Features and benefits analysis of transient processes in food technology

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ABSTRACT

The analysis of physical background features and benefits of the transition process in food technology from the point of view of the interests they intensify heat and mass transfer. A structural analysis of discrete-pulse, extruder technology and technology sudden changes of pressure transients and their application to the assessment of energy potential and concluded that common ground in the form of primary energy savings potential in these technologies.

It was concluded that for most processes in food technology it is possible to reduce the fast thermodynamic parameters such as pressure. Thus there is a change in pulse energy potential with capacities that can exceed conventional technology even several orders of magnitude. That is what defines significant prospects spread discrete pulse, extruder technologies and technologies sharp decrease pressure for gas-saturated environments.

Transients are the parts most dynamic phenomena associated with the change of electromagnetic, mechanical, acoustic, thermodynamic, mass transfer, hydrodynamic and other parameters. They correspond to variable speed motion, acceleration or deceleration until conditions stabilize and achieve static or dynamic equilibrium in which the coming steady.

Physical basis of transition is well illustrated by the dynamics of mechanical systems. For example, the phases of acceleration, steady motion and freewheel in moving mass m under the influence of the driving forces Pd and the presence of the resistance Pr. In accordance with the principle of D'alembert believed that such a mass movement is characterized by a set of inertial forces (where - the second derivative of the displacement coordinates) and the driving force and resistance.

It is important that during acceleration driving force performs work related to overcoming the resistance to a move and work simultaneously driving force is the source of growth of the kinetic energy of moving masses. Over a period of steady movement equality holds work forces and driving forces of resistance, and the accumulated kinetic energy expended in freewheel mode, often in the form of dissipative phenomena.

It follows that the greatest burden on the source of the driving force is identical to the acceleration, which also synchronizes with major mechanical components of the system load. The above feature a similar structure inherent course the vast majority of heat and mass transfer characteristic of Food Technology. However, under certain conditions and run-down modes can be characterized by significant driving differences.

Importantly, driving factor (as a driving force in the mechanical model) can not act, but the accumulated kinetic energy works as inertial power factor, or the role of energy source with the following transformation can play accumulated potential energy.

Every avalanche in stock cars and special moving mass as flywheels act as reservoirs of kinetic energy. It is important that such accumulation may be arbitrarily extended in time and reach significant levels with limited capacities driving forces.

It is logical to say that for kinetic energy storage system crucial moving mass and the speed of their movement. Thus the importance of prevailing is linear or angular velocity of the moving mass as kinetic energy of the body or of material bodies is proportional to their square.

If the ultimate goal of the process is to achieve the maximum possible power of the body or the environment, it will meet the requirement of expeditious transfer them to a state of minimized kinetic or potential energy. This transition corresponds to the principle of Le Shatel'ye, but this time it does not look like gravity as well organized process. We emphasize that the maximum effects of this energy jump corresponds to the minimum time of its course. Classic examples of this situation is the phenomenon of water hammer, cavitation vapor bubbles collapse, sudden depressurization of the reactor liquid fraction having a temperature higher than its boiling temperature at atmospheric pressure, etc. [1-4].

From this perspective, the above mechanical, hydrodynamic, hydraulic, gas-liquid system and the thermal energy potential can be seen as a kind of hub of kinetic and potential energies. It is obvious that a sharp decline in the energy potential of any system is a germ of both negative and positive impacts on the environment and their structural components. It is important that in the aggregate effects could determine the suitability of the use of certain technologies.

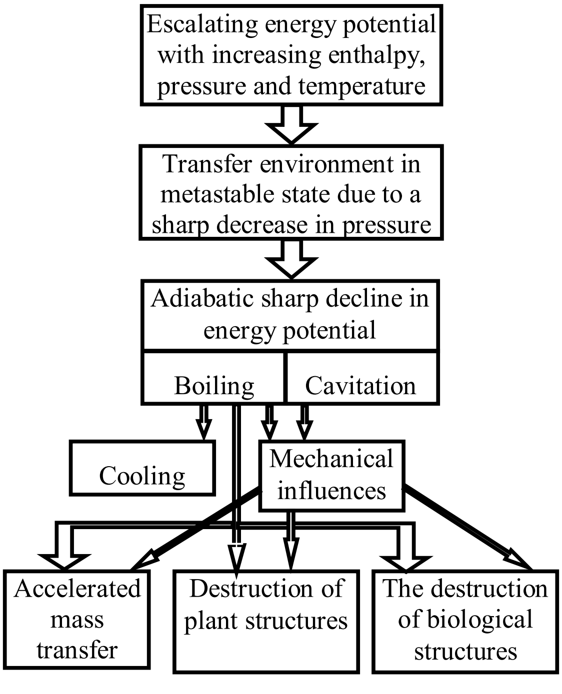

Fig. 1. Block diagram of discrete-pulse technology

It is in this way obtained the development of discrete-pulse, extruder, electrohydraulic,-ion technology, technology sudden change of pressure in relation to gas-liquid environments and more. They are increasingly using relatively Food Technology at targeted organizations transients in order to intensify mass transfer and heat transfer, directly from their course, and to speed up subsequent processing steps environments.

In this perspective among the tasks of this study include the following:

- perform a structural analysis of discrete-pulse technology and transients on their application to the assessment of the energy potential;
- perform structural analysis technology sudden pressure change and their energy basis.

Let more detail on the structure of these transient effects.

Discrete switching technology. Certainly under this name means a series of technologies that have implemented fast decrease of the energy (heat) capacity. Picture 1 shows a block diagram of the components of such technologies on the example of liquid systems. In accordance with the latter because of adiabatic boiling and cavitation achieved mechanical impacts on the environment, with all their consequences in the form of rapid mass transfer, destruction of biological structures of animal and vegetable origin, etc.

It is important to note that the latter can be achieved at the macro level and intercellular and even cellular structures, which can significantly speed up these processes of extraction, desorption, etc. homogenization.

Metastable state actually corresponds to the transfer medium in a superheated state, which usually stays short and thus it is important to enter deep into it.

Pressure from among these thermodynamic parameters for the system is the only one for which the possible implementation of the fast drop. The lower limit is determined by atmospheric or vacuum pressure volume, which connects (or created) the processed medium.

Of course, that technologically easier to organize processes with limited lower atmospheric pressure value. But that means the ultimate limit of ambient temperature t(f) ≈ 100 ° C, which corresponds to the end of adiabatic boiling. Hence it is clear that the range of temperatures in which the entire flow process, greater than 100 ° C.

If the initial temperature of the environment corresponded to the temperature t(i), the temperature range is adiabatic boiling

$$\Delta t = t_{(i)} - t_{(f)} \tag{1}$$

Hence, the energy potential of the transition process is

$$\Delta E = mc\Delta t, \tag{2}$$

where m and c - respectively, the mass and heat capacity environment.

Assessment of external impacts on the environment carried out on the basis of specific energy injected into it, and in our case we have the opportunity to perform relevant calculations, taking the value m = 1 kg, c = 4.19 kJ / (kg • K).

Their results are shown in the table.

Table 1. The results of calculations to determine the energy potential liquid system

Difference temperatures Δt, ° C	2	4	6	8	10	12	14	20	30
Energy potential ΔE, kJ	8,38	16,7	25,14	33,52	41,9	50,2	58,66	83,8	125,7

The concentration of energy impacts is important, not only in space or volume, but in the time course of the process. That last transience largely determines the outcome. For example, concerning the extruder technology, which formed a vapor phase expansion is virtually unlimited volume, final pressure for the system clearly fits the atmosphere. Also there is no influence of hydrostatic pressure, which is somewhat limiting for liquid phase in a closed volume. As a result, the output material flow from the extruder to be destructive of the generated steam is released with its full volume over time, approaching the instant action.

Extruder technology. Although the total production of extruder technology similar to discrete-pulse (they are based, the same rapid change in potential energy), but their organization is different. It is important that their progress all the components of processes occurring in a continuous mode and cover a relatively limited part of the treated environment. Block diagram of a generalized extruder technology is shown on Picture 2.

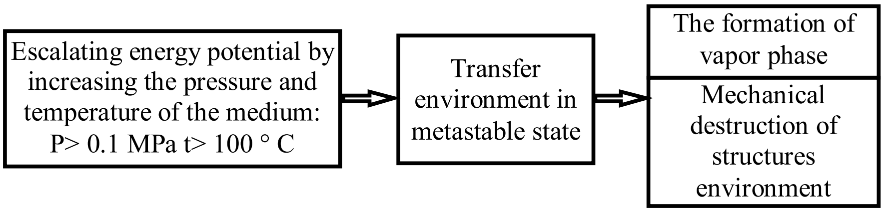

Fig. 2. Block diagram of transients extruder technology

High efficiency on the level of mechanical stress due to the brevity of the process of formation of a vapor phase. The value of the energy potential in this case is determined by the difference of the initial and final temperatures, that is depth entering the environment in a metastable state.

Although the process of generating a vapor phase is estimated as fleeting or momentary, but phenomenological considerations lead to the conclusion that the rate of vaporization dG / dτ depends on the driving force of this process, that is, the temperature difference between the fluid and the final.

$$\frac{dG}{d\tau} = \frac{dG}{d\tau}\left(t - t_{(f)}\right). \qquad (3)$$

Obviously, the maximum dG / dτ corresponds to the temperature difference, when t = t(i), while evaporation does not stop when you reach t = t(f). However, the last character if steaming is different, since the processes at a boil stop.

The value of the energy difference that wears extrusion mode is determined by the formula (2), but the value of the specific heats of grain or other product will be less because of their moisture is limited. The most heat capacity is known, the known matter in the physical world is water. Therefore, to improve extrusion process cereals moistened.

Thus, the comparison of discrete-pulse technology in their classical sense and extruder technology leads to the conclusion that the presence of similar and different patterns in them. Obviously, this indicates the possibility of combining in one complex of elements. For example, the preparation of beet chips to the diffusion process requires the greatest possible level of plasmolysis of cellular structures. The existing technologies it is achieved through temperature effects at 70 °C as a result of appropriate treatment in hot processing. However, this heat treatment has negative consequences associated with denaturation protoplasm beetroot tissue and subsequent extraction. Reducing costs and increasing the yield of the target product may seek introduction to the use of the area between hot processing and diffusers vacuum chamber through which a continuous flow mode adiabatic boiling transported beet chips.

Technology sudden change of pressure (TSCP). Take these technologies to the gas-liquid processes under aerobic cultivation of microorganisms, fermentation process of beer, alcohol, wine industries carbonated drinks champagne carbonation apparatus sugar industry and others. Gas phase for microbiological processes is air, and called on other industries such gas phase is carbon dioxide, which is directly synthesized in fermentation processes or forcibly dissolved in the liquid phase.

An important feature of the interaction of liquid media with carbon dioxide is relatively high solubility of the latter and one that depends on the partial pressure according to Henry's law. The latter provision leads to the conclusion that the use of potential energy of dissolved CO2 for intensification, absorption, absorption, desorption in gas-liquid systems, "gas - liquid - solid" and so on.

Perform initial assessment on the possible accumulation of power potential in the "gas - water."

The solubility of gases in water is known to depend on the magnitude of their partial pressures and temperature, for example, at t = 20 °C and P = 0.75 MPa CO2 solubility is 14 g / l. Suppose that in intensive mode desorption pressure of 0.1 MPa carbon dioxide content reduced to 4 g / l.

Volume of gas phase, which is released at the same time will

$$V_g = \frac{MRT}{P} = \frac{0{,}01 \cdot 188{,}9 \cdot 293}{10^5} = 0{,}554 \cdot 10^{-2} \quad \text{м}^3 \tag{4}$$

where M = 0.01 kg - weight of desorbed gas; R = 188,9 J / (kg • K) - gas constant, T = 293 K - ambient temperature, P = 105 Pa - pressure under normal conditions.

Thus, the reverse process of absorption due to the partial pressure of 0.75 MPa we achieve dissolution of gas volume in terms of normal conditions 0,554 • 10-2 m3. Maintaining such a large amount of CO2 in the dissolved state is possible with stabilized temperature of 20 ° C only for maintaining the pressure 0.75 MPa. The sharp drop in the last means transition gas-saturated environment to a new state of equilibrium. For values of these parameters the energy potential is lost by desorption, is

$$\Delta E = P_{0{,}75} V_g = 0{,}75 \cdot 10^6 \cdot 0{,}554 \cdot 10^{-2} = 4155 \ \text{J.}$$

Comparison of the obtained results with the data table shows that they are of the same order. It is possible to substantially increase the parameter ΔE as by increasing solubility at low temperature environments, and by increasing the partial pressure of the gas phase.

In accordance with this design formula for determining potential energy difference is reduced to the form

$$\Delta E = P_{(i)} \frac{\left(M\left(P_{(i)};t_{(i)}\right) - M\left(P_{(f)};t_{(f)}\right)\right)RT}{P_{(f)}} \tag{5}$$

where $M\left(P_{(i)};t_{(i)}\right)$ - mass dependence of the solubility of carbon dioxide from the pressure P(i) and temperature t(i) absorption; $M\left(P_{(f)};t_{(f)}\right)$ - mass solubility of CO_2 at the end of desorption, P(f) and t(f) - respectively the final pressure and temperature at the end of desorption.

As in the first two cases a critical factor influencing the shifting environment in the metastable state is pressure, although the temperature is also responsible for entering deep into it. Therefore, expanding the limits of potential energy should reach by increasing pressure and decreasing temperature environment escalating mode and, conversely, the pressure drop in a pre-heated in a sealed environmental conditions in a "triggering" potential.

Conclusions

1. Discrete pulse, extruder technology and technology drastic reduction pressures have common ground in the form of initial accumulation of energy potentials. The management function of the energy potential while serving pressure liquid, gas-liquid systems or systems with the addition of these solid phase.

2. For most processes in food technology it is possible to reduce the fast thermodynamic parameters such as pressure. According to the dynamic changes of the last impulse is a change of power potential with capacities in excess of traditional technologies on the order of or even several orders of magnitude. That is what defines significant prospects spread discrete pulse, extruder technologies and technologies sharp decrease pressure for gas-saturated environments.

References

1. Sokolenko A., Mazaraki A., Sukmanov V. Intensification of heat-mass transfer processes in food technology. - K.: Phoenix, 2011. - 536 p.
2. Sokolenko A., Shevchenko A., Poddubny V., Vasilkovsky K. Physico-chemical methods of processing raw materials and stabilization of food - K. Lyuksar, 2009. - 454 p.
3. Voronov, S., Melent'ev A., Kosenko V. Modern physico-chemical methods of intensification of production of beer / Food number 3. - K. NUFT, 2004. - P. 47
4. Dolinsky A. Using the principle of discrete input pulse energy to create energy-efficient technologies / Eengineering-physical journal. - 1996. - T. 69, № 6. - S. 855-896.
5. F Alhama, C.F González Fernández. Transient thermal behaviour of phase-change processes in solid foods with variable thermal properties /Journal of Food Engineering, Volume 54, Issue, 4 2002, Pages 331-336
6. Elieste da Silva Jr., Emerson Rodrigo Teixeira da Silva, Mikiya Muramatsu, Suzana Caetano da Silva Lannes. Transient process in ice creams evaluated by laser speckles / Food Research International, Volume 43, Issue 5, 2010, Pages 1470-1475
7. Iuliana Vintila. Mass and heat transfer coefficients assessment, optimisation and validation for multiphase food systems under transient stages / Trends in Food Science & Technology, Volume 26, Issue 2, 2012, Pages 114-119
8. Flavio Manenti. Natural gas operations: Considerations on process transients, design, and control / ISA Transactions, Volume 51, Issue 2, 2012, Pages 317-324 M.A. Slonim, A.A. Slonim. Transient processes in different types of solar cell panels.
9. Experimental investigation. / Solar Energy Materials and Solar Cells, Volume 90, Issue 15, 22 September 2006, Pages 2542-2548