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STUDY REGARDING THE INFLUENCE OF COOLING TIME ON THE OVERALL QUALITY OF MOLDED TECHNOPOLYMER PRODUCTS

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Abstract: This paper studies some aspects of the influence of cooling time on the quality of technopolymer molded. Such plastics are utilized in the fabrication of technical parts, and said parts must be a of higher quality because of their functional role.

Cooling time is one of the determinants in terms of both product quality and in terms of productivity. Quality of injected parts is significantly influenced by subsequent deformations occurring after release from the mold, deformations that are largely influenced by the cooling time.

1. INTRODUCTION

Cooling time has a great influence on the total processing time of a plastic product obtained by injection regardless of size and properties of the material the piece is made of, the greater the cooling time the greater the processing time .

Cooling time is influenced by a number of factors like : the properties of the plastic material, heat transmission coefficient, wall thickness as well as technical condition imposed upon the part.

Generally most manufacturers are increasingly pursuing productivity growth so that economic efficiency is high. According to research, it is very clear that with decreased cooling time, we see an increase in part deformations. This issue is somewhat concerning given the fact that most products from this category have very strict technical condition, therefore dissalowing the decrease in cooling time.

In order to diminish these problems, a very important role is given to the way the cooling circuit of the mold is designed, ie the diameter of the cooling channel, the shape, lenght and localization of the cooling channels as well as calculating the flowing liquid's debit.

This paper addresses a number of calculations relating to these issues, but also comes with some technological proposals on the shape, size and the placement of cooling channels to the contour.

2. THE DETERMINATION OF COOLING TIME EQUATION.

The productivity of injection machine depends on the time of injection cycle. Generally simplifying the injection cycle, the total injection time is:

$$t_t = t_u + t_r + t_m \qquad (1)$$

where: t_u – fulling time of the mould

t_r – cooling time

t_m– dead time (pause and times of closing and opening the mould). [9]

By introducing some simplyfing hypothesis ,it here are determined some theoretical relations in order to determine the cooling time. Based on this, it is offered the posibility of practical determination of the cooling time in case of injection pieces.

Analysing the relation (1), it is observed that the time of injection (t_t) depends direction on the cooling time (t_r). Theoretically determining t_r it is takieng into account the plastical material, which flows in the mould cavity (fig. 1).

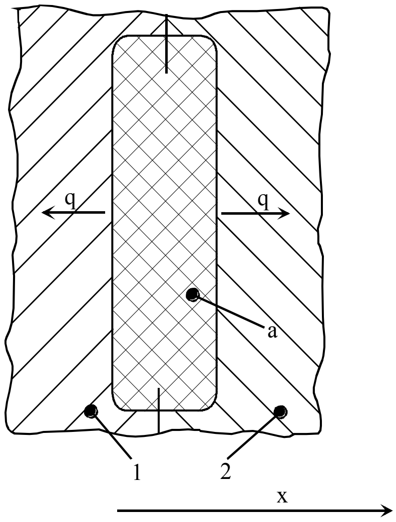

Fig.1. The thermical transfer in case of the injection pieces in mould: 1,2-forming plates; a- injected pieces; q-thermical high tide unitary on x direction

They are introduced the following symplifing hypothesis:

- Plastical material is considered like a plane plate having the constant cooled on the both faces.
- They are negletied the marginal effects;
- It is negletied the anizotropia properties due to the macromolecules orientation;
- It is negletied the coefficient dependence of the thermical diffusing of temperature;
- The warming transfer is exclusively considered conductive.

Genarally equation of the coordonating conducte is [9]:

$$\frac{\delta T}{\delta t} = \frac{\lambda}{c_p \rho}\left(\frac{\delta^2 T}{\delta x^2} + \frac{\delta^2 T}{\delta y^2} + \frac{\delta^2 T}{\delta z^2}\right) \pm \frac{q_v}{c_p} \qquad (2)$$

where: [8]:

λ – coefficient of thermical conductivity, W/mK;

c_p – specific warming to the specific presure , J/kg · K

ρ – density Kg/m^3

q_v – the warming quantity of the volume unity, W/m^3

T – temperature, K

t – time, s.

It is noted:

$\frac{\lambda}{c_p \rho} = a\left[\frac{m^2}{s}\right]$, which is called thermical difuzivity.

Analisying the thermical conductive transfer ,in case of material plastic plate, between the cooling walls of the moulds (fig.1), general shape of the equation (2) symplifies , considering that:

- The transitory transfer (interval time d_t the izoterm position is modified temporaly and in space:

  There is no inside sources of heating, $q_v = 0$;
- The heating trasfer is done perpendicular on the plate surfaces (unidirectional transfer in x axes). So:

  $q_y = 0$, $q_z = 0$

where: q_y – thermical high tide unit on y direction;

q_z – thermical high tide unit on z direction;

Due to the fact that the thermical fluxes on direction y and z are null, it results:

$$\frac{\delta^2 T}{\delta x^2} = \frac{\delta^2 T}{\delta y^2} = 0$$

3. TECHNICAL SOLUTIONS LOCATION OF COOLING CHANNELS

To obtain precision parts mold designer must pay particular attention to the location channel and moderation play against each other, compared with injection points depending on the purposes of filling the nest. Sizing and design location to channel mitigation should consider the following principles:

- uniform temperature of the entire surface of the mold nest;
- channel location along the flow path mold material;
- number of direction changes of the cooling circuit is as small.

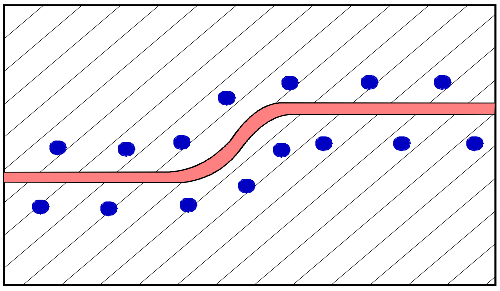

Fig.2. Ideal location of cooling channels in one piece with uniform thickness

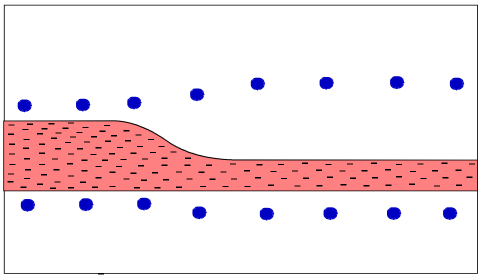

Fig.3. Ideal location of cooling channels in one piece with variable thickness.

Very important is uniformly cooling the mold surface. This is achieved by judicious arrangement applied in mold cooling channels to ensure the movement of coolant (usually water). Here the following rule works in principle:

Products with uniform wall thickness, cooling holes channels practiced regularly will outline the product (Fig. 2.), The product is not uniform wall thickness, distance to practice is inversely proportional to the thickness holes, (fig.3.)

4. CASE STUDY

The figure up shows a practical experiment using a matrix with an experiment is about the size of the study strains depending on the cooling water temperature and the input circuit, for five types of materials widely used in practice (PC, PA6 , PET, PP, PS).

Table 1.

Material number	Material	Maximum piece warping [mm]				
		Mold cooling time [s]				
		5	**10**	**20**	**30**	**40**
1	**PC** - technopolymer	6.21	3.15	1.42	0.83	0.58
2	**PA6** - technopolymer	6.78	3.43	1.65	0.9	0.62
3	**PET** - technopolymer	7.52	3.57	1.7	0.92	0.61
4	**PP** - polymer lower	7.79	3.65	1.8	0.94	0.68
5	**PS** -polymer lower	8.3	4.1	1.94	1.12	0.73

Shown in picture.5 injected mould that is the experiment and piece of evidence.

In table 1, it presents the warping measurements for the materials studied depending of the cooling time are represented. Water temperature upon entry in the circuit is (30^{0}C mold center and 42^{0}C margins)

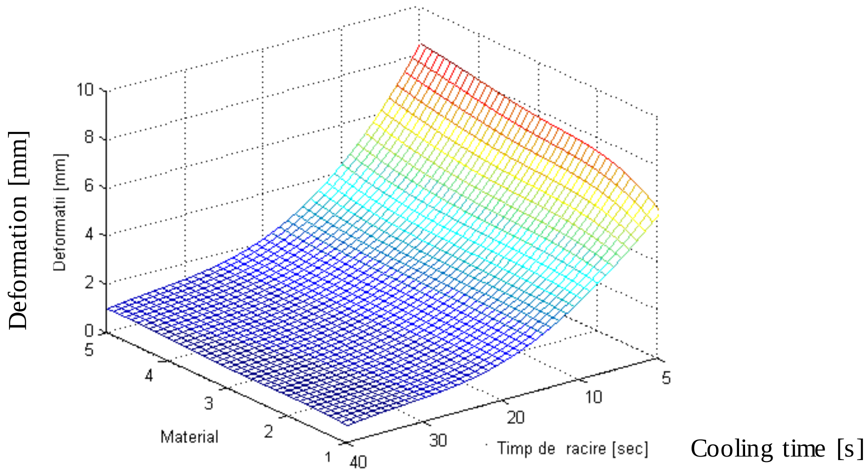

Fig. 4.Graphical representation of the warping depending upon the cooling time, utilizing a circuit entry water temperature of 20 degrees C in the centre and 40 degrees C on the margins

5. CONCLUSION

The quality of technopolymer products is directly influenced by mold temperature. It directly influences the cooling time, the duration of the injection cycle, forming efficiency in the mold, the quality of the product, cristalinity and internal tensions.

Higher temperatures of the material allow for better flow, but increase contractions as well as cooling time, which lowers productivity.

Too low temperatures reduces shrinkage in the mold,and in turn lead to stronger contractions after disposal.

When it is required for the molded product to have a superior quality both visually as well as in terms of surface quality, cooling time increases, ultimately resulting in an increase of production costs.

Cycle time, which determines the cost of injected parts, is dependent on the cooling time and also the size of the product's deformations is inversely proportional to the cooling time in the mold.

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