Studies into the aerodynamics of heating chambers for raw-smoked sausages and the determination of hydraulic resistances of air-distribution systems

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On designing equipment for raw-smoked sausages heating and drying it is necessary to calculate hydraulic (aerodynamic) resistance of a fuel mixture stream in the processing zone taking into account physico-chemical processes.
To evaluate the efficiency of a proposed pulsed fuel mixture feed to the processing zone and to determine hydraulic resistances, aerodynamics of chamber-type installation for raw-smoked sausages heat treatment is investigated.
Fuel mixture for sausage heating equipment represents a heterogeneous binary system /1/. Heat-exchange processes in these apparatus are followed with steam condensation from moist air on product's surface or with moisture evaporation. The presented stream of a fuel mixture influences the character of mixture's flow in the boundary layer thus changing hydromechanical conditions and heat-mass transfer/2/.
From the results of investigations the average rate /$\bar{u}$/of fuel mixture flow in the processing zone is 0.3 m/s., critical Reynold's number (Re) - 8.0 x 10^3. The fuel mixture flow regieme is laminary.
At the laminary regieme of the fuel mixture flow connective heat transfer coefficient(α) is determined from the following relationship/3/:

$$Nu = 0.66\ Re^{0.5},$$

$$\alpha = Nu \frac{\lambda}{l}$$

where: Nu - Nusselt's criterion ;
λ - air thermal condustivity, W/m^2K;
l - sausage stick length, m.

$$\alpha = 3.83 W/m^2K \quad ,$$

The obtained values of heat transfer coefficient (α)(from a fuel mixture to a product) should be taken into account at chamber-type installation designing with a pulsed fuel mixture feed used for raw-smoked sausages processing.
Hydraulic resistances and pressure losses of the fuel mixture in the processing zone were calculated according to I.E.Ideltchik procedure /4/.

Experimental and analytical methods, traditional for applied aerodynamics and hydraulics, were used /5/.
At calculation of total fuel mixture flow losses were taken into account. They consisted of losses at processing zone inlet and outlet and of losses due to friction.
The total coefficient of resistance in the frame with products (at one-store sausage hanging) equals:

$$\xi_{tot} = \beta_1 \cdot K_1 \cdot n + \lambda \frac{l}{d} ,$$

where: β_1 - barrier's coefficient (cylinder), being determined according to a reference book /4/, $\beta_1 = 1.76$;
$K_1 = \left(\frac{S_1}{a_0} - 1\right)$ - according to the graph /4/, $K_1 = 1$;
S_1 - distance between sausage sticks' axises, m;
a_0 - distance between sausage sticks, m;
n - a coefficient characterizing a specific form of sausage, n=1.5;
λ - linear coefficient of friction resistance, $\lambda = \frac{64}{Re}$;
d - sausage diameter, m.

According to the formulae the total hydraulic resistance of fuel mixture equals:to:

$$\xi_{tot.} = 3.$$

Therefore, losses of the fuel mixture flow (Δp) in the processing zone are:

$$\Delta p = \xi \frac{\rho \bar{u}^2}{2} ,$$

where: ρ - air density according to the refernce book /4/, ρ = 1.2 kg/m^3.

$$\Delta p = 0.162 \text{ Pa.}$$

At two-stored sausage hanging:

$$\Delta p = 0.324 \text{ Pa.}$$

Obtained total coefficients of hydraulic resistances (ξ) and pressure losses (Δp) of the fuel mixture in the processing zone are not significant; they may be emmited at chamber-type installation designing. Fot the chambers with one-stored distribution of products hydrodynamics of air-distribution system should be taken into account (air ducts of the fuel mixture discharge under pressure and suction). At more than one-stored frame distribution by height total coefficient of resistance (ξ) and pressure losses (Δp) increase and influence air distribution in the processing zone.

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