333

325

STUDY OF PHYSICO-MECHANICAL PROPERTIES OF MINCED MEAT AND ITS FLOW IN PIPELINES

V.M.Gorbatov, N.E.Fyodorov, A.V.Gorbatov,
S.P.Kazakov, I.A.Rogov.

Experimental investigations of physico-mechanical properties of minced meat and its flow in pipelines are of great importance for scientifically based calculations for development of new technological lines and installations and improvement of old ones in view of automation and mechanization of processes of production.

Physico-mechanical properties of minced meat

We investigated the following properties: modulus of elasticity for shear, ultimate shearing stress, plastic viscosity and changes of effective viscosity for a wide variety of stresses and speed gradients and depending on the degree of the destruction of structure.

A rotary viscosimeter of Prof. Volarovich system (1,2) was the main instrument for these investigations. The viscosimeter was tested for different systems including minced meat and curds (5, 6). We determined the ultimate shearing stress by a conical plastometer (7) and by a shearmeter of Simonyan (8). The aforesaid instruments are based on stationary methods of measurement.

We used the rotary viscosimeter as the main instrument because of the following reasons: this instrument can be used for determining the majority of physico-chemical properties without changing its design; its construction is simple; its readings are primary and do not require taring; the instrument is transportable and can be used not only in scientific laboratories but also in plants.

Analysing the work of the three instruments note should be taken that the rotary viscosimeter gives higher readings of ultimate shearing stress than the shearmeter of Simonyan and the conic plastometer, which give approximately equal readings. We believe that this phenomenon is due to the fact that the last two instruments make measurements at low speed gradients, giving thus the possibility of measuring "static" ultimate shearing stress at the first moment of destruction of the structure. At the same time the speed gradient of the first instrument may be relatively high and permits the measurement of "dynamic" ultimate shearing stress, that corresponds to the destroyed structure, - the situation that occurs in fact in working parts of machines. However, the shearmeter of Simonyan and, especially, the conic plastometer as a result of their simplicity can be used for an objective assessment of the quality of minced meat.

The experiments were carried out along three directions in order to determine: a) complete rheological diagram for computing modulus of elasticity for shear, effective viscosity for almost undestroyed structures etc. Experiments began after the tixotropic restoration of the structure. For this purpose minced meat was stored in the instrument for several hours at a fixed temperature, the enlargement of the load was carried out gradually, beginning with small values; deformations were measured by means of a binocular magnifying glass with a 119 magnification and a dial with 10 micron points; b) effective viscosity at different degrees of destruction of the structure and ultimate shearing stress. Methods of the experiment are the same; c) ultimate shearing stress of plastic and effective viscosity for considerably destroyed structures. The structure was destroyed primarily either by rotating the rotor by hand, or by placing sufficient loads. Hysteresis was eliminated by double or triple change of the load from minimum to maximum.

It should be mentioned, that the stress emerging in minced meat is proportional to the loads causing the rotor to rotate. There is the following relation between stress and weight of loads (2):

$$\theta = K_1 \cdot P \text{ dynes/cm}^2$$

where K_1 - the constant of the instrument for this experiment;

P - the weight of the loads (grams).

However it is more convenient to consider all the experimental data as relations to the weights of the loads rather than to the stress.

The measurement of the angle of turn of the rotor of the viscosimeter for a fixed time as relation to the weights of the loads, revolving the rotor, made it possible to calculate all the values and to plot for them specific graphical relations.

Fig.1 shows a complete rheological diagram of minced meat for frankfurters. For an easier handling of the experimental data, reduction of the number of curves and greater community on the Y-axis are put the values of volumetric strain divided by shearing stress, i.e. values of volumetric strain reduced to the unit of stress, and not the values of volumetric strain.

The curve 1 shows that at low stresses (1025 dynes/cm^2) minced meat behaves as an elastic body, because the strain does not change depending on the time and is completely and instantly eliminated after the removal of the stress. The plotting of the relation "stress-volumetric strain" on the axes of coordinates gives a straight line.

Using the curve 1, we can calculate the modulus of instant elasticity for shear according to the Guok's law:

$$G_{mc} = \frac{\theta}{E_0} = \frac{1}{8,15.10^{-6}} = 1,23 \cdot 10^5 \text{dynes/cm}^2$$

where E_0 - the primary value of volumetric strain*.

The curve 2 shows that at increasing the stress till 1540 dynes/cm^2 a process of elastic aftereffect takes plase, which, after the removing of the stress, is characterized by an instant decrease of the strain at the value of the primary (E_0) and by a subsequent fall of the strain till zero. The transition from elastic strains to elastic aftereffect occurs at stresses greater than the elastic limit, which is between 1000 and 1500 dynes/cm^2. Using the curve 2 we can calculate the modulus of shear of elastic aftereffect:

$$G_{ea} = \frac{\theta}{E_{ea}} = \frac{1}{9,7 \cdot 10^{-6}} = 1,03 \cdot 10^5 \text{dynes/cm}^2$$

where $E_{ea} = E_m - E_0$ - strain of elastic aftereffect;

E_m - maximum of volumetric strain.

Creep appears at a subsequent increase of the stress (curve 3). After eliminating the stress, strains decrease instantly by the value of the primary strain (E_0), and after that gradually diminish until a certain volumetric strain, which is constant for three stresses 3a-2250, 3b-2665 and 3c-3065 dynes/cm^2 at the same time after unloading. At the last stress, which is near to the ultimate strength, a partial destruction of the structure

---

* Primary strain is always denoted by E_0, but its value is different for every curve.

329

happens and a viscous - plastic flow with an extremely little gradient of speed begins. This viscous-plastic flow is characterized by effective viscosity in accordance with the Newton's law:

$$\eta_f = \frac{\theta}{\frac{\Delta E}{\Delta t}} = \frac{\Delta \tau}{\frac{\Delta E}{\theta}} = \frac{26}{5,2 \cdot 10^{-6}} = 5 \cdot 10^6 \text{poise}$$

Viscosity, corresponding to the creep, will be of a greater value, since the movement occurs without destruction of the structure. It is possible after all, using these curves, to calculate indirectly the period of relaxation, which ranges from 300 to 400 seconds and depends on the value and duration of stresses. This instrument cannot be used for a direct calculation of the period of relaxation.

A characteristic feature of the curves shown on fig.1 is that all of them begin at the same point $\frac{E}{\theta} = 8,15 \cdot 10^{-6} cm^2/dynes$. Thus, we may suppose, that at any instantly applied stresses (up to 3000 dynes/cm^2) minced meat will obey the Guck's law, and volumetric strains will come to nought.

The analysis of the curves (fig.1) shows that: 1. Minced meat can be regarded as a rheological viscous - plastic body of Shvedov-Bingham (9, 10), which is characterized by the above-mentioned properties; 2. Minced meat, as well as curds, has a fixed spatial structure (6); 3. The main equation of the viscous-plastic flow of minced meat is the Shvedov-Bingham's equation (2,3,5,6,9,10,11). Also it should be noted that: 1. All the curves on fig.1 are plotted for value of absolute strains up to 170 microns with almost undestroyed structures; 2. We used method of plotting rheological diagram as the relation $\frac{E}{\theta} = f(\tau)$ for the first time. The working of experimental data of other investigators (12) according to this method gives analogous relations.

Fig.2 shows the curves for the change of viscosity according to the degree of destruction of the structure and integral rheological relations of the flow of minced meat for frankfurters. The upper, horizontal section of the curve 4 shows effective viscosity for insignificantly destroyed structures, which coincides with the viscosity calculated according to Fig.1. An avalanche destruction of structure begins at a subsequent increase of the stress (load), which is shown by the straight - line section of the curve 4 for loads ranging from 250 to 300 grams. At similar loads the curve 3, characterizing the degree of destruction of the structure, also represents a straight line. Thereupon the effective viscosity decreases slowly and the degree of destruction of the structure aims at 100%. The curve of the degree of destruction of the structure does not reach 100% because the effective viscosity at different gradients of speed and completely undestroyed structure cannot be determined by this instrument.

The curves of the relation between the number of revolutions per second of the rotor of viscosimeter and shearing load (shearing stress) for undestroyed (1) and destroyed (2) structures present special interest. These curves confirm the fact that the Bingham-Shvedov's equation can be applied to minced meat. They are prolongation of the curve 4 on Fig.1 for greater strains.

The plastic viscosity is calculated by the curves 1 and 2, the ultimate shearing stress which is, as it is seen on the diagram, greater for undestroyed structure, than for destroyed one, is calculated by the point of intersection of the curves and the X-axid.

The calculation of the ultimate shearing stress, plastic and effective viscosity was made by the formulas mentioned in literature (1,2,7,8). The calculation of the degree of destruction of the structure was made by the relation

$$\alpha = \frac{\eta_f'}{\eta_f''} \cdot 100\%$$

where the values of effective viscosity η_f' and η_f'' are calculated by the curves 1 and 2 respectively, as the values inversly proportional to the tangent of the angle of slope of the section linking the origin of coordinates and the point selected.

Experiments and the relations plotted confirm the conclusions made by Fig.1 and correspond to modern ideas about rheological bodies (2,3,6,10,11,12).

Fig.3 shows in logarithmic scales relations between effective viscosity of minced meat for frankfurters for rotors of two diameters (32 and 15 mm) with a cup of 38 mm diameter and circumferential velocity of rotation of the rotor. The diagram shows that effective viscosity (instrument readings) depends on the diameter of the rotor as a result of the fact that spreadings of shear in the thickness of the minced meat ring are different for these two diameters, but the angles of slope (exponents) are equal. We used the functional dependence of the change of effective viscosity upon the speed for the rotor of greater diameter for summarizing experimental investigations of the flow of minced meat in pipes by means of criterion equations and the Buckingham's equation for higher speeds.

Experiments show that effective viscosity can be lower than plastic viscosity but in that case this term means effective viscosity with regard for the slide of minced meat on the surface of the rotor or the pipe. This assumption does not contradict to the settled opinion that effective viscosity in limit aims at a value of plastic viscosity (10,11,12,13).

We have considered the principal properties of minced meat for frankfurters. Experimental and theoretical investigations and relations plotted by them show that other types of minced meat have similar properties and that the above made conclusions can be spread to all types of minced meat.

Table 1 presents the values of the principal physico-mechanical properties in the technical system of units in accordance with the Shvedov-Bingham's and Newton's equations.

333

	Ultimate shearing stress		Viscosity (kg sec/m^2)	
	Mean	For destroyed structure	Plastic	Effective
Pork frankfurters	45	29-46	0,96-1,04	0,296 . $W^{-0,765}$
Sausage lyubitelskaya	70	50-84	1,80-2,80	0,5 . $W^{-0,79}$
" doctorskaya	52	36-52	1,60-1,90	0,42 . $W^{-0,74}$
" zakusochnaya	70	42-55	0,74-1,10	0,51 . $W^{-0,67}$
Pork sausage, II grade	48	39-48	1,90-2,10	0,41 . $W^{-0,72}$
Small sausages	-	34-40	0,76-0,86	-
Pork sausages	-	40-51	0,92-0,98	-
Half-fat cuttered pork	65	63-80	1,90-2,20	0,60 . $W^{-0,72}$
Cuttered beef	-	63-74	1,80-1,90	-
Rissoles domashniye	-	35-49	0,80-2,0	-
" kiyevskiye	-	35-56	0,96-1,0	-
" moscovskiye	42	33-47	0,8-1,1	0,38 . $W^{-0,72}$

Note: Average speed of the movement of minced meat (W) is measured in m/sec.

Flow of minced meat in pipelines

We investigated the flow of minced meat on special laboratory stands and industrial installations (3, 6). The principal aim of investigations was to find the simplest and, at the same time, sufficiently precise equations for calculating losses of pressure. But it is necessary to know conditions of movement of minced meat in pipes before the solution of this problem. We proved scientifically and confirmed experimentally that a certain creep of minced meat on pipe walls begins with an increase of speed.

Therefore we used for calculations the Buckingham's equation (3,4,5,6,9,11), in which plastic viscosity is used at low speeds of movement and effective viscosity - at higher speeds. Fig.4 presents the dependence of the coefficient of hydraulic resistance upon the generalized criterion of Reynolds for 400 experiments approximately. As it can be seen on Fig.4 the experimental dependence is the same as the theoretical one:

$$\lambda^* = \frac{64}{Re^{*o}}$$

However, Buckingham's equation is correct for a structural movement, i.e. for low speeds. At a higher speed creep of minced meat along the walls begins. The formation of a fatty layer on the walls will contribute to a further increase of creep at the same speed. It was found as a result of experiments and calculations that this equation is correct for high speeds with the use of effective viscosity only. In view of this fact the methods of calculation become much more complicated, since it is difficult to define the limits for the use of plastic and effective viscosity.

Taking into account the aforesaid, we carried out the elaboration of the experimental data, as relations (14) between reduced pressure (stress along the wall of the pipe) and the average speed of the flow. Fig.5 presents these relations for some types of minced meat. But these relations are correct in the first approximation because in fact losses of pressure are proportional to the diameter not in the first power. We recommended them for the diameters ranging from 30 to 70 mm because the calculation error in this range of diameters lies in the limits of experimental error.

The received values of effective viscosity in the practically applicable range of speeds permit generalize theoretically exporimental data as a result of modification of the general functional dependence $p = f(l, d, \theta_o, \eta_f, W)$ with the use of the dimensions theory. They also permit to find a criterion equation of the general character both of theoretical and practical interest. In this relation we took account for: length and diameter of the pipe; ultimate shearing stress; viscosity and creep, joined by the notion "effective viscosity"; average speed of the movement of minced meat in the pipe. Density is not considered as a defining factor because its values for different minced meats do not differ from the mean value more than ± 5%. The principal units for transformations were: d - m, θ_o - kg/m^2 and W - m/sec. Using the π-theorem we obtained a criterion equation of viscous-plastic masses in general aspect:

$$f\left(\frac{Eu}{Eu'}, \frac{l}{d}, Eu\,Re\right) = 0,$$

where $Eu = \frac{p}{\rho W^2}$ - Euler's criterion,

$Eu' = \frac{\theta}{\rho W^2}$ - modified Euler's criterion,

$Re = \frac{Wd\rho}{\eta_f}$ - Reynolds' criterion.

Solution of the general equation along experimental data of minced meat in the range of speeds from 0,01 to 1,6 m/sec. gives a criterion equation which is true for any minced meat:

$$\frac{Eu}{Eu'} = 2000\, ld^{0,1}\, (Eu'Re)^{-0,882}$$

and after transformations - design equation for defining losses of pressure in pipelines:

$$p = 2000\, ld^{-0,782}\, \theta_o^{0,118}\, \eta_f^{0,882}\, W^{0,882}$$

This equation shows that an enlargement of the diameter of the pipe, the rest of the values being constant, leads to a decrease of losses of pressure. The values of physico-mechanical properties of minced meat for this equation are shown in Table 1.

Since the criterion equation is true for any minced meat, the problem of calculation for any pipeline consists in evaluating the ultimate shearing stress and effective viscosity of minced meat by means of a rotary viscosimeter of dimensions mentioned.

Mathematical investigations showed that the three equations: Buckingham's one, a system of empiric equations obtained by us and the general criterion equation give almost equal results, which are near to the results of the experiments.

Conclusions

1. It was found experimentally that minced meat is a viscous-plastic body. At low stresses it obeys the laws of elastic bodies, at high stress it flows like a viscous liquid.

By means of experiments we defined the most important physico-mechanical properties of minced meat; ultimate shearing stress and viscosity, and at low stresses - modulus of elasticity for shear.

2. It was proved that the Buckingham's equation is true for the calculation of pipelines with structural movement.

3. Dynamics of the movement of viscous-plastic bodies in pipelines is presented in the form of a criterion equation. As a result of the experiments conducted we obtained the criterion equation true for all types of minced meat and proposed a design equation for losses of pressure in pipelines during the movement of different types of minced meat.

337

Bibliography

1. Specification and Instruction for Rotary Viscosimeter RV-8, MTI, 1958.

2. Volarovich M.P., "Viscosity and Plasticity of Printing Paints", Works of the Polygraphic Institute of the OGIZ, No.5, 1937.

3. Gorbatov A.V., Gorbatov V.M., Fyodorov N.E. and Kazakov S.P. "Investigation of Minced Meat Flow in Pipelines", 4 Meeting of European Research Workers, Cambridge, September, 1958.

4. Gorbatov A.V. "About the Possibility of Transportation of Some Meat Products by Pipelines", Works of the All-Union Scientific-Technical Conference of the Workers of the Meat Packing and Poultry Processing Industry, Dealing with the Problems of Intensification of Technological Processes. Moscow, December of 1958.

5. Gorbatov A.V. "Calculation of Pipelines for Viscous and Plastic Dairy Products". Molochnaya Promyshlennost SSSR", N 6, 1957.

6. Surkov V.D., Fyodorov N.E., Kazakov S.P., Gorbatov A.V. "Investigation of the Movement of Curds in Pipelines". Izvestiya Vysshikh Uchebnykh Zavedeniy MVO SSSR, Pischevaya Tekhnologiya, No.6, 1958.

7. Specification and Instruction for Conic Plastometer KP-3, MTI, 1957.

8. Instruction for Simonyan's Instrument for Evaluating Ultimate Shearing Stress of Viscous-Plastic Masses.

9. Reiner M. Ten lectures on Theoretical Rheology. GTI, 1947.

10. Rebinder P.A. Physico-Chemical Mechanics. Znaniye, 1958.

11. Rebinder P.A. "Summary of General Course of Colloidal Chemistry", Moscow, 1950.

12. Malinin N.I. "Investigation of Rheological Properties of Peat with Low Water Content", MTI works, Issue VI, 1957.

13. Moscalyov N.M. VASHNIL, VNIIGM, Works, Vol.XXIX, Moscow, 1957.

14. Gorbatov A.V. "Calculation of Losses of Pressure during the Movement of Minced Meat in Pipes", "Myasnaya Industriya SSSR", No.3, 1959,

----

FIGURES

1. Complete rheological diagram of minced meat for frankfurters.

2. Dependence of the speed of relative shearing (number of revolutions per second of the rotor of the viscosimeter) of partly (1) and completely (2) destroyed structure, the degree of destruction of the structure (3) and effective viscosity (4) upon the shearing load for minced meat for frankfurters.

3. Dependence of the effective viscosity of minced meat for frankfurters upon the circumferential speed of the rotor (average speed of the movement of minced meat in pipes).

4. Diagram of dependence of hydraulic resistance coefficient upon the generalized Reynolds' criterion for different minced meat.

5. Dependence of the pressure (stress along the pipe wall) upon the average speed of the movement of minced meat: 1 - minced beef; 2 - half-fat cuttered pork; 3 - pork frankfurters.

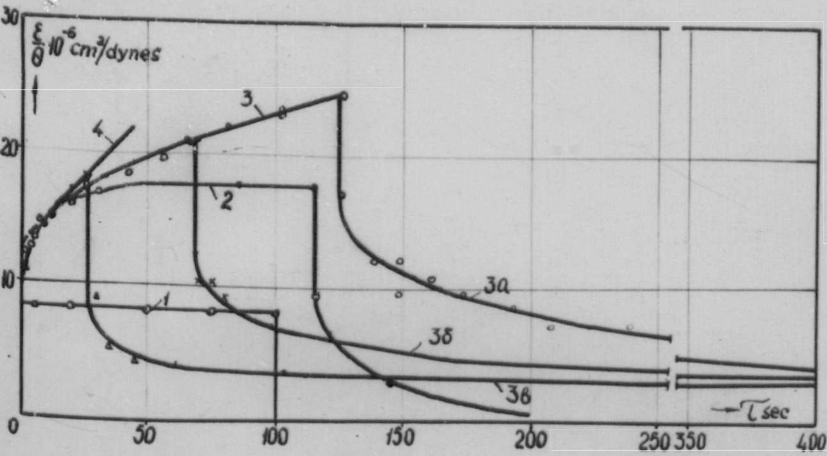

Fig. 1

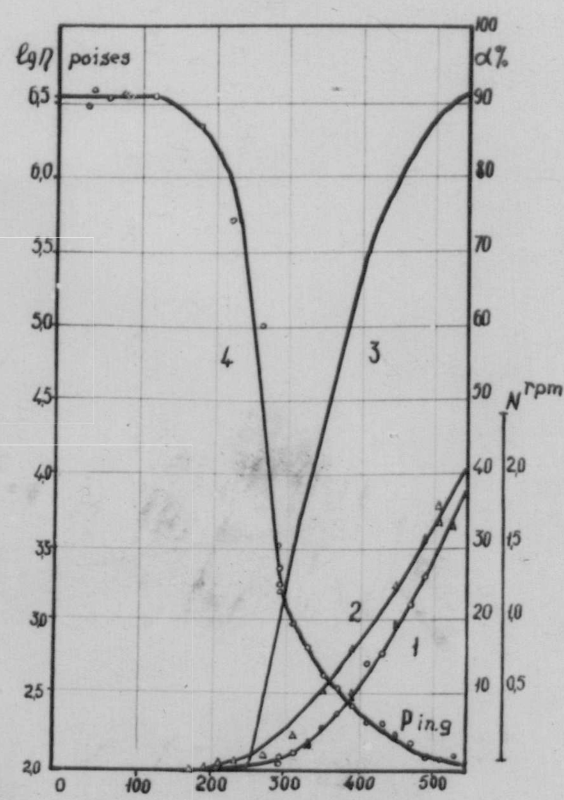

Fig. 2

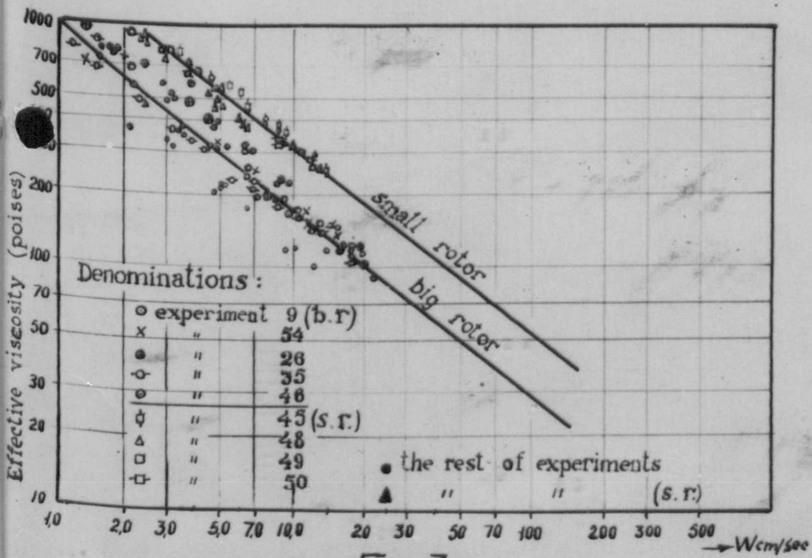

Fig. 3

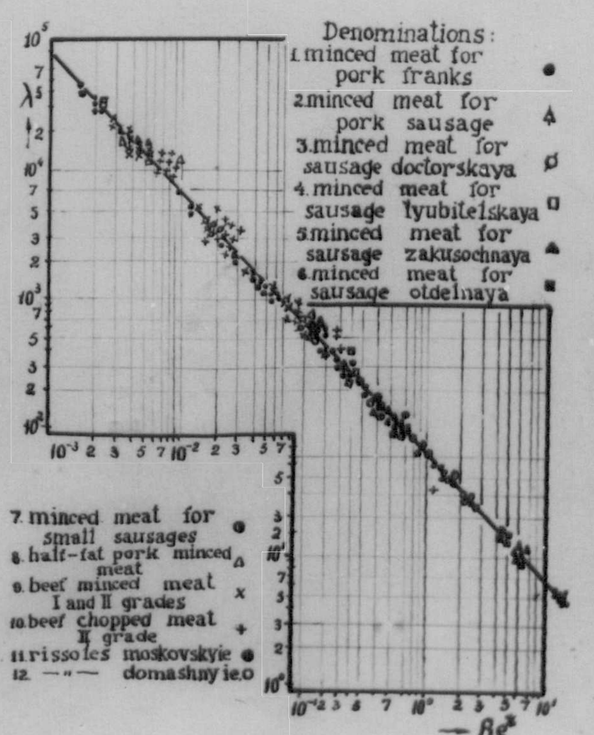

Fig. 4

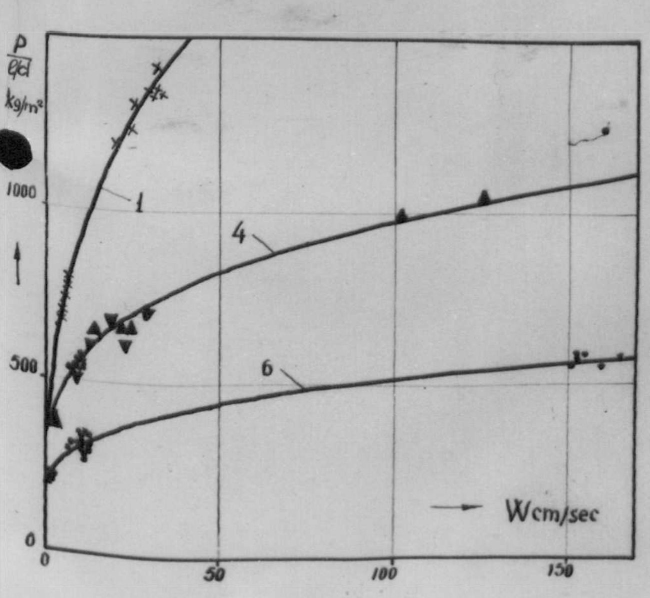

Fig. 5

SUMMARY OF THE PAPER "STUDY OF PHYSICO-MECHANICAL PROPERTIES OF MINCED MEAT AND ITS FLOW IN PIPELINES"

V.M.Gorbatov, N.E.Fyodorov, A.V.Gorbatov, S.P.Kazakov, I.A.Rogov.

The knowledge of the principal physico-mechanical properties of minced meat and changes of pressure, developing during its movement in pipes, is necessary for scientifically based calculations for development and improvement of installations and technological lines of sausage production.

Experimental investigations showed that minced meat can be regarded as a viscous-plastic body. At low stresses (strains) it is characterized by modules of instant elasticity and elastic aftereffect. At high stresses creep occurs and strain is not eliminated completely after removing the stress. At stresses higher than ultimate shearing stress minced meat flows like viscous liquids. The Shvedov-Bingham equation was selected as the principal equation for characterizing viscous-plastic flow.

It was proved, that the Buckingham's equation is true for calculating pipelines with structural movement, i.e.movement at low speeds.

An analytic investigation of the flow of viscous-plastic bodies in pipelines was carried out on the basis of the dimension theory. A general criterion equation with regard for physico-mechanical properties of viscous-plastic bodies was obtained. Solving this equation and using the data of our investigations of the movement of different types of minced meat in pipelines and effective viscosity values for different speeds, we obtained a partial relation - the criterion equation of minced meat dynamics, upon which we based the equation for calculating losses of pressure in pipelines during the movement of any minced meat.

SOMMAIRE DE L'ARTICLE "L'ÉTUDE DES PROPRIÉTÉS PHYSICO-MÉCANIQUES DE LA PÂTE DE VIANDE ET DE SON ÉCOULEMENT DANS LES CONDUITES

W.M.Gorbatov, N.E.Fjedorov, A.W.Gorbatov, S.P.Kasakov, I.A.Rogov.

Pour les calculs scientifiques, relatifs à la construction des nouveaux appareils et à l'amélioration des vieux, ainsi que des lignes technologiques de la charcuterie, il est nécessaire de bien connaitre les propriétés physico-mécaniques de la pâte, et le caractère des changements, qu'elle subit pendant son mouvement dans les conduites.

Les études expérimentales ont montré, que les pâtes de viande appartiennent aux matières visco-plastiques; dans le cas des tensions taibles (déformations) elles se caractérisent par des modules d'élasticité instantanée et de l'action postérieure élastique.

Dans le cas des tensions élevées on observe "le creep"; cependant, quand on enlevè la tension, la déformation ne disparait pas complètement avec le temps. Enfin dans le cas des tensions excédant la tension limite de déplacement, les pâtes coulent comme des liquides visqueux. Pour la caracteristique d'écoulement viscoplastique on a choisi l'équation de Chwodov-Bingham, comme base.

Pour les calculs des conduites dans le domaine du régime structural du mouvement, c'est à dire à petites vitesses, l'applicabilité de l'équation de Bukingham `a eté prouvée.

Se basant sur la théorie de dimension on a effectué l'investigation de la dynamique de l'écoulement des matières visco-plastiques dans les conduites et on a obtenu, une équation critère de forme générale, prenant en considération les propriétés physico-mécaniques des matières visco-plastiques. Au cours de la résolution de cette équation, en utilisant les résultats, de nos investigations du mouvement de la pâte de différentes espèces dans les conduites, ainsi que tenant compe du rôle important de la viscosité effective pour l'ample diapason des vitesses, on a obtenu un rapport de genre particulier - une équation critère de la dynamique des pâtes, pouvant servir, à notre avis, de base pour l'équation de calcul des pertes de pression dans les conduites pendant le mouvement des pâtes de différentes espèces.

UNTERSUCHUNG VON PHYSICO-MECHANISCHEN EIGENSCHAFTEN DES BRÄTS SOWIE DESSEN STRÖMUNG DURCH DIE ROHRLEITUNGEN

(Zusammenfassung)

W.M.Gorbatow, N.E.Fjodorow, A.W.Gorbatow, S.P.Kasakow, I.A.Rogow.

Für die wissenschaftlich-begründeten Berechnungen beim Schaffen neuer und Modernisieren alter Apparate und technologischer Wurstherstellungslinien sind die Kenntnisse sowohl der physikomechanischen Eigenschaften des Bräts, als auch der Art der Druckänderung während dessen Bewegung durch die Röhren erforderlich.

Die experimentellen Untersuchungen haben gezeigt, dass Fleischbrät zu viskos-plastischen Körpern gehört. Bei niedrigen Beanspruchungen (Deformationen) werden sie durch die Augenblickselastizitäts- sowie die elastischen Nachwirkungsmoduln charakterisiert. Bei hohen Beanspruchungen wird Kriechen (Creep) beobachtet, wobei nach der Beanspruchungslosmachung verschwindet die Deformation nicht vollkommen. Bei den Beanspruchungen, die die Grenzbeanspruchungen der Verschiebung übersteigen, strömt das Brät wie viskose Flüssigkeiten. Als Grundgleichung für die Charakteristik der viskos-plastischen Strömung wurde die Schwedow-Bingham-Gleichung gewählt.

Für die Berechnung von Rohrleitungen auf dem Gebiet des strukturellen Bewegungsregimes, d.h. bei geringen Geschwindigkeiten, ist die Eignung der Buckingham-Gleichung bewiesen.

Auf Grund der Dimensionstheorie wurde eine analytische Untersuchung von Strömungsdynamik der viskos-plastischen Körper in den Rohrleitungen vorgenommen und eine kriterielle Gleichung allgemeiner Art mit Berücksichtigung der physico-mechanischen

Eigenschaften der viskos-plastischen Körper erhalten.

Auflösen dieser Gleichung und Ausnützen unserer Untersuchungsergebnisse betreffs der Bewegung des Fleischbräts in Rohrleitungen und der Bedeutung der effektiven Viskosität bei unterschiedlichen Geschwindigkeiten ergab einen Zusammenhang spezieller Art - die kriterielle Gleichung der Fleischbrätdynamik, auf deren Grund wir eine Rechnungsgleichung für Druckverlüste in den Rohrleitungen während der Strömung verschiedener Fleischbrätarten vorschlagen.
