The method of agricultural lands conditions determined on basis of electromagnetic separation results for cereal crops and herbal flour

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Abstract. In article the appearance reasons of metal different forms elements in assembled crop of cereals or herbal flour are considered. It’s noted that these elements are almost not extracted from agricultural products by screening, sorting by weight, etc. The different methods (magnetic, nuclear-magnetic, X-ray, etc.) for presence determined of metal particles in this product with elative concentrations determined. A method is proposed which on basis of electromagnetic separation of these products allows us to establish of agricultural land pollution state of different foreign elements.

1 Introduction

The food and processing industry is one of the priority areas of the Russian economy [1-8]. In conditions of population growth, as well as various unfavorable climatic factors affecting the ripening and harvesting processes, there is a constant need for high-quality collection, processing, storage and rational use. The latter depends very much on processing [5, 9-13]. There are many ways of processing various agricultural products [14-20]. But in each of them there are separation processes aimed at isolating from it foreign particles that are dangerous, both for living organisms during its consumption after processing, and for machines used in processing industry [14, 17, 21-24].

The most difficult processes is processing of herbal flour and various cereals due to the processes of their multi-stage separation. This is due to the fact that during harvesting in the fields there are stones, various objects (for example, nuts and keys from machinery and mechanisms, plastic bottles, wood, etc.). When they interact with harvesting mechanisms

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technology formed metal particles, which in size and weight correspond to the components of the harvested crop. In addition, they are densely packed in it. Optical devices for the control of these products allows to establish [25-30].

The primary screening that occurs when collecting this product on harvesting machinery does not allow them to be extracted. And they go with the harvested crop for further processing. Larger metal elements, as well as stones, crushed plastic, wood and others, in most cases are thrown on the field during sieving. It is very rare when in harvesting machinery there is a special bunker for temporary storage of such elements, which are then shipped to a special machine and taken away from the field. Every year, if not clean, then the amount of such debris in the fields will increase for various reasons. One of the tasks that arises before sowing works is an assessment of the degree of contamination of the field. Therefore, the indicator can determine the presence of a violation of the ecological balance and the need to conduct environmental monitoring of the field, which is quite a costly exercise. Based on the results of this, a set of works will be determined to clean the agricultural land from garbage, etc. In addition, in terms of the degree of contamination of the field, it is possible to plan the possible additional costs for the deterioration of agricultural machinery during its operation under these conditions.

We suggest one of the possible options for assessing the pollution of the field based on the results of electromagnetic separation collected from this field of agricultural products of cereals or herb flour. The harvested grain crop or herb flour, as previously noted, contains metal particles in its composition, the number of which increases with the amount of debris (including stones) that has got into the moving parts of the harvesting machine, as well as the degree of wear of its mechanisms. These particles can damage the working bodies of processing machines, accelerate their wear, cause arcing, followed by ignition and explosion in industrial premises. When these particles get into the organisms of animals and poultry during feeding in most cases, their death occurs. Therefore, to prevent the considered severe consequences, the separation of these particles from agricultural products by means of electromagnetic separation takes place. Numerous studies have shown that very much depends on the quality of electromagnetic separation of agricultural products.

Therefore, the goal of this work is to determine the most effective design of an electromagnetic separator for these types of agricultural products, as well as to develop a simple and reliable method for setting up its magnetic system in real time during a long operation of the separator. Also, the aim of the work is to develop a methodology for assessing the pollution of agricultural fields based on the results of the separation collected from the harvest.

2 Electromagnetic separation of agricultural products

Our researches, as well as the analysis of the experience of agricultural production in the processing cycle of which various processes of agricultural products separation are used, have shown that the most rational and effective for cereals and grass meal is the type of electromagnetic separation in which agricultural products pass through a magnetic field under the action of gravity (from top to bottom).

Fig. 1 shows the design of one of the models of this type of separators for herbal flour.

In separator devices of this type, as shown by our experiments, the distance between the poles of the electromagnet, the value of the induction $B_0$ of the magnetic field in the interpolar space, and the nonuniformity of the field in the gap between the poles are chosen for each species, both grain products and grass meal.
Fig. 1. The separator for herbal flour

Fig. 2 shows the scheme of motion of a metal particle in the magnetic field of the separator.

![Diagram of forces acting on a particle](image)

**Fig. 2.** The forces acting on the magnetic particle in the electromagnet of the separator, where $F_{mx}$ - the magnetic force acting on the particle along the OX axis; $F_{cx}$ - force of resistance to movement of a particle in a material medium; $F_{cy}$ - the force acting on the particle of the OY axis (the aerodynamic force is the resistance to movement of the particle in the air); $mg = F$ - the weight of the particle.

Our studies have shown that the process of separation of a particle by deviation from a grain crop or grass meal is possible only if the time of motion of the particle $t_1$ along the axis OX from its location in the flow to the magnetic pole is insignificantly greater than the time $t_2$ moves along the pole diameter of the electromagnet $h$ (along the OY axis). Metal particles in the magnetic system of the separator will change their trajectory along the axes OX and OY, so that after leaving the electromagnet they will be at a distance no less than 15 cm from the edge of the stream of the cereal stream. Further under the action of gravity they will fall into a special compartment located on the bottom of the separator. The stream of cereal crop purified from them will be directed to another compartment located in the direction of its initial movement.
Solving the system of differential equations for the ones shown in Fig. 2 forces with respect to the coordinate of the magnetic particle along the OX axis, it can be established, for a given value of the induction of the field $B_0$, of the initial velocity, for example of grain, and other parameters, that the degree of inhomogeneity of the magnetic field along the OX axis should be no worse than $10^{-3}$ cm$^{-1}$. This value of the magnetic field inhomogeneity is ensured in the electromagnetic system for a long time of its operation is quite difficult [31-33]. In addition, at the poles of the electromagnet, a part of the metal particles for which $t_1 > t_2$ will gradually accumulate. This will gradually worsen both the value of $B_0$ and the degree of inhomogeneity of the magnetic field. The carried out experiments have shown that the most expedient is the operation of the electromagnetic separator for two hours with the subsequent switching off of the voltage on the windings of the electromagnet. After switching off the supply voltage, after a while all the metal particles from the electromagnet poles will fall into a special hopper, where such particles already get there when the separator is operating with the electromagnet turned on. Unlike permanent magnet separators, the process of cleaning the poles of a magnet takes no more than 10 minutes. During this time, the coils of the electromagnet are cooled from overheating and the electromagnet of the separator is again ready for operation. Since the voltage due to the large ohmic resistance of the electromagnet windings is set with a certain error and there can be other malfunctions during on and off, the degree of magnetic field inhomogeneity should be checked in a simple and reliable manner, which would, if necessary, adjust the magnetic system in real time.

### 3 Method for monitoring the parameters of the magnetic field of the separator

At present, several different methods have been developed to monitor the state of the magnetic field, the most common of which is using a thin magnetic film. But in the interpolar space, it is not very effective. The method based on the use of a matrix consisting of Hall sensors, placed at a fixed distance from each other with large dimensions of the magnetic system, is also ineffective. In addition, there are problems with its attachment to measurements in the interpolar space and fixation with the required accuracy of the distance as it moves between the poles. The method of controlling the parameters of a magnetic field developed by us on the basis of recording a diffraction image transmitted through a ferrofluidic cell of laser radiation is fairly simple to operate and reliable in application [34-36]. In Fig. 3, an example is given of a diffraction pattern (after computer processing) of the laser radiation transmitted through the cell in the direction perpendicular to the induction of the magnetic field $B_0$.

![Fig. 3.](image)

**Fig. 3.** The diffraction pattern of laser radiation in the case of placing a ferrofluidic cell from a magnetic fluid: (a) in a homogeneous magnetic field; (b) in an inhomogeneous magnetic field.
The resulting image allows to determine the degree of inhomogeneity from the distance between the maxima, and also to adjust the magnetic system when the electromagnet is energized in real time, since this image can be stored, for example, in the laptop's memory. With the definition of distance, there is also no problem, since the ferrofluidic cell is placed on a moving table of non-magnetic material, the support of which moves in two planes.

4 Results and discussion

Experimental studies on the separation of three samples of a dry mixture of herbal flour collected in several fields of the Leningrad Region were carried out on a laboratory installation based on an electromagnet with induction \( B_0 \) varying in the gap between the poles from 0.0004 to 0.9623 T at a distance \( l = 42 \) cm, \( h = 15 \) cm. The working diameter of the flow of the dry mixture in the gap between the poles was 3.6 cm. The separation efficiency in 2 hours was 2 bags of a mixture of herb flour. From each field, two bags of a dry mixture were electromagnetically separated.

The metal particles collected after the separation of the mixture from each field were weighed and their visual evaluation was carried out according to their dimensions.

From the separated mixture of herbal flour (for each field), 10 samples were taken, which were checked for the presence of metal particles in them by nuclear magnetic resonance and X-ray spectroscopy.

Also, data were obtained on the state of the fields on which the grass was harvested for which the herb flour was made. The condition of the two fields by the presence of rubbish and stones on them was approximately the same, the difference in cleaning was the period of operation of agricultural machinery. For the third field harvesting technique was quite new, but the contamination of this field compared to the other two was significant (several times).

Table 1. The separation results and the life of the equipment

| number of magnetic field | The degree of pollution and types of debris on the field | Service life of harvesting equipment | The amount of metal particles in grams |
|--------------------------|--------------------------------------------------------|-------------------------------------|--------------------------------------|
| 1                        | Small stones, branches from trees and shrubs, small metal objects, very rare plastic | more than 15 years | 3.7 |
| 2                        | A similar situation, as in the first field Stones of various sizes, parts of construction debris, various metal objects, plastic and wood | more than 15 years | 4.4 |
| 3                        | less than 5 years                                       |                                      | 11.2 |

The conducted studies of control samples of samples of mixtures of herbal flour after its separation showed the absence of metal particles in them, which confirms the high quality of the separation carried out.
The results obtained by the number of metallic impurities indicate the need for an urgent ecological survey of the field condition followed by its purification, since during the harvesting a considerable deterioration of the agricultural machinery takes place.

5 Conclusion

A preliminary analysis of the results shows that the methodology we proposed for assessing the state of farmland based on the results of electromagnetic separation of the harvested crop is workable. According to the results of electromagnetic separation, as subsequent studies show, even in most cases it is possible to determine the degree of pollution of the field and the need for environmental monitoring on it, without additional costs and a thorough (with an accuracy of up to a year) period of operation of agricultural machinery.

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