The Research of The Gas-Filled Dough Rheological Characteristics

Telichkun Yu., Telichkun V., Taran V., Gubenia O., Desik M.
National University of Food Technologies, Kiyv, Ukraine

Abstract: *We explored reological descriptions of yeast dough , which filled with carbon dioxide. For researches the methods of capillary viscometery are used. Dependence of tension on speed of change is got at different content of gas phase, and dependence of effective viscidity on speed of change.*

Keywords: *dough, rheological characteristics, viscosity*

For research and control of structural - mechanical properties of the yeast dough and also for the definitions of their quantitative characteristics the rheological methods are proposed [1]. The capillary viscometry method gives the fullest information when using in the investigation of dough rheological characteristics - gas phase contents dependence. On the basis of this method we develop experimental stand, which enables to carry out a wide spectrum of researches: kinematics factors (average speed of a flow, volumetric, mass productivity); dynamic factors which including dough rheological characteristics; to determine change of dough - carbonic gas contents dependence.

During the yeast dough fermentation there is a continuous allocation of carbonic gas. Thus dough density constantly changes. The density changing is determined only by that quantity of gas, which is in dough specimen in a free condition. The carbonic gas in adsorption state does not influence on dough density. The dough density characterizes the liquid and gaseous of phase's parities in the material.

We investigate the dough density change by the gas phase contents (fig. 1).

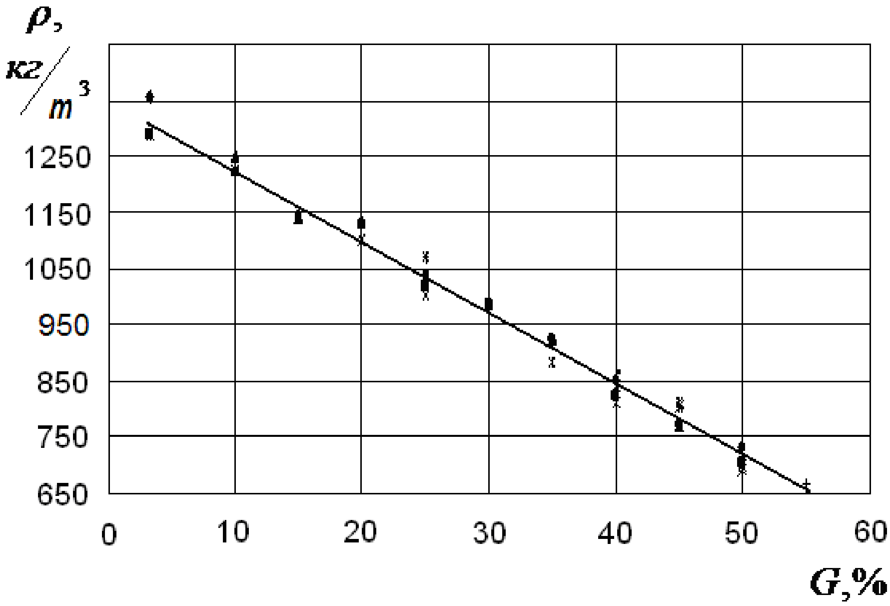

Fig. 1. The dough rope density change from the contents of a gas phase

Dough rope density is precisely correlated with the contents of a gas phase in the dough G and can be submitted by dependence:

$$\rho = 1380 - 13{,}5G \text{, kg / м}^3.$$

As a result of processing experimental data we receive the dough density and a gas phase contents in a free condition linear dependence.

For construction of flow curves for yeast dough with different contents of carbonic gas we use the experimental data that received on the base of volumetric productivity V (м3/c) and length of the capillary with round section differential pressure dependence.

As a result of experimental data mathematical processing is received flow curves for yeast dough with contents of carbonic gas from 0 up to 40 % (fig. 2).

The received graphic dependences characterize qualitative gas-filled dough behavior as abnormal (non- newton) pseudo-plastic liquid [1].

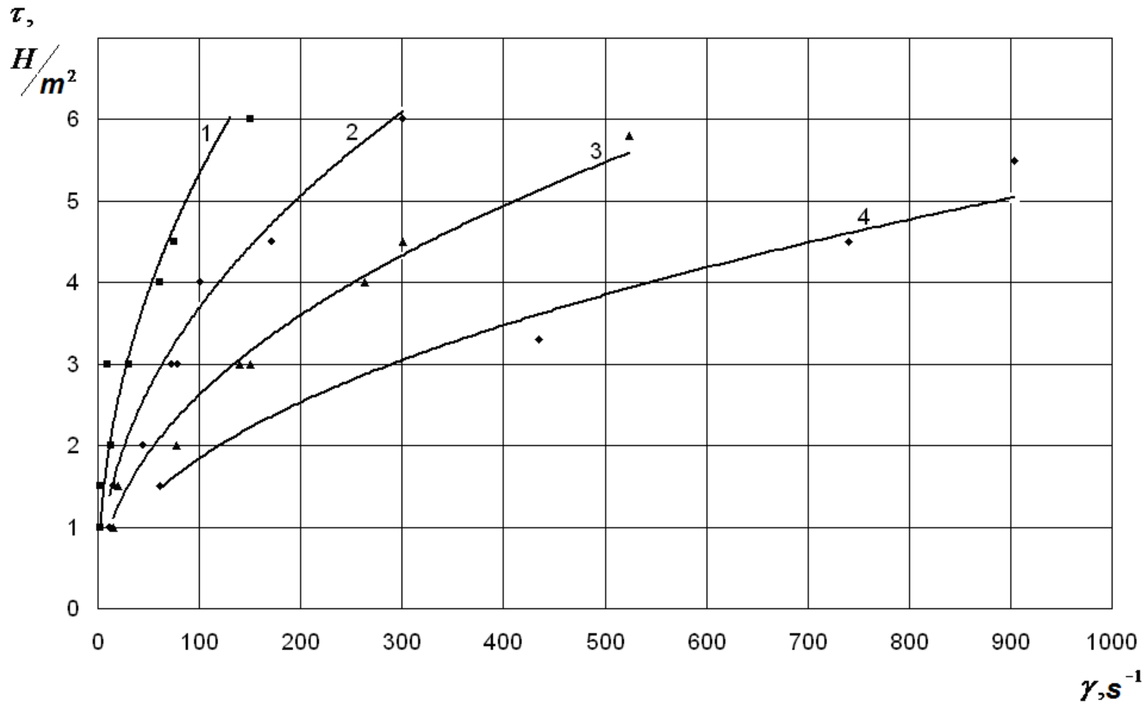

Fig. 2. The shear stress and shift rate dependence at different gas-filled dough: 1-9; 2- 33; 3- 38; 4- 42 %.

The received curves show, that the shear stress and shift rate dependence carries sedate character. This dependence in a general view can be submitted by the equation:

$$\tau = C \cdot \gamma^n$$

where: c - factor, which depends on the contents of a gas phase;
n - a parameter of a degree, which shows the deviation size of a researched material from non - newton liquid.

The dough filling by carbonic gas results in reduction of shear stress, which take place on the capillary walls. At the maximal contents of gas the shift rate is increased by the order at the same levels of a shear pressure. Then the generalized formula of shear stress and shift rate dependence for different gas-fillies will look like:

$$\tau = (-0.01 \cdot G + 0.76) \cdot \gamma^{0.457}$$

Thus, the carried out researches have permitted to receive a flow curve for gas-filled dough from the contents of a gas phase, to define the law of communication between a shear stress and shift rate and to receive the concrete mathematical dependences and numerical results. This flow curves allow to determine dough effective viscosity and it's dependence of the contents of carbonic gas.

Effective viscosity we may find as the shear stress and shift rate ratio [2]:

$$\eta_{еф} = \frac{\tau}{\dot{\gamma}}$$

where τ - shear stress, H/м^2; $\dot{\gamma}$ - shift rate, 1/c.

The dependence of effective viscosity on speed of shift is submitted in a fig. 3.

The analysis of curves shown, that the gas-filled dough viscosity is reduced exponentially with the increase of the contents of carbonic gas and shift rate. The effective viscosity decreases with shift rate increasing, which is caused by orientation high-molecularity connections in the dough in a direction of movement under action of growing forces. The increase of dough particles speed leads the reducing of force interaction between particles. The increase of the contents of carbonic gas leads to the reduction of effective viscosity of the dough by the reason of expense of infringement of longitudinal orientation high-molecularly of connections in the dough at gas allocation. With increase of shift rate the influence of a gas component of the dough becomes minimal.

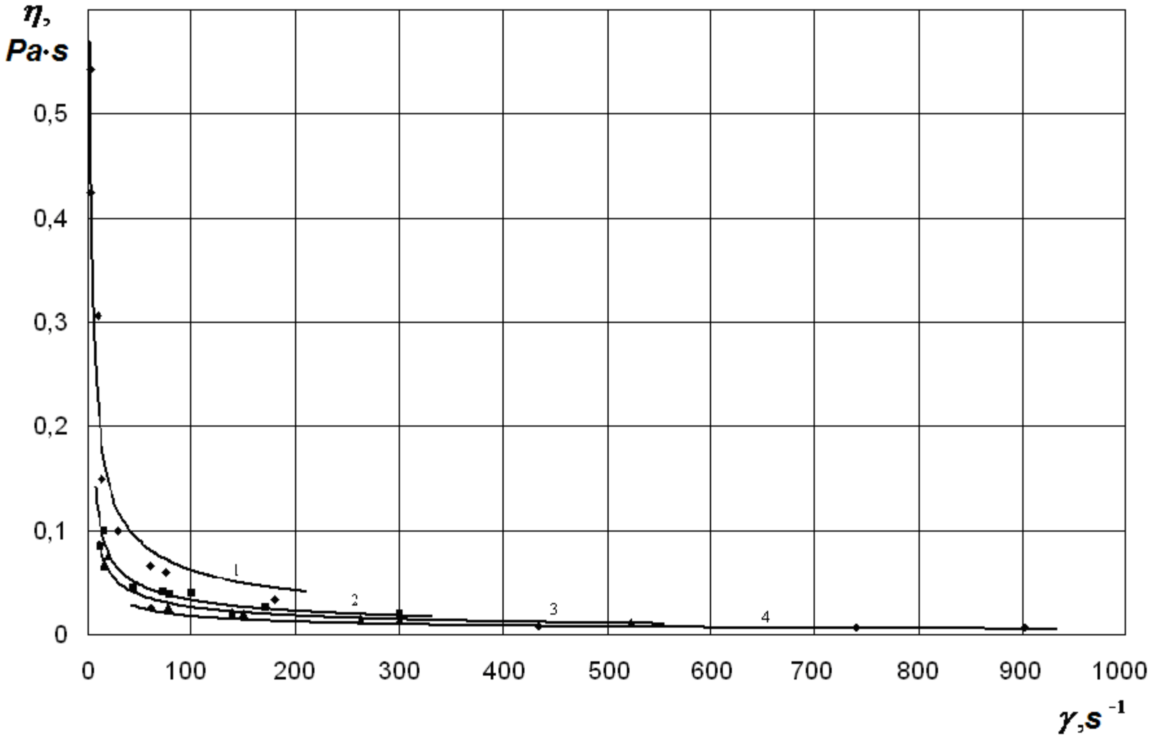

Fig. 3. The effective viscosity and shift rate dependence at different gas-fillies G: 1 - 9; 2 - 33; 3 - 38; 4 - 42 %.

After mathematical processing the general formula for effective viscosity and shift rate dependence at different gas-fillies will look like:

$$\eta = (-0.015 \cdot G + 0{,}89) \cdot \gamma^{-0.543}, \text{ Pa·s}$$

The analysis of the received results has shown, that the maximal shift rate, at which it is possible to receive qualitative extruding product (an interval up to 100 c-1 at the contents of a gas phase 30-40 %) connected with the beginning of smooth transition in area of the destroyed structure. In the given interval we obtain uniform small porous structure extruding product. Contents of a gas phase are less than 30 % is not enough for leavenity , at contents is higher than 40 % at all parameters extruding character and the porous structure of the dough rope is worsened owing to stay in a zone of the destroyed structure.

The character of the viscosity change by extruding pressure at different gas-fillies yeast dough shows, that the viscosity at gas-fillies 30-40 % practically does not depend on extruding pressure, i.e. the increase of pressure will not result in reduction of dough rope quality.

Thus, as a result of the carried out researches we receive flow curve gas-filled dough depending on the contents of gas, the viscosity and it's dependence from gas-filled dough, extruding pressure and shift rate during the extrusion process is determined. The optimum extruding parameters for uniform small porous structure of extruding product formation are determined.

The received dependences are used for engineering calculation of new equipment, mathematical modeling of yeast dough behavior during fermentation in closed volume and gas-filled dough movement in forming channel. Received rheological parameters are used for the mathematical model of extrusion process development.

References.

1.Мачихин Ю.А. Берман Г.К. Максимов А.С. Достижения реологии пищевых продуктов. М.: Известия вузов. Пищевая технология. - 1985, №4, С. 9-4.

2. Товажнянский Л.Л., Готлинская А..Г., Лещенко В.А. и др. Процессы и аппараты химической технологи. Учебник. В двух частях. /Под общ. ред. Л.Л.Товажнянского. - Харьков: НТУ «ХПИ», 2004. - 632с.