The Study of the Behaviour of Polytetrafluoroetylene Dies for Pasta Extrusion Comparative with Bronze Dies

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This paper presents the results of the experimental researches made on an extruder for pasta, in which the extrusion die has the active extrusion surfaces from two different materials: plastic and metallic. The subject is focused on polytetrafluoroethylene, to indicate the advantages of this material comparative with bronze. The experimental part consists of diameter measurements of the intern extrusion holes with the optic microscope.

Keywords: polytetrafluorethylene, bronze, extrusion, die

The dies for pasta extrusion represent the most important part of the extruder, which gives the pasta the final form and dimensions [6, 7]. These dies must support the pressures through the pasta modelling process (up to 10 MPa [1]) and must be made from hard materials. In present, the dies bodies are made from materials with high mechanic resistance: stainless steel and bronzes.

In the dies are made holes and through these the dough is modelled. In the holes are introduced cores which represent the active extrusion surfaces.

The material for the cores has to meet the following requirements [2, 3]:

-high resistance to wear, pressure, temperature, shocks;

-easy workability, to obtain different forms of the holes;

-very low friction coefficients and very little adherence with the dough, to make easy the pressing process, to avoid adherence and deformation of the pasta;

-should not oxidize in contact with air or under the influence of the dough components;

-should not react with the dough, or transfer to this smell, taste, colour.

In present, these modelling surfaces are made from two different groups of materials: metals and plastics. From the last, the lowest friction coefficient has polytetrafluoro-ethylene PTFE (commercial name Teflon; values of the friction coefficient 0.1 – 0.05 [5]). PTFE has good chemical resistance and withstand to temperatures between -265°C and +260°C [5].

Politetrafluorethylene (PTFE = Teflon) is a vinyl polymer which has the same structure with polyethylene, obtained through vinyl polymerisation of the tetrafluorethylene monomer. The PTFE cores for pasta dies are made as follows:

- forming of granular polymer by pressing, syntherisation, cooling and extrusion;

- thermal stabilisation by heating at a temperature which makes possible a high slide resistance, then low cooling to eliminate the tensions;

- mechanic working methods to obtain the final forms of the cores.

From the chemical properties of PTFE, we must mention the good resistance to oxidation; PTFE is an inert material between 190°C and +200°C, has very high inertia relative to all the chemical products, exception made the alkaline materials in melt stage, fluour at high temperatures and halogen compounds [5].

PTFE cannot be disolved by any substance at temperature under 300°C [5].

PTFE has specific weight between 2.1 and 2.3 daN/dm^3, resistance to aging almost unlimited and is inflammable [4, 5, 8].

From the physico-mechanical properties, we must mention [4, 5, 8]:

-density: 1450 [kg/m^3]

-superficial tension: 20 – 30 [N/mm^2]

-elongation: 20 – 100 [%]

-Young's modulus: 0,7 [GN/m^2]

-Brinell hardness: 2.

From these advantages of PTFE relative to bronze, we made an experimental research relative to wear resistance, durability and stability to proove in practice the necessity to use PTFE PTFE for the dies from extruding pasta. The experiments follow the intern holes during the extrusion, in both cases: PTFE and bronze.

Experimental part

The experimental stand is an extrusion plant for pasta (fig. 1and fig 2) with the following principal components:

-feeding part for row materials (flour and water) (1), in which an axe with pallets mix the row materials to obtain the dough;

-extrusion part (2) in which the dough is pressed in the end, to the die;

-extrusion die (3), which gives the final form to the pasta; this part has an external cooling circuit.

Figure 1 presents the principal view of the experimental plant and the view from above, with opened dough cuve.

The principal element of this experimental plant is the extrusion die, with the scheme in figure 3.

Through this experimental plant we extruded a half tone of flour (ratio 4 : 1 – flour : water). We measured the internal diameters of the extrusion holes, three times, at exact predefined moments of the experiment: at the beginning, after the extrusion of the half part of the row material and at the end. Each time, we put the extrusion cores on the optic microscope, in the measurement zone. Relative to these positions, we established the measurements which allow to determin the real diameters of the extrusion holes.

The microscope increase the imagine 100 times, so that we can identify the axis after which the hole has maxim ovalization through the experiment. The direction after we

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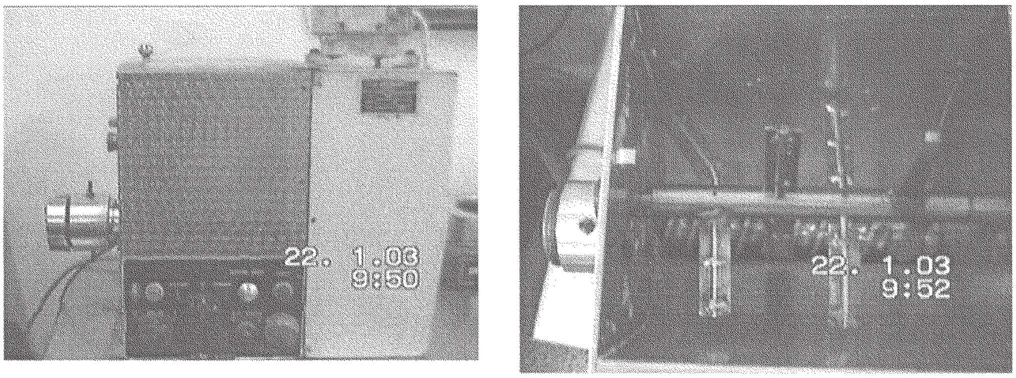

Fig. 1. Experimental plant for pasta extrusion

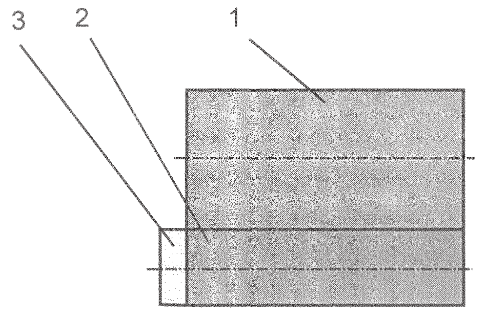

Fig. 2. Scheme of the pasta extrusion plant

can observe the maxim ovalization determines the maxim diameter of the extrusion hole.

All the measurements are made on two perpendicular directions, with the optic microscope which has the measurement domain of 25 mm (longitudinal and transversal) and 0.01 mm divisions. The precision of the apparatus is of hundreds of millimeter. The microscope table rotates with 360° in horizontal plane. The precision at the rotation of the table was 3'. The measured element (the extrusion holes) was limited by two fictive circles, to which were reported two measurements and the difference between these two measurements gives the measured diameter: a tangent to the left (for D_1), than to the right (for D_2) and then was read the lateral diameter on the direction x; analog was read the diameter on a perpendicular direction y, through tangents at the inferior part (for D'_1), and superior (for D'_2) (fig. 4).

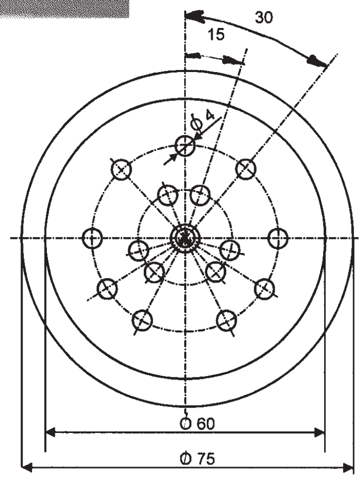

Fig.3. Scheme of the extrusion die for pasta

The two perpendicular diameters, D_x and D_y, result from the differences between the read measurements D_2 °i D_1 ($D_x = D_2 - D_1$), respectively D_1' and D_2' ($D_y = D_1' - D_2'$).

Results and discussions

The measurements of the internal diameters were made to draw a line on the dimensional changes, after two perpendicular directions, x and y, at three different moments of the experiment: before the experiment starts (table 1), after extruding the half of the quantity of row material (table 2) and at the end of the experiment (table 3). Figure 5 gives the numbering of the holes in each material group. Figure 6 presents the photography of the holes, made at the end of the experiment (a – holes in bronze; b – holes in PTFE).

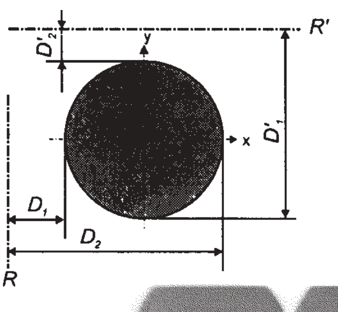

Fig.4. Measurement scheme with the optic microscope

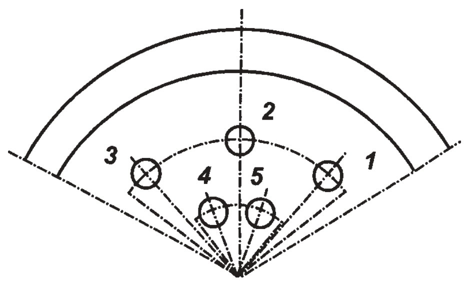

Fig.5. Numbering of the holes in each material group

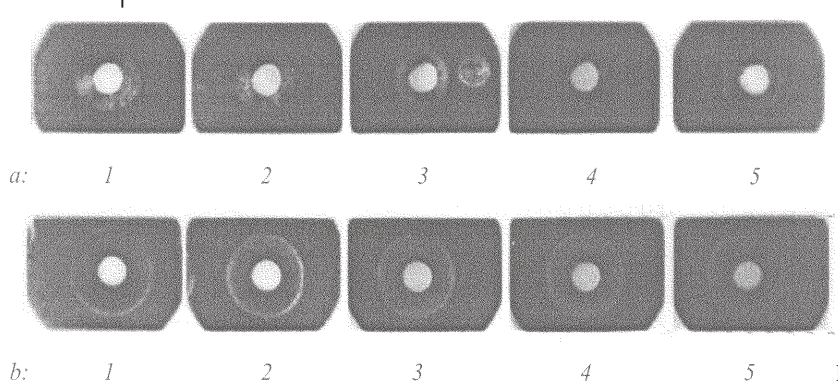

Fig.6. Holes photography

Table 1
READINGS OF THE INTERNAL DIAMETERS WITH OPTIC MICROSCOPE, BEFORE THE EXPERIMENT STARTS (ALL THE DIMENSIONS IN [MM])

Holes ordering		*1*	*2*	*3*	*4*	*5*		*1*	*2*	*3*	*4*	*5*
Material												
Bronze	D_1	8.58	8.53	8.54	8.54	8.54	D'_1	12.90	14.04	13.91	11.83	10.65
	D_2	10.58	10.53	10.54	10.54	10.54	D'_2	10.90	12.04	11.91	9.83	8.65
	D_x	***2.00***	***2.00***	***2.00***	***2.00***	***2.00***	D_y	***2.00***	***2.00***	***2.00***	***2.00***	***2.00***
Teflon	D_1	8.66	8.68	8.50	8.44	8.57	D'_1	9.60	8.53	8.11	6.23	5.46
	D_2	10.66	10.68	10.50	10.44	10.57	D'_2	7.60	6.53	6.11	4.23	3.46
	D_x	***2.00***	***2.00***	***2.00***	***2.00***	***2.00***	D_y	***2.00***	***2.00***	***2.00***	***2.00***	***2.00***

Table 2
READINGS OF THE INTERNAL DIAMETERS WITH OPTIC MICROSCOPE, AT HALF TIME OF THE EXPERIMENT (ALL THE DIMENSIONS IN [MM])

Holes ordering		*1*	*2*	*3*	*4*	*5*		*1*	*2*	*3*	*4*	*5*
Material												
Bronze	D_1	1.48	2.54	3.47	4.19	2.05	D'_1	5.05	4.15	5.28	7.36	7.41
	D_2	3.53	4.59	5.54	6.18	4.15	D'_2	2.98	2.11	3.23	5.26	5.30
	D_x	***2.05***	***2.05***	***2.07***	***2.09***	***2.10***	D_y	***2.07***	***2.04***	***2.05***	***2.10***	***2.11***
Teflon	D_1	3.11	1.85	3.27	0.84	2.29	D'_1	7.36	7.33	6.45	8.97	6.56
	D_2	5.14	3.89	5.30	2.89	4.35	D'_2	5.31	5.37	4.43	6.92	4.51
	D_x	***2.03***	***2.04***	***2.03***	***2.05***	***2.06***	D_y	***2.05***	***2.04***	***2.02***	***2.05***	***2.05***

Table 3
READINGS OF THE INTERNAL DIAMETERS WITH OPTIC MICROSCOPE, AT THE END OF THE EXPERIMENT (ALL THE DIMENSIONS IN [MM])

Holes ordering		*1*	*2*	*3*	*4*	*5*		*1*	*2*	*3*	*4*	*5*
Material												
Bronze	D_1	4.65	5.12	5.33	5.50	5.63	D'_1	10.58	9.56	9.41	8.40	8.78
	D_2	6.79	7.27	7.50	7.71	7.81	D'_2	8.44	7.42	7.26	6.21	6.60
	D_x	***2.14***	***2.15***	***2.17***	***2.21***	***2.18***	D_y	***2.14***	***2.14***	***2.15***	***2.19***	***2.18***
Teflon	D_1	6.40	6.12	6.20	6.25	6.64	D'_1	8.51	8.07	7.23	5.98	6.29
	D_2	8.48	8.22	8.28	8.38	8.74	D'_2	6.43	5.41	5.15	3.86	4.18
	D_x	***2.08***	***2.10***	***2.08***	***2.13***	***2.10***	D_y	***2.08***	***2.10***	***2.08***	***2.12***	***2.11***

From the analyses of figure 6 and the dates presented in tables 1 – 3 we can observe that the modification of form and dimensions in the case of PTFE are lower relative to bronze.

The higher wear of bronze relative to polytetrafluoroethylene, can be explaind by:

the very little friction coefficient of PTFE (0.05) offering an extrusion of the pasta dough on an almost mirror surface;

in the extrusion area are developed temperature shocks, in large intervals (between the ambient temperature and 70 – 80°C) and pressure shocks (the pressure picks can have values of $120 \cdot 10^5$ N/m^2, followed on quickly decrease of the pressure at values of units of N/m^2, at dough extrusion speeds of 3 – 4 m/min), which create conditions that modify the resistance behaviour of the bronze;

the temperature shocks, pressure shocks and friction coefficient dough – bronze, allow conditions that have as consequence the bronze strain hardness which determines bronze fragility and destruction of active margins.

Conclusions

Due to of the very low friction coefficient, PTFE offers a mirror extrusion surface and low relative hardness, a compact structure and, together with the almost unlimited resistance to aging and resistance at temperatures upon +260°C, justifies the proposed solution: to change the cores of the pasta extrusion dies, made from metals, with plastic materials – polytetrafluorethylene (PTFE = Teflon).

The result is an extrusion die which has a resistant active extrusion surface, which doesn't wear quickly.

Bibliography

1. BAIRD, D.G., LABROPOULUS, A.E., Food dough rheology, Chem. Eng. Commun, **15**, 1982
2. BARILLA, G., Pasta. History, technologies and secrets of italian tradition, Arti Grafice Amilcare Pizzi, Italia, 2000, p. 111
3. BAROZZI, A., Pasta dies: design techniques. Porduction systems, în Un Mondo di Pasta, Chiriotti Editori, Italia, 1996, 95
4. GHITA, E., GILLICH, G.R., BORDEAªU, I., VODÃ, M., TROI, C., Mat. Plast., **44**, nr. 2, 2007, p. 158
5. ICLÃZAN, T., Plasturgie. Tehnologia prelucrãrii materialelor plastice, vol. I., Litografia Universitãþii „Politehnica" Timiºoara, 1995
6. MEDVEDEV, G., Aspetti non convenzionali della pastificazione – non conventional aspects of pasta making, În rev. Tecnica molitoria, noi. 1997
7. NICULESCU, N., Producerea modernã a alimentelor fãinoase, Editura Ceres, Bucureºti, 1980
8. VODÃ, M., BORDEAªU, I., MESMACQUE, G., CHIÞAC, V., TABÃRA, I., Mat. Plast., **44**, nr. 3, 2007, p. 254

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