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INTERMITTENT VIBRATION EFFECT IN THE SEPARATION WITH SIFTING OF MIX POLIDISPERSE SYSTEMS USED IN FOOD INDUSTRY AND ANIMAL SCIENCE

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Abstract

In frequent technological processes of food industry or animal science, the use of classification, gradation, calibration or sifting operation becomes a necessity. Sifting is a mechanical operation realized through separation in granulometric factions of some polidisperse mixtures of granules and powder on the basis of particle shape and size. Sifting can be achieved as a stand-alone operation or as a preliminary operation for the preparation of raw materials for further processing operations. Sift method consists in locating the plates one in extension of another, the later having the dimensions of the orifices of the sieves arranged in ascending order. This method presents the advantage of using a small space from the sieving machine, a slight supervision and a good accessibility to perform proper maintenance operations. The vibration motion used in the separation operation can be an advantage only for some raw materials, while for the others it can be a disadvantage because of the congestion particle phenomenon on the plate surface.

INTRODUCTION

Much of the raw materials used in different branches of food industries (cereal crops, vegetables, fruits) and intermediate products or finished goods are solid-solid mix heterogeneous polidisperse systems [1, 3].

In many technological processes it becomes necessary to introduce classification, gradation, calibration or sieving operations.

Classification is the separation process of solid-solid mix heterogeneous polidisperse systems that belong to the same categories of material in granulometric factions or classes after certain criteria.

Factions (class material) used in gradation operations are differentiated in terms of granulometric point of view. In terms of physical principle applied, classification can be realized mechanical, pneumatic or hydraulic [1, 3].

Gradation is the operation of heterogeneous particle separation from mixed solid-solid components based on their belonging to a certain category of material (sorting by components).

Separation after the nature of the components can be done on the basis of differences between the physical or chemical constants values (density, color, magnetic susceptibility, solubility etc).

In terms of principle applied, gradation can be realized on the basis of shape differences of the particles (also called sorting), based on different magnetic susceptibility (also called magnetic separation) and based on color (called color sorting).

Calibration is the process of separation by size of various raw materials. It applies both to sort vegetables and fruits and seeds for various agricultural crops.

Sieving (sifting) is a mechanical operation realized through separation in granulometric factions of some polidisperse mixtures of granules and powder on the basis of particle shape and size. Separation is achieved through area separation in shape of metallic fabrics.

Within the technological processes of food industry, sifting can be achieved as a stand-alone operation or as a preliminary operation for the preparation of raw materials for further processing operations [2].

Depending on the purpose, the devices for the sifting operation are called: grates, sieves or plates. During sieving operation, the polidisperse granular mixture is divided into two granulometric categories: sieve residue or superior current and sift or inferior current [3, 4].

Sieving operation can be achieved by two methods: sift method and residue method.

Sift method consists in locating the plates one in extension of another, the later having the dimensions of the orifices of the sieves arranged in ascending order. In this way, every sieve plate receives the residue of previous plate and finally are achieved many sifts and one residue. This method presents the advantage of using a small space from the sieving machine, a slight supervision and a good accessibility to perform proper maintenance operations [3, 4].

The residue method consists in the overlapped location of the plates, one above the other, sieves being arranged in descending order of the sizes of the orifices of the sieves. In this way finally are obtained more residues and one sift. The advantage of this method consists in eliminating the top of the particles protecting large areas of separation of a rapid wear. Sift from the collector is the finest fractions obtained with this method [3, 4].

MATERIAL AND METHODS

In order to study the sieving operation four mix polidisperse granular materials were examined: corn, soya-bean groat (SH), sunflower groat (SH) and a mixture of them combined (used for feeding hens and having the following composition: corn

55.39 %, soya SH 20 %, sunflower SH 10 %, oil 1.5 %, starch 2.0%, monocalcium phosphate 1.2%, premix 2004 1.0%, metionyme 0.07%, salt 0.34%, calcium 8.5%). Each of these mixing components were milled in a 25 kW power milling machine from Tehnofavorit Bontida, in 30 min/ton of material (figure 1) samples of material, that are presented in figure 2 being drawn out.

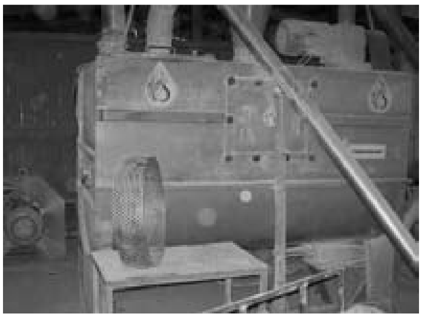

Fig. 1. Milling machine used for mix polidisperse granular material

Fig. 2. Samples for the study of sieving operation

For sifting the material samples was used a sieving machine AS 300 (figure 3) which was passed by an amount of 1.0 kg of each sample material, 10 transitions for each sample in 60 seconds.

On the top of the machine were placed 3 plates and the collector, the plates having mash size of 2.5, 1.25 and 0.63 mm. Machine working mode was set for each sample in part to be firstly continuously and secondly intermittently with an amplitude of vibration of 2.0 mm/g. The intermittent working mode means that the machine through programming would stop every 10 seconds for 2 seconds, afterwards the process being started again. In fig. 4 is shown an aspect of carrying out the sunflower SH sieving operation and in figure 5 an aspect of soy SH.

Fig. 3. Sieving machine AS300

Fig. 4. Sample of sunflower SH sieving

In figure 6 is shown the balance used to make calculations for mass residues for each sieve used and for the collector.

Fig. 5. Sample of soy SH sieving

Fig. 6. Weighing one mix sample

RESULTS AND DISCUSIONS

After conducting the sifting operation (10 determinations for each component) were obtained average values of sifts and residues shown in table 1.

Table 1

Raw material	Residue on plates 2.50 mm [g]	Residue on plates 1.25 mm [g]	Residue on plates 0.63 mm [g]	Sift on collector [g]	Total/ losses [g]	Observations
corn	62	226	266	442	996/4	continous
	53	229	317	396	995/5	intermittent
sunflower SH	18	100	295	582	995/5	continous
	15	96	318	564	993/7	intermittent
Soy-bean SH	4	60	344	589	997/3	continous
	3	50	347	596	996/4	intermittent
mixture combined	58	192	289	456	995/5	continous
	47	196	288	464	995/5	intermittent

Following the sifting operation, the separation efficiency can be determined. The mass flow of the material debit m_A that supplies the plates is divided through the sieving process in two elements: the sift mass flow m_C and residue mass flow m_R.

Balance equations regarding mass material flows that are entering and leaving the system and partial balance equations regarding the concentration of the particles that have smaller sizes than the mashes of the sieve are:

$$m_A = m_C + m_{R_1} + m_{R_2} + m_{R_3} \tag{1}$$

where m_{R_1}, m_{R_2} şi m_{R_3} are residues on the 3 plates.

$$m_A \cdot \varepsilon_A = m_C \cdot \varepsilon_C + m_{R_1} \cdot \varepsilon_{R_1} + m_{R_2} \cdot \varepsilon_{R_2} + m_{R_3} \cdot \varepsilon_{R_3} \tag{2}$$

where ε_A, ε_C and $\varepsilon_{R_{1...3}}$ each represents the percentage of raw materials with smaller sizes than the mashes of the sieve from the initial mixture, sift and residue.

Sieving efficiency in sifting is defined as the ratio between the mass particles with sizes smaller than the size of the mashes of the sieve and that can be located in sifts and material mass flow:

$$\eta_C = \frac{m_C \cdot \varepsilon_C}{m_A \cdot \varepsilon_A},[\%] \tag{3}$$

where: m_C - sift mass flow, m_A -material mass flow, ε_A, ε_C the percentage of raw materials with smaller sizes than the mashes of the sieve from the sift and initial mixture.

Sieving efficiency in residue is defined as the ratio between the mass particles with sizes bigger than the size of the mashes of the sieve and that can be located in residue and material mass flow [3]:

$$\eta_R = \frac{m_R \cdot (100-\varepsilon_R)}{m_A \cdot (100-\varepsilon_A)},[\%] \tag{4}$$

where: m_R - residue mass debit, m_A -material mass debit, ε_R, ε_A the percentage of raw materials with smaller sizes than the mashes of the sieve from the residue and initial mixture.

Plate's total efficiency is the result between the separation efficiencies for sifting and for residue[3]:

$$\eta_T = \eta_C \cdot \eta_R,[\%] \tag{5}$$

The determination of the percentage content of the particles ε_A, ε_C and ε_R in residue or sift was done from each sample. Value of these sizes and parameters are shown in table 2.

Table 2

Material	**Work mode**	**ε_C** [%]	**ε_A** [%]	**ε_T** [%]	**η_C** [%]	**η_R** [%]	**η_T** [%]
corn	continous	92	70	80	58,1	36,9	21,4
	intermittent	90	70	85	50,9	29,9	15,2
sunflower SH	continous	95	85	89	65,0	30,2	19,5
	intermittent	93	85	86	61,0	40,0	24,4
Soy-bean SH	continous	91	86	88	62,3	34,9	21,75
	intermittent	94	86	89	65,1	31,4	20,4
mixture combined	continous	89	77	83	52,7	39,8	20,98
	intermittent	91	77	86	54,9	32,3	17,74

CONCLUSIONS

1. Due to the very similar quantities of the residues on the sieves and in the collector, the material nature has a low impact on the sieving operation even if vibrations in continuous mode or discontinuous mode were used; if on the first 2 plates the residue quantities are similar in both working modes, in the

collector and on the third plate a greater quantity will be noticed in the continuous mode as compared to the intermittent mode.

2. Tabular or needle shape of particles makes difficult the sifting process because even if their thickness allow their passage through the meshes of the sieve, they deposit in the top of raw materials being prevented from reaching in contact with the separation area. Also tabular shape particles that reach the surface of the plate can close the holes which has the effect of decreasing the capacity of separation.
3. Material granulometric factions affect plate efficiency and the capacity of the sieve in the process of separation. Hereby, particles with size less than 0.75 of mesh size pass easily through the meshes of the sieve; those particles with size larger than 1.35 of mesh size remain in residue. Particles that have size between 0.75…1.35 of the meshes of the sieve generate difficulties in the sifting process. If it is working with mixtures containing a high percentage of particles between these critical limits, it is advisable to work with sieves which have larger mesh size to 10 ... 15% higher.
4. Orifice shape can be adopted according to the geometric shape of the particles: for sphere particles, are recommended to be used plates with square or circular orifice shape; for irregular shapes can be used plates with oblong shape (rectangular).
5. The sizes of the orifices of plates influence the efficiency of the sifting operation, the efficiency decreasing as the size of the orifice is diminishing.
6. The vibration motion of the plates doesn't have a notable influence on the sifting efficiency; the vibration motion used in the separation operation can be an advantage only for some raw materials, while for the others it can be a disadvantage because of the congestion particle phenomenon on the plate surface.

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