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Continuous Mixer With Heat Treatment Of Feed

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Abstract: the article provides a definition of steam consumption for heating feed mixtures in a continuous flow, taking into account its losses when unloading the finished feed mixture**.**

Keywords: mixer, feed, heating, steam, steam distributor, heat transfer, airlock, steam loss, steam line, coil, free space, mixing quality, steam consumption.

Introduction

In livestock farming, steam is widely used for heat treatment of feed. The main advantage of heating feed with steam is better preservation of vitamins and nutrients than when heating with other types of heating media. It is convenient to transport it through pipes over a considerable distance without large additional costs, and it is easy to regulate the flow and temperature by changing the pressure. Steam has a high latent heat of vaporization and heat transfer coefficient; its production does not require large costs compared to other types of coolants. There are two ways to heat feed with steam:

heating through a dividing wall, that is, between the material and the steam there is a wall through which heat is transferred to the material and the material does not have contact with the steam;

heating by direct contact of steam with the heated material.

Heating through the dividing wall increases processing costs and reduces equipment productivity. This is due to the low heat transfer coefficient, since due to the dividing wall between the heated material and the steam, heat can penetrate into the internal layers of the material mass only due to thermal conductivity. This method requires a special design of equipment that provides the highest heat transfer coefficient. For example, equipment can be manufactured with double walls, between which steam is passed: with a rotating coil, which is part of the heating surface and ensures mixing of the material, etc.

All these designs complicate manufacturing and increase cost. equipment. In addition, the use of equipment with costs compared to equipment that provides direct contact of steam with the heated material (cleaning the heat exchange surface from scale and soot, maintaining mixing mechanisms, etc.).

Therefore, to heat feed, it is advisable to use devices that provide steam input directly into the mixing chamber.

One of the main factors influencing steam consumption and feed heating temperature is the method and device for supplying steam to the mixing chamber. The best arrangement for the steam distributor should be one in which the steam reaches all the most distant points and the material is heated in a relatively short time. In this case, heat loss for heating the product and heating the environment will be minimal.

The proposed design of a mixer with thermal treatment of feed includes a frame-mounted housing with a lid, loading and unloading sluice gates, a double-threaded auger with gaps between the turns, a steam distributor and a drive (Fig. 1).

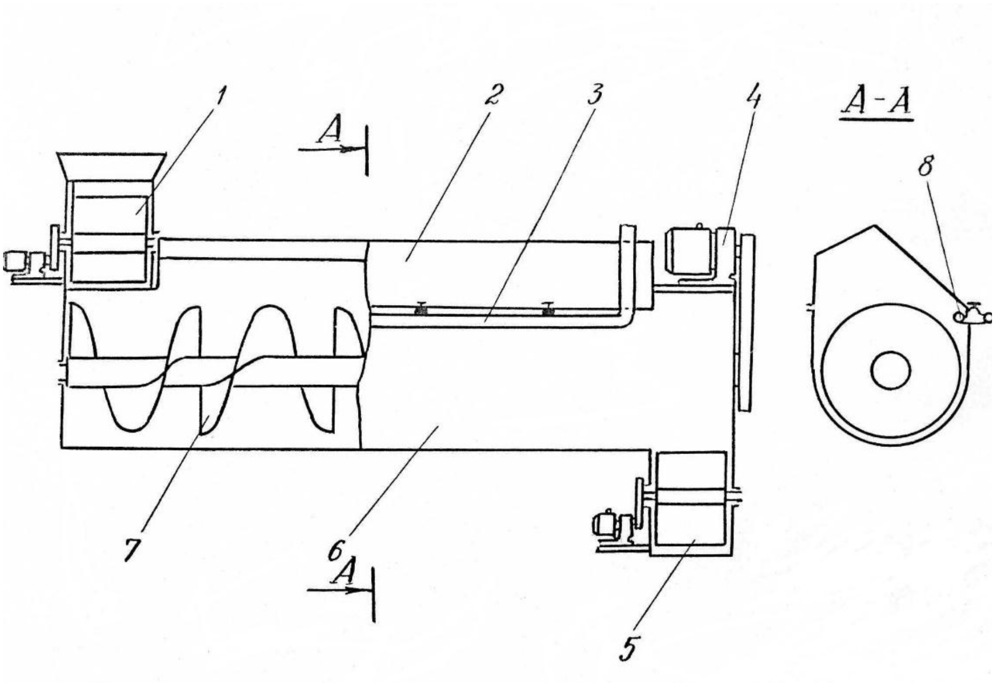

Fig.1. Recommended continuous mixer design actions with heat treatment of feed; 1.5-sluice gates with drive; 2- cover, made in the form triangular box; 4- gear motor; 6- casing; 7-screw;8-paroras-distributor

The steam distribution pipe is installed inside the casing along the mixer on its right side along the technological process above the axis of the screw, which eliminates steam loss into the environment (Fig. 2.). In addition, the pipe additionally heats the air space inside the mixer casing. Steam distribution cone-shaped holes are located in a single row on the steam distribution pipe to ensure uniform distribution of steam in the mixing chamber. A tap is installed to regulate the steam supply.

Calculation of steam consumption for heating the product was carried out by many scientists [1, 3...6]. The resulting formulas for calculating steam consumption practically do not differ from each other and they can be represented in general form by the following expression

$$q = q_1 + q_2 + q_3. \quad (1)$$

where q_1 - steam consumption for heating the product, kg;

q_2 - steam consumption for heating the walls of the installation, kg;

q_3 - steam loss to the environment through the walls of the installation housing, kg.

This formula is only valid for steamers or batch mixers. With continuous mixing with heat treatment of feed, the finished product is discharged from the mixer in a continuous stream. In this case, along with the finished product, a certain amount of steam also leaves the mixer through the discharge neck. Therefore, in formula (1) for a continuous mixer with thermal treatment of feed, it is necessary to additionally include steam losses that occur during continuous unloading of feed. Taking this into account, formula (1) for continuous mixers can be written as follows

$$q = C(q_1 + q_2 + q_3). \quad (2)$$

where C - coefficient taking into account steam loss when unloading the finished feed mixture.

Coefficient C is determined experimentally.

Steam consumption for heating products was determined by the formula [2, 4,6, 7]

$$q_1 = \frac{10^3 \cdot Q_{см} \cdot C_k (t_1 = t_o)\tau}{r}; \quad (3)$$

where $Q_{см}$- mixer productivity, t/h;

$C_к$ - specific heat capacity of feed components, J/kg°C;

t_1 - Let us express the axial velocity of the particle in terms of the absolute velocity Vo

$V_n = V_o \cdot \sin \beta_o$ or considering (13) the finished product, °C;

t_o - initial temperature of feed components, °C;

τ - duration of the heating process, h;

r - latent heat of vaporization, J/kg.

The steam consumption for heating the walls of the mixer was determined by the formula [1],

$$q_2 = \frac{M \cdot C_{cm}(t^1{}_{cm} - t^1)}{r} \quad (4)$$

where M- weight of heated parts of the mixer, kg;

C_{cm}- specific heat capacity of the mixer wall material, J/kg-°C;

$t^1{}_{cm}$ и t^1 - final and initial wall temperatures, °C.

Steam losses to the environment were determined using the formula [1]

$$q_3 = \frac{3600 \cdot A_1 \cdot f \cdot (t_{cm} - t_{ok}) \cdot \tau}{r}; \quad (5)$$

A_1 - heat transfer surface area of the walls, m^2;

t_{cm}- average temperature of the outer surface of the walls, °C;

t_{0k} - average ambient temperature, °C;

f - total heat transfer coefficient by convection and radiation [6], W/m2 °C.

$$f = 9{,}07 + 0{,}055(t_{cm} - t_{ok}); \quad (6)$$

Knowing the calculated values of q_1, q_z, q_3 and experimental values of the total steam flow, you can determine the coefficient C from the following expression

$$C = \frac{q}{q_1 + q_2 + q_3}; \quad (7)$$

Experimental values of the total steam consumption were determined by measuring the resulting amount of steam condensate on a specially manufactured installation simulating a mixer steam distributor (Fig. 3), in which all the geometric dimensions of the supply sections of the steam pipes installed in the mixer were preserved.

The installation consisted of a tank with a capacity of 1.6 m3, three coils, each of which was connected at one end to the supply steam line, the other ends to the discharge pipeline, inlet and drain pipes for cold water (Fig. 3.).

The experiments were carried out as follows: the supply steam line was disconnected from the mixer and connected to the installation. The container was connected to the flowing water supply system. When the container was filled with cold water, the steam supply was turned on at the same pressure and temperature as during heat treatment of feed in the mixer.

Fig.1. Steam supply to the mixer

Fig. 2. General view of the installation for determining steam consumption

After reaching a steady state of steam supply, measurements were made of the resulting amount of condensate using a measuring container per unit time. Time was controlled with a stopwatch.

The experiments were carried out in triplicate, with 5 samples taken in each experiment.

To obtain more reliable data, experiments were carried out at different pressures in the steam line, namely at 0.04 and 0.05 MPa.

The coefficient taking into account steam loss when unloading the finished feed mixture is C=1.08...1.10.

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