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PROCESS OF HOP PARTICLE PRECIPITATION IN COMBINED WORT BREW MACHINE

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Introduction. The development of new equipment capable of performing several operations is an urgent task for small-scale enterprises, in particular mini-breweries, where there is an urgent need for multifunctional equipment. The task was set to create an adequate mathematical model of the process of separation of solid particles of crushed hops from the wort in order to improve the combined wort brew machine, which will provide not only heating and boiling of the wort with hops but also the separation of hop pellets.

Material and methods. The precipitation of hop particles occurs during the slow rotational motion of the wort in the apparatus. To calculate the area of sediment accumulation, we used the results of the well-known problem solved by U.T. Bedevadt on the rotation of a liquid over a fixed bottom. It is advisable to describe the motion in the apparatus mathematically in a cylindrical coordinate system. The problem statement includes equations of motion and uniqueness conditions.

Results. The theory of viscous fluid motion states that a boundary layer is formed near a solid surface, in the middle of which the velocities of the fluid particles vary from zero to a certain distribution typical for each individual problem.

If the flow velocities exceed the uniform deposition rate and the initial velocity, the particle is suspended. When the vertical velocity component is less than the deposition velocity, the particle slides along the bottom. Taking into account the active frontal force on the particle, the friction force of the particle on the bottom surface, and Archimedes' law, the relationship for the speed of the particle's initial movement on the bottom (the deposition rate in the reverse process) is obtained.

A formula for determining the radius of the sediment formation region, which depends on the characteristics of the medium, the operating modes of the apparatus, and the functions characterizing the velocity distribution in the boundary layer, is proposed.

The experimental results at stirrer rotation speeds of less than 15 rpm are fully confirmed by the data obtained from the mathematical model. Thus, at n = 10 rpm, particles of all sizes begin to settle to the bottom. The largest particles of granulated hops (2.8–8 mm in size) settle over the entire surface of the bottom of the apparatus. Particles with a size of 2.0–2.8 mm settle in the zone. And the particles that make up almost 63% of the total amount (their size is 0.28–2 mm) settle in the radius r*=0.12–0.17m. Further slowing of the agitator speed expands the settling zone of the smaller fraction.

Conclusion. The dependence for calculating the deposition rate at which moving particles settle to the bottom of the combined wort brew machine was obtained. It was found that for particles of different sizes and shapes the deposition rate under the condition of wort movement in the apparatus ranges from 0.65 to 0.08 m/s. Based on of the obtained results, recommendations on the design and operating parameters of the device are given. The deviation of theoretical and experimental data obtained does not exceed 7.15%, so the developed model is adequate to the actual sedimentation process.

Keywords: *wort brew machine, particles, sedimentation, stirrer, speed*