European Scholar Journal (ESJ)
Available Online at: https://www.scholarzest.com
Vol. 2 No. 5, MAY 2021,
ISSN: 2660-5562

RESEARCH THE INFLUENCE OF FRICTION ON FEATURES OF MOLDED MACARONI PRODUCTS

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Article history:
Received: 7th April 2021
Accepted: 22th April 2021
Published: 27th May 2021

Abstract:
The article covers the influence of structural, mechanical and frictional properties of raw macaroni food on technological process of cutting.

Keywords: Food material, macaroni dough, tribometer, adhesion, slip, structural and mechanical properties, coefficient of friction, adhesion force, frictional property, friction force.

Processing of various food materials is accompanied by complex physical-chemical, biological and mechanical processes, the study of which allows organizing effective and objective quality control and control of the technological cycle of production.

Structural and mechanical properties of raw macaroni products are determined by combination of technological characteristics of initial raw material, kneading formulation and conditions of production. Let us consider the influence of structural, mechanical and frictional properties of raw macaroni products on cutting process. Industry experience has shown that excessively wet molded macaroni tubes make cutting difficult. They become deformed and rumpled. Cut quality deteriorates, products lose their form, and drier products break, which requires additional costs and lengthens the production cycle of finished products. Various processes of mechanical processing of food raw materials and products are inseparable from friction. Knowing the parameters characterizing the frictional interaction of raw macaroni products with labor bodies of cutting machines is necessary for the correct calculation of equipment and reasonable choice of structural materials [1, 2].

Influence of the microgeometry of working surfaces and blow-off parameters of pressed-out macaroni strands on friction indicators and adhesion properties of the half-finished product has practically not been studied. The purpose of the research is to determine the characteristics of friction of the labor bodies of the cutting equipment for the processed half-finished product in relation to the choice of rational modes of their operation. To achieve this goal, a disk-type tribometer was developed and made, schematic diagram of which is shown in Fig. 1.

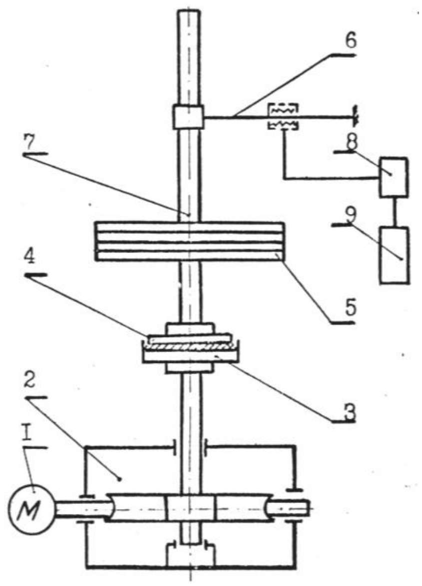
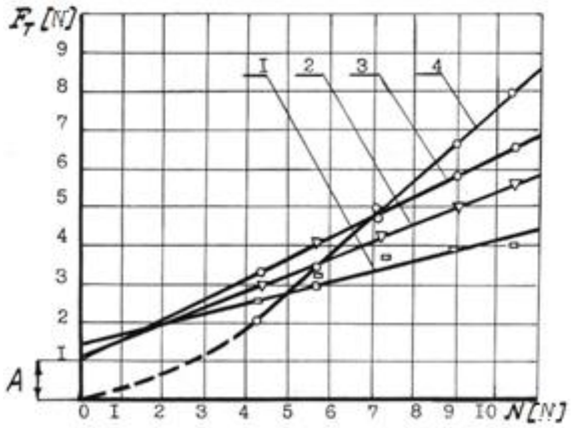


Fig. 1. Schematic diagram of disk-type tribometer. 1 – electric motor; 2 – worm reducer; 3 – rotating disk; 4 - stationary disk; 5 – load; 6 – strain beam; 7 - rod, 8 - amplifier; 9 – recorder.

The experiments carried out show that adhesion force depends on sliding speed, and decreases with increase in the speed from 0.117 to 0.22 m/s.

With an increase in the speed to 0.25 m/s, the rectilinear extrapolation of $F_T = f(N)$ dependence is violated, and the adhesion force tends to zero. This shows that at high sliding speeds, the contact time is reduced, and the dough sticking is reduced to the minimum.



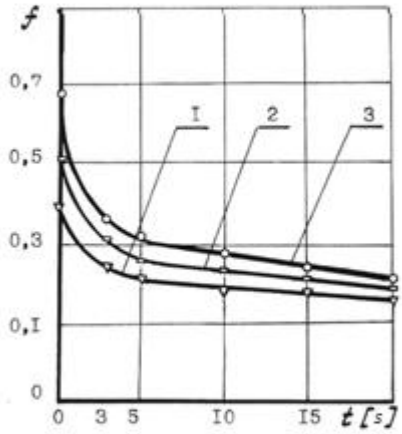


Fig. 2 Dependence of friction force from the value of normal load:
1- U= 0.117 m/s; 2 –U= 0.175 m/s; 3- U= 0.22 m/s; 4- U= 0.25 m/s.
Fig. 3 Dependence of friction coefficient on blow-off duration:
1-W=29 %; 2-W= 30%; 3- W=31%.

From the graph of the dependence of the friction coefficients, it can be seen that their value is largely determined by the sliding speed. The value of the friction coefficient has an extreme character with a zone of minimum f at U=016-0.18 m/s (Fig. 3). This character is most clearly seen for large values of σ_K. The drop in f in the initial range of change in speed is, in all likelihood, associated with a decrease in adhesion, as was established earlier (Fig. 2). The subsequent increase in the friction coefficient can be explained by an increase in its interaction between the dough and the opposite body [3]. The dependence of the friction coefficient on the value of the normal pressure is much more varied (Fig. 4). An increase in σ_K practically does not affect the value of f at U=0.117 m/s (curve 1). However, the change in speed towards an increase shows itself first in the form of a falling (curve 2) and then an increasing (curve 3) dependence.

Results of the experiment were processed on ES 1022 computer. The Fisher criterion was used to compare the adequacy of various approximating models: linear, quadratic, exponential and power. For all studied dependences, the highest value of the F criterion had an equation of quadratic regression $y = a + bx + cx^2$; the corresponding values of the empirical coefficients are presented in Tables 1 and 2.

Table 1. Dependence of friction coefficients on pressure
4.63 <σ< 11.6 kPa.

Coefficient	At sliding speed u, m/s				
	0,117	0,145	0,175	0,20	0,22
A	0.515	0.416	0.468	0.545	1.00
B	-0.031	-0.006	-0.021	-0.036	-0.163
C	0.002	-0.0005	0.00001	0.002	0.012

Table 1. Dependence of friction coefficients on pressure
0.117<u<0.22 m/s.

Coefficient	At pressure value σ, kPa				
	4.63	6.37	8.11	9.85	11.6
A	1.16	1.03	1.39	1.97	3.22
B	-10.1	-8.41	-13.16	-20.37	-37.10
C	32.6	25.61	39.85	61.05	114.4

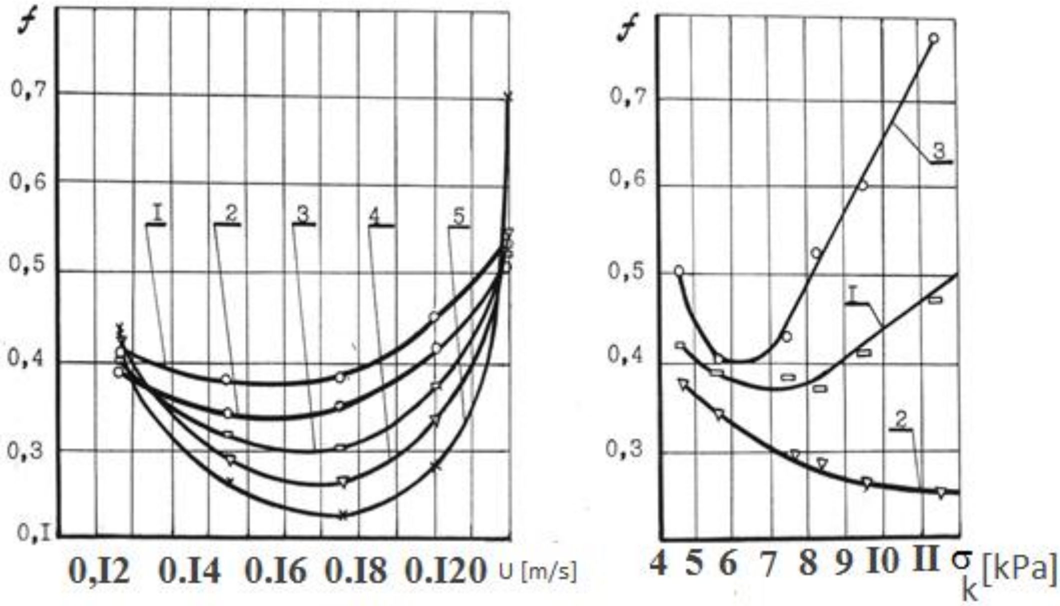


Fig. 4. Dependence of the friction coefficient a) on the sliding speed 1- $\sigma_к$ = 4.63 kPa; 2- $\sigma_к$ = 6.37KPa; 3- $\sigma_к$ = 8.11 kPa; 4- $\sigma_к$ = 9.85 kPa; 5- $\sigma_к$ = 11.6 kPa. b) on the value of normal pressure 1- U = 0.117 m/s; 2- U = 0.175 m/s; 3- U = 0.22 m/s.

Decrease in the adhesion properties of molded macaroni products during cutting in production conditions is achieved by blow-off. When studying the effect of blow-off on the change in friction coefficient, an installation, made according to the type of production installations 16 and consisting of a low-pressure fan and a system of air ducts has been used.

For the experiments, macaroni dough with a moisture content of 29-31% has been used. Before placing the sample in the tribometer holder, the dough surface was blown-off. In this series of experiments, the constant parameters were: contact tension equal to 8.11 kPa, surface roughness of the opposite body according to GOST 2789-63 Ra 6.3, sliding speed 0.175 m/s, air temperature 25 °C. In this series of experiments, the duration of blow-off and the humidity of the dough were changed. The research results showed that the dependence of the friction coefficient on the duration of blow-off for dough with different humidity has the form of falling exponentials. In the first 5 sec of blow-off, the friction coefficient decreases by two times, and then after 10 sec of blow-off the value of f characterizes the friction of the dried dough surface formed by blow-off. At the same time, if for a half-finished product without blow-off, the value of f significantly depends on its initial moisture content, then after blowing for 15-20 sec, the friction coefficient for all samples of macaroni dough stabilizes at $f \cong 0.2$.

Structural-mechanical and strength properties of a layer of raw macaroni tubes depend on the complex of technological and rheological properties of macaroni dough, molding conditions, features of geometric shape of the half-finished product and the density of their packing in the layer. The adhesion component of friction decreases with increasing sliding speed. The friction coefficient of the macaroni dough on the polished steel surface has a minimum zone in the speed range U = 0.16-0.18 m/s. Blow-off significantly reduces the value of the friction coefficient, which, with an increase in its duration over 10 sec, asymptotically approaches to the value 0.2.

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