
\end{cases}
\]  

where \(J\) – functional of increasing the quality of mixed fodder preparation in the conditions of enterprises \(J (E) \rightarrow \text{max}\) (increasing the productivity and separation of grain heap; increasing uniformity of granulometric content; increasing the effectiveness of vibromixing and vibrodosing of mixed fodder components).

Last indexes changing of mixed fodder preparation technology according to the suggested interactive scheme (4) will be carried out by optimization parameters suggested feed preparing machines with intensified action.

The main criterions of technical efficiency of process are quality indexes of prepared product and specific energy cost.

The analyses of researches and practice show that mixed fodder production in the conditions of agricultural enterprises on higher level is not possible due to low quality of typical process of raw material treatment (cleaning, chopping, dosing and mixing), defined technological efficiency of whole mixed fodder production.

For realization of suggested technology of mixed fodder preparation in the conditions of agricultural enterprises during the fulfillment of each operation it is rationally to use intensified attachments of vibrating and percussive principle, providing maximum quantitative indexes of process with minimum energy consumption.

Thus, prototypes of new mixed fodder preparation machines of vibrating and percussive principle, included in technological scheme of mixed fodder aggregate are created during the investigations carried out in agroengineering department of the Omsky SAU [12]. Mixed fodder aggregate includes experienced prototypes of mixed fodder preparation machines of intensified principle of action for vibrodosimetering, chopping and vibromixing of mixed fodder ingredients passed the production test and applied in the form of independent machines in different agricultural enterprises including peasant and farm holdings.
We suggest technological scheme of small-size mixed fodder aggregate for production of bulk feed mixture directly in the conditions of agricultural enterprises, from feed grain crops of own production: wheat, barley, oats, peas and purchased protein-vitamin supplements (fig. 2).

Technological process of loose mixed fodder preparation includes the following operations:
- reception and treatment of starting raw material;
- feeding and distribution of components in bin sections of multicomponent vibrodosimeter;
- volume continuous and simultaneous dosing of all mixed fodder ingredients;
- chopping of ingredients in general purpose chopper with simultaneous premixing;
- final mixing of all without exceptions components in vibromixer;
- feeding of prepared mixed fodder to the bin of final production;
- storage and extradition of mixed fodder;
- Small-size mixed fodder aggregate includes multicomponent vibrodosimeter 1, bin divided into sections for different mixed fodder ingredients, two extreme sections for microsupplements, not requiring chopping.

![Diagram of mixed fodder aggregate](image)

Figure 2 – Suggested technical schemes of small-size mixed fodder aggregate with intensified attachments of vibrating and impacting action

Universal chopper 2, is set under the multicomponent vibrodosimeter which allows to chop feed grain of different moisture. Prepared grinding product has lined granulometrical content at lower energy cost and the least dust-like fraction (less 5%). Mixed fodder aggregate is supplied with vibromixer 3, which is set under the universal chopper. Mixing elements with different form of working surface are set one by one inside vibromixer section. They allow to reflect bulk mixture particles with different rates and directions in the result of connection with mixing elements that promote to get feed mixture of high uniformity.

Small-size mixed fodder aggregate operates as preliminarily cleaned starting grain components from impurities from the bin section of the multicomponent vibrodosimeter 1 are delivered in predetermined ratio to the universal chopper, where subjected to grinding. Microsupplements and chopped components are delivered to the vibromixer 3, where under the influence of mixing working attachments and mixed in ready mixed fodder of high uniformity (95-97%) at the least energy consumption. Prepared mixed fodder is fed to the bin for shipping to consumers.
Thus, suggested innovative equipment and technology for the production of mixed fodder in the form of small-size mixed fodder aggregate provides effective process of bulk feed mixture preparation at the least energy consumption. It is achieved by using intensified attachments of vibrating and percussive principle of action, according to energy consumption technology. The novelty of technical solutions of mixed fodder aggregates is protected by patents of the RF on inventions and useful models. Due to its reliability, economy, simplicity in maintenance, mixed fodder aggregate can be used in small (IP, KH, KFK and others) as well as big agricultural enterprises. Model line-up suggested mixed fodder aggregate with different productivity (from 0.1-0.2 to 2-3 t/h) for commodity producers is provided for.

Conclusions

1. It is proved by scientific researches and practice that increasing the productivity of cattle and poultry depends upon the quality of feeds, and that is why it is necessary to process feed grain more rationally and efficiently in mixed fodder in the places of direct consumption.
2. Structural and technical schemes of small mixed fodder aggregate with intensified attachments of vibrating and percussive principle of action for preparation of bulk feed mixture in the conditions of big and small enterprises of agro-industrial complex were developed.
3. The usage of suggested mixed fodder aggregate allows to get mixed fodder of high-grade uniformity (95-97%) at the lowest energy costs and to reduce costing of production that becomes economically rational maintenance of livestock breeding.

References