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Assessing the Adequacy of Mathematical Models of Light Impurity Fractionation in Sedimentary Chambers of Grain Cleaning Machines

V.E. Saitov[a], R.F. Kurbanov[a,]*, A.N. Suvorov[a]

[a] *Vyatka State Agricultural Academy, 133 October Avenue, 610017, Kirov, Russia*

Abstract

Grain heap contains high-grade grain, weed and grain impurities. At the preliminary stage of grain processing, it is necessary to clean the grain heap and allocate the fraction of light waste grain impurities which are a valuable food for farm animals. This paper proposes a technical solution for the implementation of this process and derives a mathematical model thereof. The authors analyze the modeled process of grain impurities allocation from the fraction of light waste sediment in the area of the suction port flow fan. The results of modeling are verified by comparison to experimental data. It is found out that the results of theoretical studies fit the ± 10% tolerance of the experimental data difference. The agreement between the theoretic generated and the experimental results on the hypothesis on the samples belonging to the same general population based on the sign test is considered acceptable. The resultant mathematical model adequately describes the process of fractionation of light waste in the sedimentary area of the suction chamber in diametrical fan window.

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Keywords: grain cleaning machine, pneumatic system, suction channel the grain material, air flow, mathematical model ;

1. Introduction

Grain heap, coming from the field of combine harvesters in the post-harvest handling items includes a full grain, weed and grain impurities. Therefore, at the initial grain treatment step is necessary to clean grain heap allocation and fractional grain impurities (fraction of feed), which are a valuable food product for domestic animals. To per-

* Corresponding author. Tel.: +7-332-57-43-11.
E-mail address: kurrust@mail.ru

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form this operation, apply an initial cleaning machine grain allocation impurities (waste) are carried out in an air stream and sieves [1-4].

Quality separation waste chamber included in the sediment, a fraction trash and fodder can be achieved using an air stream, let down in fractional separation zone. And this separation is feasible by depositing a fraction of feed in the sedimentary chamber and removal through diametral fan and the subsequent capture dust separator fraction trash or precipitation of both factions in the compartments of the precipitation formed in the bottom of the sediment chamber [5-7].

2. Mathematical model of the fractionation of light impurities in sedimentary chamber

The most viable option of waste separation by precipitation of feed fractions in the sedimentary chamber and removal through diametral fan dust separator and the subsequent capture of light impurities fraction of weed is air stream separation in the area of the suction flow fan window [8-10].

To analyze the likely use a bin containing grain heap full grain main crop m_{10} = = 85%, shrunken and crushed grains m_{20} = 5% and trash m_{30} = 10%, with average speeds of flight $\upsilon_{vit.cf.10}$ = 9,5 m/s, $\upsilon_{vit.cf.20}$ = 6,2 m/s, $\upsilon_{vit.cf.30}$ = 3,7 m/s and standard deviation σ_{10} = 0,999 m/s, σ_{20} = 1,142 m/s, σ_{30} =2,321 m/s. In this study the scientists show that the laws of the distribution of high-grade seeds of the main crop, grain and trash by airborne airspeed $\upsilon_{vit.}$ close to the normal laws of the [11-13].

Therefore, for any flight speed $\upsilon_{vit.}$ of full seeds (grains and trash) formula probability density $f(\upsilon_{vit.10(20,30)})$ and distribution functions $F(\upsilon_{vit.10(20,30)})$ have the form [14]:

$$f(\upsilon_{vit.10(20,30)}) = \frac{e^{-\frac{(\upsilon_{vit.10(20,30)} - \upsilon_{vit.cf.10(20,30)})^2}{2\sigma^2_{10(20,30)}}}}{\sigma_{10(20,30)}\sqrt{2\pi}}, \quad (1)$$

$$F(\upsilon_{vit.10(20,30)}) = \int_0^{\upsilon_{vit.10(20,30)}} f(\upsilon_{vit.})d\upsilon_{vit.}. \quad (2)$$

To construct the curves of probability density functions $f(\upsilon_{vit.10(20,30)})$ used statistics on each component of the heap and the corresponding values of the Laplace function [11], as in the normal distribution of the probability of hitting any grains or particles of impurities in the interval from $\upsilon_{vit.1}$ to $\upsilon_{vit.2}$ is determined by the relation [14]:

$$P(\upsilon_{vit.1} < \upsilon_{vit.} < \upsilon_{vit.2}) = \Phi\left[\frac{\upsilon_{vit.2} - \upsilon_{vit.cf.10(20,30)}}{\sigma_{10(20,30)}}\right] - \Phi\left[\frac{\upsilon_{vit.1} - \upsilon_{vit.if.10(20,30)}}{\sigma_{10(20,30)}}\right], \quad (3)$$

where – Laplace function of continuous random variable *x*.

In a normal distribution of high-grade seeds of the main crop, grain and trash airspeed $\upsilon_{vit.}$ with probability 0,9973 (rule of three «sigma») is within the following limits [14]:

$$\upsilon_{vit.if.10(20,30)} - 3\sigma_{10(20,30)} \le \upsilon_{vit.10(20,30)} \le \upsilon_{vit.if.10(20,30)} + 3\sigma_{10(20,30)} \quad (4)$$

Therefore polygons relative frequency components cleaned grain blend of speed $\upsilon_{vit.}$, content and statistical parameters show the real picture of the possible separation of the air flow.

Consequently, part of the fraction $\beta_{10(20,30)}$ of each component in the waste light can be estimated by the formula (2):