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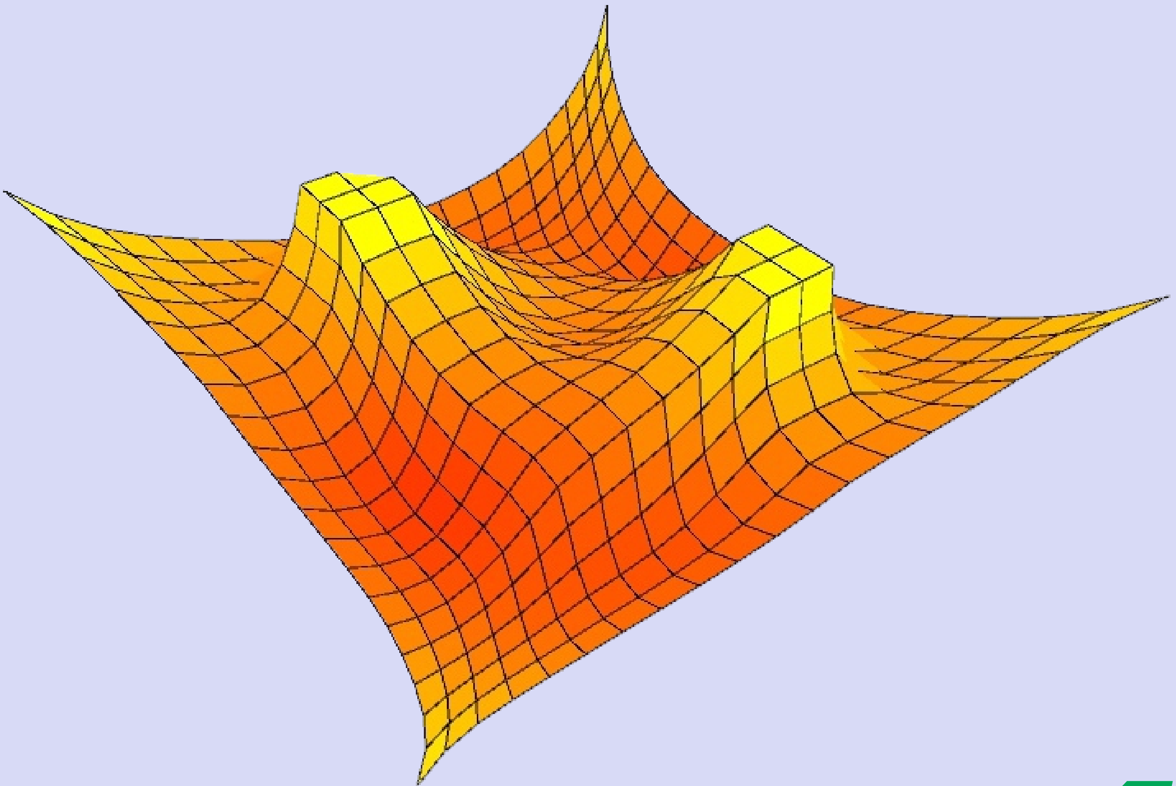

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Research of hydrodynamics in the vacuum apparatus crystallization Massecuite with a view to intensifying

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Abstract: *The purpose of the study - increased efficiency in the production of sugar. Object - massecuite heating in a vacuum apparatus. Way - additional steam in massecuite.*

Keywords: massecuite, steam, intensity

Introduction

One of the main ways to improve crystallization technology is to maximize the removal of sucrose from beet with minimum energy consumption. Vacuum devices are the major consumers of energy in a sugar factory.

Research in the area of bulk crystallization of sucrose are traditional for the National University of Food Technologies, which carried out fundamental research on heat and mass transfer in boiling sugar massecuite, sugar crystallization kinetics and fluid dynamics in the vacuum apparatus.

The objective of our work is theoretical and experimental study of the recycling process in obtaining a sugar massecuite and study design factors on the process.

The purpose of research is to determine the impact of the introduction of water vapor from the outside in sugar solution and massecuite to intensify the process of bulk crystallization.

Mixing and circulation speeds up the process of crystallization. The most intensive growth of crystals is observed in the circulation rate of massecuite 0.5 ... 1,0 m/s. Achieving this rate of circulation throughout the cooking, especially at the end of the process, the existing designs of vacuum pans with natural circulation is not possible. At the end of boiling massecuite circulation rate is significantly reduced, and may reach 0,02 ... 0,043 m/s.

In the case of forced circulation of the massecuite in vacuum pans increases the overall heat transfer coefficient and reduces the boiling massecuite. This improves the quality of crystal sugar.

Experimentally [1] that the growth of crystals in boiling affect the frequency of recycling. The crystal growth rate is proportional to the frequency of recycling massecuite.

Hydrodynamic methods of intensifying the process of crystallization of sucrose different input methods of steam or gas. [2]

One method to intensify the process of recycling mass, which crystallizes in the vacuum apparatus is the introduction from the outside in massecuite boiling steam. The introduction of steam improved hydrodynamic properties of massecuite, and causes a redistribution of the solute between the unit cells of massecuite [3] as a result of recrystallization [4, 5].

Reducing the speed of circulation of the massecuite is accompanied by a reduction of heat transfer, the temperature increases in the heat transfer surface and the increase in the value of specific heat flux. This leads to a decrease in the driving force of natural circulation. [1]

We have studied the bubble flow steam and massecuite mixtures typical of industrial vacuum apparatus. The data on the hydraulic characteristics of the flow of massecuite in forced circulation. We used a method of hydrodynamic intensification boiling massecuite by injecting steam into each tube apparatus [6]. Injected steam flow was maintained in the optimal range for each stage of boiling. [5].

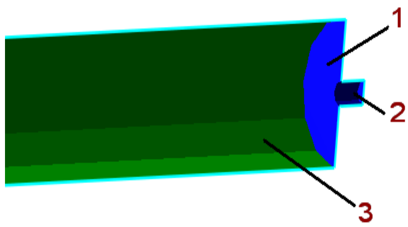

Figure 1. *The geometric model of a single tube heat transfer in a vacuum apparatus.*

It was first used to simulate the movement of the massecuite in vacuum apparatus using software system FlowVision. This complex is designed to simulate three-dimensional flows of liquid and gas in the technical and natural objects, as well as the visualization of these flows by computer graphics.

The proposed geometrical model shown in Fig. 1.

In our case, we consider the problem of modeling of turbulent flow between two media with properties that are different in many times. Massecuite is fed to the main entrance to the canal, and steam is supplied from the auxiliary input in the center of the tube.

This task was chosen model of an incompressible fluid. In the calculation equations are solved Navier–Stokes equations for turbulent transfer functions and equations of convective-diffusive transport.

Analysis of simulation results

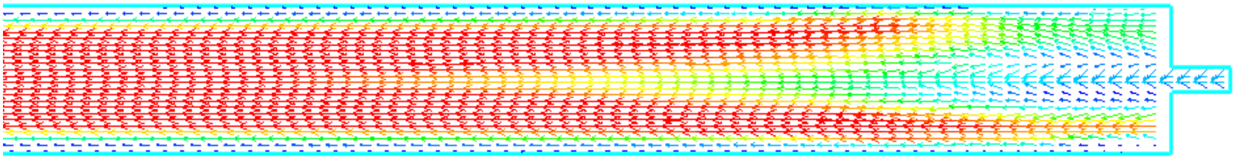

Figure .2. *Velocity vectors of the product*

From Fig. 2 that massecuite moves through the pipe evenly. In the initial step of the way is the distribution steam massecuite. And then both products are moving through the pipe a common substance.

Concentration of the mixture of the massecuite and the pair gradually aligned (see Fig. 3). Most of the steam remains in the center of the stream. This is a favorable factor, as the center of the heat from the hot walls of all comes later.

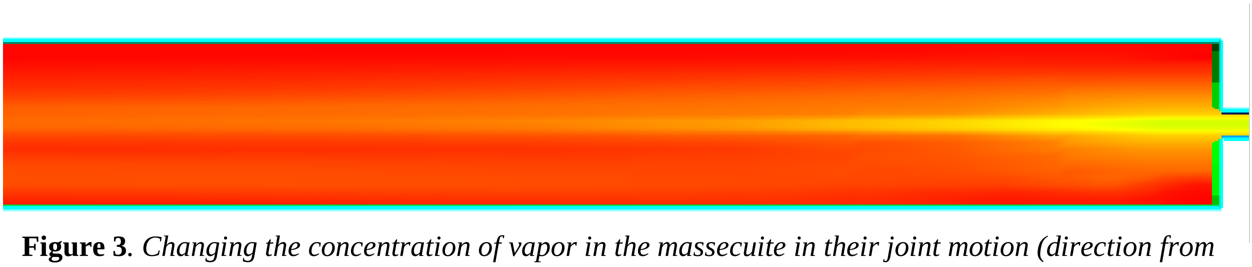

Figure 3. *Changing the concentration of vapor in the massecuite in their joint motion (direction from right to left).*

Process in Fig. 4 allows us to assess the pattern of heat transfer in a pipe. The heat enters the system from two sources: from the outer walls of the pipes and steam.

In this case, significantly increases the efficiency of central heating layers massecuite.

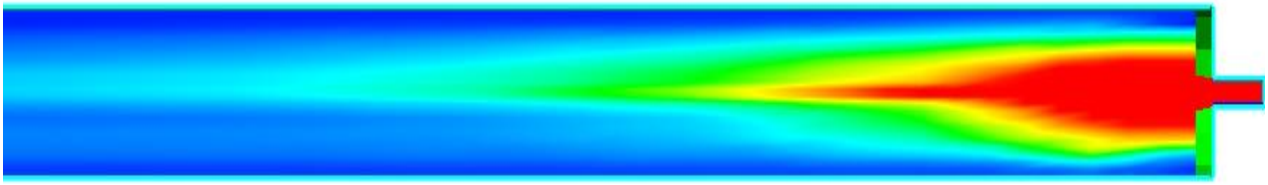

Figure 4. *Temperature change in the massecuite by simultaneous heat from the walls and from the steam*.

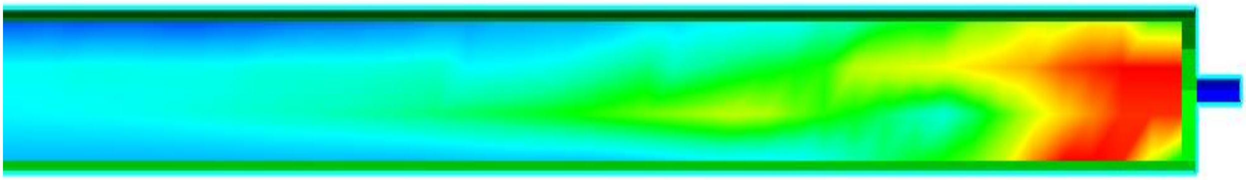

Figure 5. *Changing the flow of heat introduced into the system.*

After analyzing the data modeling made the following experiments and mathematical generalization.

Studies on the effects of water vapor introduced from outside into massecuite at the rate of crystallization of sugar massecuite last crystallization was carried out in the range of 80...220 kg/h (Fig. 6). This corresponds to 1,8...3,52% of injected steam to the total steam flow to the full cycle of the vacuum apparatus.

The analysis shows that the introduction of water vapor from the outside more than 3,52% did not give a significant intensification of the process of crystallization.

Influencing factors were selected: the number of additionally introduced from outside into the boiling sugar solution of water vapor as a percentage of total expenditure pair (*Q*) and the relative time of boiling ($\tau_i/\tau_{ц}$).

The rate of crystallization of sugar last product viewed as a state variable.

Normalization was performed by independent factors dimensionless variables.

After confirming the adequacy of the mathematical model obtained a formula for practical calculations:

$$G = -0{,}62 + 5{,}26 \cdot \tau - 4{,}225 \cdot \tau^2 - \\ -0{,}181 \cdot \frac{Q^2}{2{,}56} + 0{,}138 \cdot \frac{\tau . Q}{0{,}64} + 0{,}29 \cdot Q$$

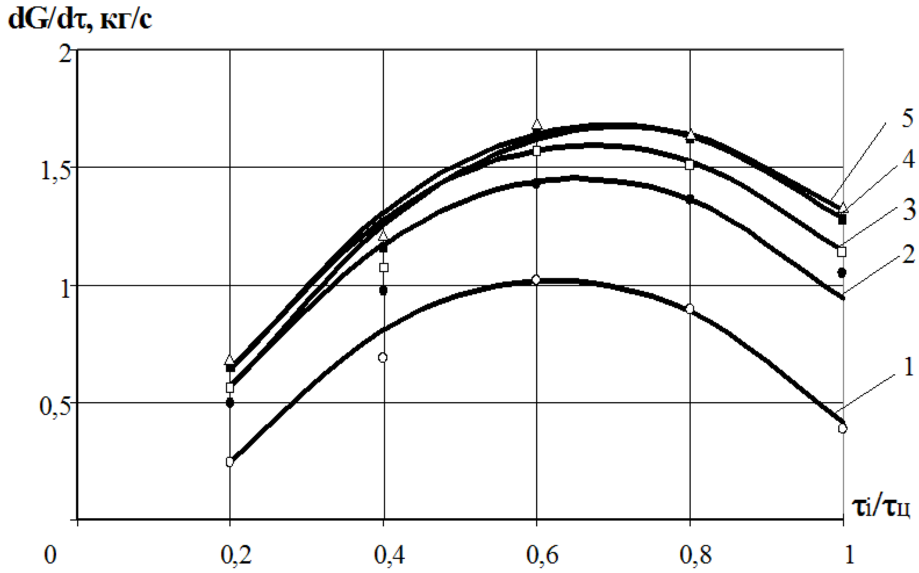

Figure 6. *Dependence of the rate of crystallization of sugar massecuite last crystallization from boiling time with the additional introduction of a couple: 1 - 0%, 2 - 1.28%, 3 - 2.0%, 4 - 2.28%, 5 - 3.52%*

Clarification of the optimal amount of steam injected conducted using the methods of mathematical planning of the experiment.

For the construction plan of the second order and the creation of the mathematical model used quadratic matrix of optimal planning of Boxing (Bn). This method of planning refers to D-optimal methods, the use of which guarantees a maximum amount of reliable information in a minimum number of experiments.

For finding the minimum of the response surface gradient method is applied.

Having the greatest speed crystallization of sugar at the maximum amount of steam injection (Q = 3,52%) in massecuite weight of the total cost for a pair of full cycle vacuum apparatus.

Based on the analysis of mathematical calculations proposed a new scheme for building a vacuum apparatus.

In Fig. 7 is a vacuum apparatus with increased hydrodynamic circulation. Manifold runs between rows of water tubes close to the bottom of the tube sheet unit.

Vacuum apparatus has a housing 1, in which the two suspended heating chamber and trap separator 3. Heating chamber tube sheet is 4, which is located in the middle of the circulation pipe 5.

The steam in the heating chamber passes through the device 6. Between the body and the body of the heating chamber apparatus has an annular space for the circulation of the massecuite.

To separate drops of the product being made secondary steam at the top of this unit is set trap separator 3, the bottom of which runs a baffle plate. Arrangements for additional steam injection 7 placed under heating chamber. At the bottom of the unit is set to walk down the massecuite discharge valve 8.

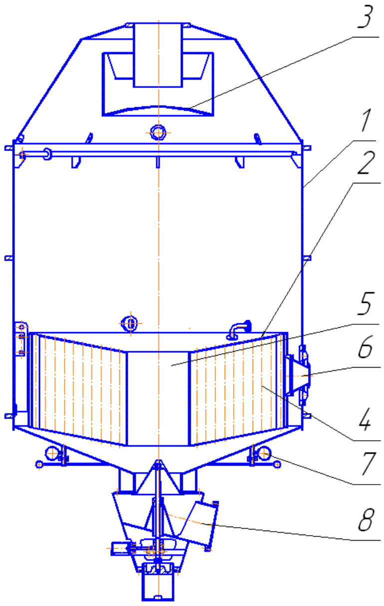

Figure 7. *Vacuum apparatus with provision for additional steam injection*

Conclusions

Computer simulation of motion of the massecuite in vacuum-tube device with additional steam injection allowed us to obtain quantitative and qualitative data on the process of heat transfer.

On the basis of studies of the process of heat transfer and hydrodynamics in a vacuum apparatus proposed upgrading unit batch. It is equipped with a device for amplification of hydrodynamic circulation in order to intensify the process.

References

[1] Guly I.S. Continuous cooking and crystallization of sugar.-Moscow:Food Engineering Industry, 1976. - 268 p.

[2] Intensification of the process of boiling massecuite / Garyazha V.T., Kulinchenko V.R., Artyukhov Y.G., Didushko V.G. - Moscow: Light and Food Industry, 1981. – 152 p.

[3] Mironchuk V.G. The influence of the vapor phase on the crystallization of substances from solutions / / Industrial power. - 1998. V. 20., p. 31.

[4] Intensification of melting and crystallization of sugar massecuite by recrystallization / Guly I.S., Shtangeev V.A., Mironchuk V.G. etc. / / K: Food Engineering Industry, 1978. - № 3. - p. 24.

[5] Investigation of the influence of an external water vapor at the evaporation of sugar solutions / T. Pogorely, E. Babko, V. Mironchuk, I. Guly. - K.: Food Engineering Industry, 2000. - № 45. - p. 14.

[6] V.I. Pavelko, D.V. Potapsky. The intensification of the processes of heat and mass transfer and mass transfer in the hydro vacuum apparatus sugar production / / Proceedings NUHT. - 2010. - № 32. - p. 39-43.