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THEORETICAL ASPECTS OF MIXING PHENOMENA OF AGRICULTURAL MATERIALS WITH A SPECIAL ATTENTION TO MIXING UNIFORMITY AND POWER CONSUMPTION

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Abstract: *Different theoretical aspects of mixing processes concerning agricultural materials were describe. Some very important parameters as: mixers types, mixing time, mixing uniformity, power consumption, dimensional analysis were discussing. Some equations describing power consumption and sampling methodology of mixing processes were presented.*

Key words: mixing, agricultural materials, mixing time, uniformity of mixture, power requirement, mixer types

Introduction

Proper preparation of high quality feed and ecological products depends very often on uniform mixing. Many different systems are used to achieve uniform mixtures. The most typical materials to be mixed are classified as: powders, granules, fibrous materials, dough's or liquids. Uniform distribution between particulates is brought by relative motion of sub elements of mixture. Level of mixing may be described by mixing indices. A typical index compares the variation in concentration of sub elements at given time to the ideal or ultimate distribution. The quantitative study of such mixing processes is difficult to describe, because of the complex mechanisms by which mixing is achieved and besides that the random state of well mixed materials is not easily defined. Commonly used measures of mixer performance include: the time required to achieve a desired blend, the energy requirement and the properties of the final product.

Description of the processes

Mixing is a very important operation encountered in many industrial and agricultural applications. The effectiveness of different mixers can be assessed by comparing their performance using a standard mixture. The only reasonable basis for comparing mixer efficiencies is to consider the quality of the equilibrium mixture. There are number of situations where excessive mixing is not only wasteful of energy but also counter productive. Excessive power inputs or impeller speeds may damage suspended biological materials, it they have an elongated shape with hyphen connected to them. Excessive mixing of solids may produce segregation heaving had an initially good mix. A wide range of agricultural materials to be mixed are: granules and they include combination of maize, potatoes, vegetable, fruits, complete animal feed and proteins. Granules particulates have size 1-7 mm and their mass depends on their density and moisture content. Fibrous materials are: straw, hay, silage and vegetables. The mass of fibrous materials depends also on density and moisture content. Particle size of such materials varies from 1-50 mm and depends on its use. They have special elasticity and higher shear strength compared to granules and lower resistance to abrasion, which arises from the shape of the particulates [1, 2].

Material and method

Defining the mixing end point depends on how precisely the mixture is scrutinized. For fibrous materials, proper information on the end point of mixing time is particularly important, because such materials are very susceptible to abrasion. Over mixing leads to damaging of such materials. Very little is known about the mixing rate, about nature of mixing process or about the effect of the properties of fibrous materials on mixer performance.

To obtain proper accuracy of measurement the mass of a sample should be established as follows:

$$m = 4 \cdot 10^3 \frac{\xi \cdot a^3}{C \cdot b^2} \qquad (1)$$

Where:
m - sample mass
a - average density of defined tracer
C - tracer concentration in the mixture
b - acceptable error of analysis
ζ - mass density of defined tracer

To achieve proper arrangement of given component in the mixture, a characteristic mixing time required. However mixing time does not depend on the quantity of components and in case of feed preparation on industrial scale, it takes from 4 to 6 minutes. Mixing time can elongate due to imperfection of mixer design [3, 4].

The energy consumption characteristic of a mixer, provide simple and quite valuable information for evaluation of mixing processes. Besides that energy consumption provides also a useful basis for comparing mixing rate and mixing efficiency of different mixer design. Because of the complex motion of any mixing process dimensional analysis is widely used to establish simple relationships between power consumption and the controlling variables. In the process industries, dimensionless groups are widely used to correlate data. Some of the most important groups in the field of mixing are described below

$$P_0 = \frac{P}{N^3 \cdot D^5 \cdot \xi} \tag{2}$$

Where:
P_o – Power Number, kW.
P – power, kW.
N – impeller speed, m/c.
D – impeller diameter, m.
ζ – density, kg/m^3.
Some typical energy consumption for certain duties are as follows:
- powders – 0,2 kW/m^3
- granules – 0,3 kW/m^3
- fibrous material – 2 kW/m^3
- doughs – 4 kW/m^3
- liquids – 0,6 kW/m^3

To evaluate the motion of particulates inside the mixing chamber, it is very important to describe the velocity of one single particulate. Because the most popular agitator has the screw type of mixing unit then it will be this type of motion as shown on Fig 1.

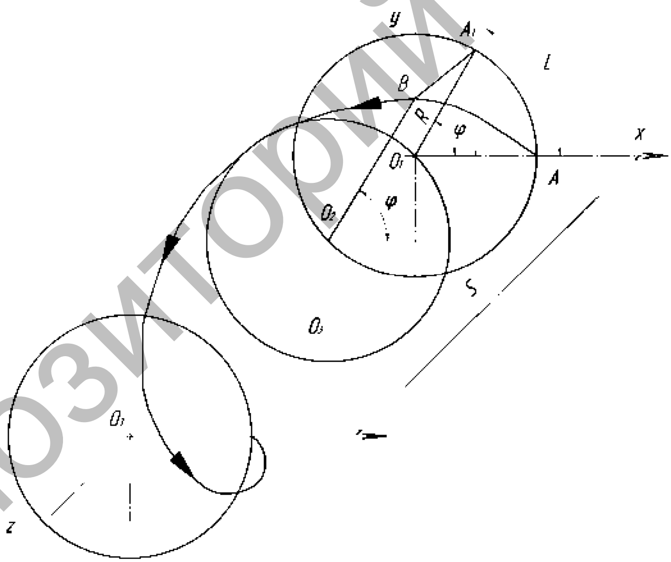

Fig 1 Single particulate motion in a mixing chamber

From Fig 1we can calculate the particulate velocity in the direction of axle z as follows:

$$Vz = \frac{dz}{dt} = \frac{S \cdot \omega}{2\pi} \tag{3}$$

Where:
ω – radial velocity of a mixing unit
S – screw pit size

Power requirement can be calculated from the following equation

$$N = \frac{C \cdot \xi \cdot R^3 \cdot A \cdot n \cdot \omega}{2000} \quad (4)$$

Where:
C – coefficient of resistance
ζ – mass density
ω – radial velocity of a mixing unit
n – number of mixing units
R – mixer diameter
A – area of mixing units

Conclusions:

1. The effectiveness of different mixers can be assessed by comparing their performance using a standard mixture.
2. Excessive mixing is not only wasteful of energy but also counter productive.
3. The energy consumption characteristic of a mixer provides simple and quite valuable information for evaluation of mixing processes.
4. Because of the complex motion of any mixing processes, dimensional analysis is widely used to establish simple relationships between power consumption and controlling variables.

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Abstract:

The most important technological operation of mixed fodders preparation is mixing of their components as the quality of an end-product greately depends on it. Different theoretical aspects of mixing processes concerning agricultural materials are considered in the article. Some very important parameters as: mixers types, mixing time, mixing uniformity, power consumption, dimensional analysis were discussing. Some equations describing power consumption and sampling methodology of mixing processes were presented.

ТЕОРЕТИЧЕСКИЕ АСПЕКТЫ ПРОЦЕССА СМЕШИВАНИЯ СЕЛЬСКОХОЗЯЙСТВЕННЫХ МАТЕРИАЛОВ С УЧЕТОМ ТРЕБОВАНИЙ К ОДНОРОДНОСТИ СМЕСИ И ПОТРЕБЛЯЕМОЙ МОЩНОСТИ

Резюме:

Одной из наиболее ответственных технологических операций приготовления кормовых смесей является смешивание компонентов, так как от этого во многом зависит качество конечного продукта. В статье рассмотрены теоретические предпосылки расчета производительности и оценки однородности смеси горизонтального смесителя. Обсуждены такие важные параметры, как время смешивания, однородность смеси, расход энергии. Представленные уравнения, описывающие расход энергии и анализ процесса смешивания, позволяют определить параметры и режимы работы смесителя, при которых с минимальной энергоёмкостью обеспечивается требуемое качество смешивания компонентов кормовых смесей.