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WATER STEAM CONSUMPTION AND FEEDING SELECTION DEVICE CALCULATION INTO THE MIXING CHAMBER

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Abstract

Feed heat treatment analysis in stock breeding is given, the steam consumption results for heating feed mixtures in a continuous flow is determining with taking into account its losses when unloading the finished feed mixture.

Key words: mixer, feed, heating, steam, steam distributor, heat transfer, steam losses, steam line

Introduction

In Uzbekistan, research is underway aimed at resource-saving technologies development and technical means for soil cultivation, sowing, harvesting and crops primary processing, production and feed preparation. [1-10].

In feed preparation mechanization in stock breeding and complexes, it provides for the production flow organization, when the feed arriving for processing undergoes interrelated operations series without reloading operations that require large costs of living labor. The final operation for preparing feed mixtures is mixing the components, which is carried out in special devices - batch or continuous mixers.

In animal husbandry, steam is widely used for feed heat treatment. The main advantage of heating feed with steam is vitamins and nutrients better preservation than when heated with other types of heat carriers. It is convenient to transport it through pipes over a considerable distance without large additional costs; it is easy to adjust the flow rate and temperature by changing the pressure. Steam has a large vaporization latent heat and a heat transfer coefficient; its production does not require large costs in comparison with other types of heat transfer fluids.

There are two ways to heat feed with steam:

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

Heating through the dividing wall increases processing costs and reduces equipment performance. 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 material mass inner layers only due to thermal conductivity. This method requires equipment special design that provides the highest heat transfer coefficient. For example, equipment can be made with double walls, between which steam is passed: with a rotating coil, which is heating surface part and provides material mixing and etc. All these designs complicate manufacturing and increase the equipment cost. In addition, the equipment use with costs compared to equipment that provides direct steam contact with the heated material (heat exchange surface cleaning from scale and carbon deposits, stirring mechanisms maintenance, etc.).

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

Materials and methods

One of the main factors affecting the steam consumption and feed heating temperature is the method and device for supplying steam to the mixing chamber. The best location of the steam manifold should be such that the steam reaches all the most distant points and the material heats up in a relatively short time. In this case, the heat loss for heating the product and for heating the environment will be minimal.

The proposed design of a mixer with feed heat treatment includes a frame-mounted housing with a cover, loading and unloading sluice gates, and double-threaded auger with breaks between the turns, a steam distributor and a drive.

The steam distribution pipe is installed inside the casing along the mixer on its right side along the technological process above the screw axis, which eliminates steam losses to the environment. In addition, the pipe additionally heats the air space inside the mixer shell. The cone-shaped steam distribution holes are arranged in one row on the steam distribution pipe to ensure uniform steam distribution in the mixing chamber. A tap is installed to regulate the steam supply.

Results and discussion

The steam consumption calculation for heating the product was carried out by many scientists [1, 3, 5]. The obtained formulas for calculating the steam consumption practically does not differ from each other and they can be represented in general form by the following expression:

$$q = q_1 + q_2 + q_3, \tag{1}$$

where q_1 – is steam consumption for heating the product, kg; q_2 – is steam consumption for heating the walls of the installation, kg; q_3 – is steam losses to the environment through the walls of the casing installation, kg.

This formula is only valid for steamers or batch mixers. With continuous mixing with feed heat treatment, the finished product is discharged from the mixer in a continuous flow. In this case, together with the finished product, a certain amount of steam also leaves the mixer through the unloading neck. Therefore, in formula (1) for a mixer, continuous action with feed heat treatment, it is necessary to additionally include steam losses arising from continuous feed unloading. With this in mind, formula (1) for continuous mixers can be written as follows:

$$q = C(q_1 + q_2 + q_3). \tag{2}$$

where C – is a coefficient that takes into account the loss of steam when unloading the finished feed mixture.

Coefficient C is determined experimentally.

Steam consumption for heating the products was determined by the formula [2, 5]

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

where $Q_{см}$ – is mixer capacity, t / h; $C_к$ – is a specific heat capacity of feed components, J / kg °C; t_1 – is a temperature of the finished product,°C; t_o – is an initial temperature of feed components, °C; τ – is heating process duration, h; r – is a latent heat of vaporization, J / kg.

Steam consumption for heating the mixer walls was determined by the formula [1],

$$q_2 = \frac{M \cdot C_{cm} (t^1{}_{cm} - t_{cm}{}^{11})}{r} \tag{4}$$

where M – is a mixer heated parts mass, kg; $C_{ст}$ – is a specific heat capacity of the mixer wall material, J/kg ·°C; $t^1_{ст}$ and t^{II}_{cm} – are final and initial wall temperature,°C.

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

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

where A_1 – is a heat transfer surface area of the walls, m ^{2}; t_{cm} – is an average temperature of the outer surface of the walls, °C; t_{0k} – is an average ambient temperature, °C; f – is the total coefficient of heat transfer by convection and radiation [5], W / m^2 °C.

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

Knowing the calculated values of q_1, q_z, q_3 and the experimental values of the total steam consumption, it is possible to determine the coefficient C from the following expression:

$$C = \frac{q}{q_1 + q_2 + q_3}. \tag{7}$$

The total steam consumption experimental values were determined by measuring the steam condensate amount obtained on a specially made installation that simulates the mixer steam distributor, in which all the geometric dimensions of the steam pipelines inlet sections installed in the mixer were preserved.

The tank installation consisted with a capacity of 1.6 m^3, three coils, each of which was connected at one end to the supply steam line, and at the other ends to the outlet pipeline, filling and drain pipes for cold water.

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 running water system. When the container was filled with cold water, steam was turned on at the same pressure and temperature as when the feed was heat treated in the mixer. After reaching a steady-state mode of steam supply, the amount of condensate obtained was measured using a measuring container per unit of time. Time was controlled by a stopwatch.

The experiments were carried out with three repetitions, in each experiment 5 samples were taken. To obtain more reliable data, the experiments were carried out at different pressures in the steam line, namely at 0.04 and 0.05 MPa. According to the results of the experiments, it was established that the coefficient taking into account steam losses during unloading of the finished feed mixture is C=1,08-1,10.

Conclusion

A refined formula has been determined for calculating the steam consumption when heating the feed mixture, taking into account the steam losses arising from its continuous unloading. The coefficient taking into account steam losses during unloading of the finished feed mixture is 1,08-1,10.

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