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Temperature distribution on the molding surface during cooling stage and its influence on the molding structure

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Empirical research results concerning influence of injection moulding parameters on quality features such as: after-shrinkage (longitudinal and transverse), moulded piece weight and the structure have been presented in this article. Parameter range has been defined on the basis of series of tests. Polyacetal POM (Sanital M8 Nyltech) has been chosen for research. Five parameters, determining quality features to a largest extent have been chosen; then, applying experiment planning theory, samples for further research have been injected.

1. INTRODUCTION

During multimolecular polymers processing for precision, motor and medical industry i.e. wherever quality and dimensional accuracy high-level demands of product are being made, very important thing is, undoubtedly, apart from cleanliness and high quality of output plastic itself, controlled conducting and familiarizing with the injection process, and, to be exact, phenomena which they are described with and which occur during the process.

During preliminary research these parameters were assessed, which were of great importance for moulding quality. Those included: injection pressure, material temperature (assuming linear temperature distribution in plasticization system), holding pressure (which have a big influence on moulding shrinkage and mould cooling time and temperature, on which diversity of shrinkage and its scale is dependent.

Received results have been presented in the form of graphs of crystallization degree dependence on selected technological parameters, mainly cooling time, mould temperature and holding pressure [1, 2, 3, 4].

2. BASIC RESEARCH AND SAMPLE PREPARATION

Polyoxymethylene POM (SANITAL) M8 from group of partly crystalline polymers has been used for research. This is one of constructional materials commonly used in different types of precision mechanisms parts. It is characterized by large abrasion/high temperature resistance and low water absorbing capacity.

Within the confines of the experiment some samples for moulding shrinkage investigation have been made by means of Krauss Maffai KM65/160 C1 according to guidelines of ISO 294-4:1997 standard.

Then, cuttings (to investigate the crystallization degree) have been taken from characteristic places of samples by means of differential scanning calorymetry DSC method, using DSC device, model 204 *Phox*® by NETZSCH made and weight was defined on the semi analytical laboratory balance made by SARTORIUS, measuring with accuracy of 0,01 mg.

2.1. Molded piece and measurement diagram

View of arrangement of measurements points of moulding was presented on figure 1.

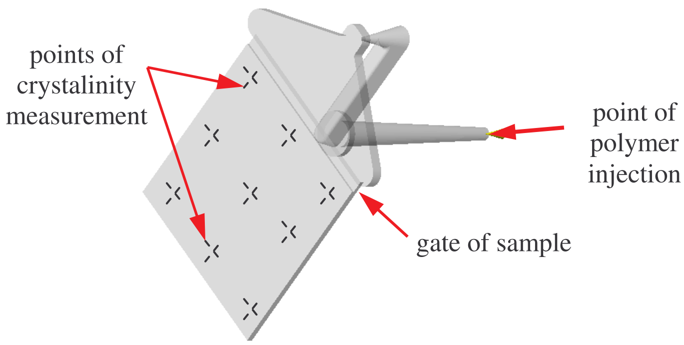

Figure 1. Molded piece diagram, arrangement of measurements points

2.2. Operating conditions

Range of parameters assumed for experiments is shown in table 1.

Table 1
Operating conditions

No.	Parameter, symbol	Unit	Polyoxymethylene POM	
			low value	high value
1.	Mould temperature, T_{for}	deg. C	30	70
2.	Polymer temperature, T_{tw}	deg. C	175	210
3.	Cooling time, $t_{chł}$	s	10	56
4.	Holding pressure, p_{doc}	bar	300	600
5.	Injection velocity, v	mm/s	20	120

3. ANALYSIS OF RESEARCH RESULTS

3.1. The results of computer simulation of filling stage

During the research the computer simulation of filling stage of injection mould were conducted. The results were presented in fig. 2a and 2b.

The pressure distribution on the moulding (on the left bottom corner we can see the decrease of pressure) is not symmetrical although the front flow of polymer is symmetrical to the axis of moulding. Analyzing below-shown images of temperature distribution on the surface of the moulding we can assume that one part of the moulding is cooling faster. It is connected with faster solidification of polymer and with lower pressure of polymer in the mould.

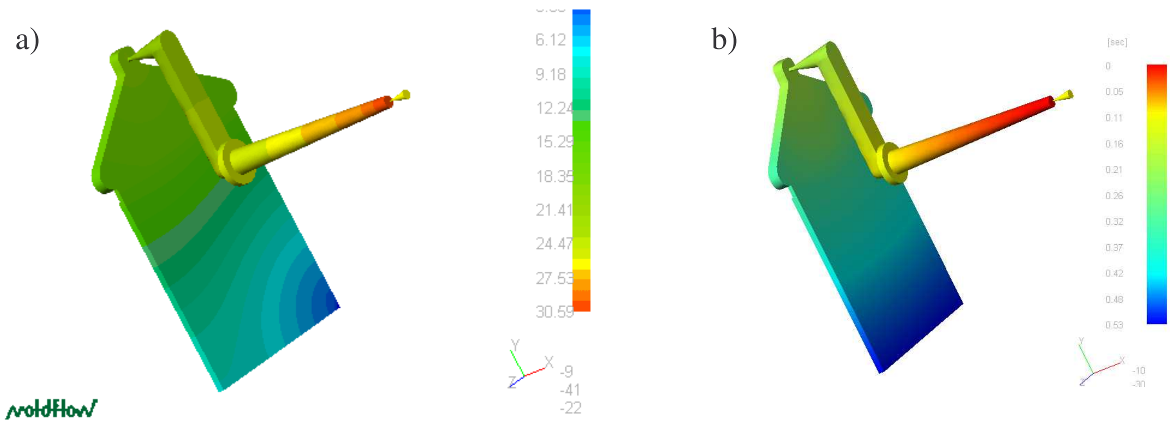

Figure 2. Results of computer simulations injection molding: a) distribution of injection pressure, b) flow front and filling stage

3.2. The results of the moulding cooling observed with the use of thermovision camera

We can get very interesting information from the photo analysis taken with the use of ThermaCam PM 590 thermovision camera (produced by American company FLIR) [4]. The process of the moulding cooling immediately after the injection was recorded. The figures 3a and 3b show that the temperature distribution is not symmetrical.

We can observe that thicker part of the moulding is giving up the heat longer while the remote parts and the less-thick parts are cooling faster.

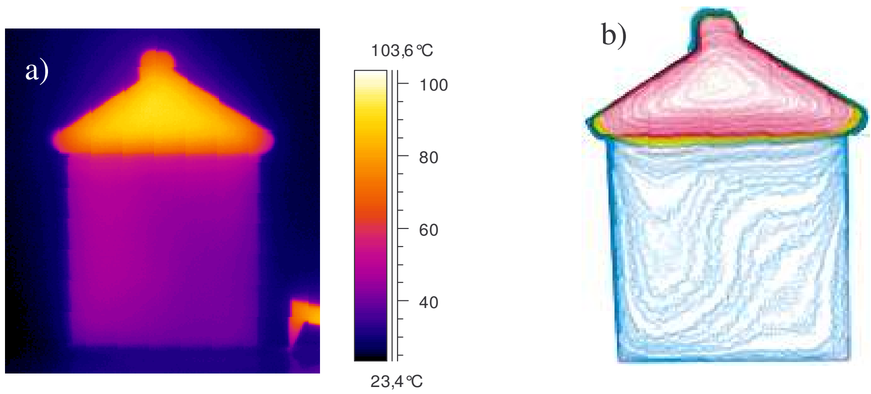

Figure 3**.** The photos of moulding taken using thermovision camera: a) the photo before processing, b) the photo after the processing using finding of edge (isotherm lines) procedure

3.3. The results of structure analyzing of polymer using the DSC method

The research of differential scanning calorymetry (DSC) method provides the significant information concerning the structure of polymer. We can estimate all the processes of the polymer during heating and cooling, the value of enthalpy and the crystalinity [5], which influences the mechanical properties of moulding. During the DSC research 9 samples form the surface of a moulding were taken according to the scheme shown on fig. 4a and fig. 4b. The crystalinity degree, the enthalpy of phase transition and the melting temperature were estimated.

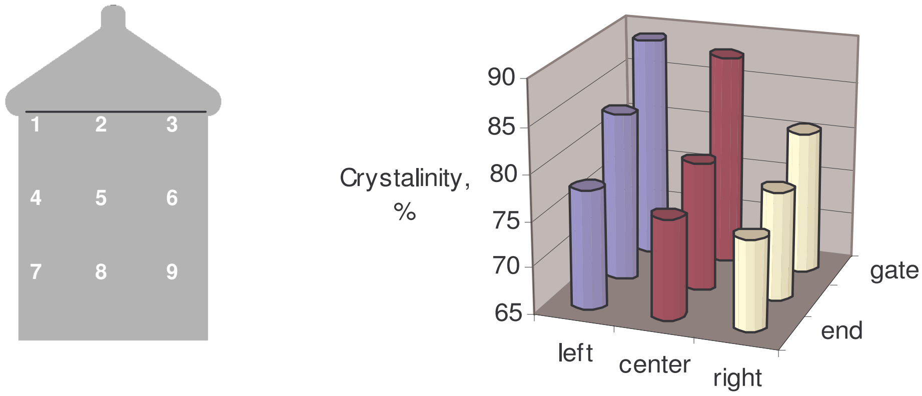

Figure 4. Points of DSC measurement and distribution of crystalinity degree

4. CONLUSIONS

The analyses of the effect prove that we should follow the conditions polymer processing and be concerned with stability of the process. It is very significant in the production of the dimensional accurate parts.

To avoid deformation and shrinkage stress of the parts it is necessary to conduct injection and stably analyzing all the defects and finding the causes.

Special attention should be given to the procedure of cooling injection moulding in the mould as it influences the quality of the product, its mechanical properties and the internal stresses.

Recognition of all of the possible relationships describing influence of parameters on each other will enable exact and accurate injection process control and conscious decision-making (on manufactured parts quality improvement). It must be clear that such in-depth process recognition is necessary only when one wants to manufacture parts whose quality and repeatability requirements of all features (not only mechanical but also functional, quality) are imposed at the first place.

Wherever these properties matter, in-depth analysis of the whole process and all possible parameters is therefore necessary. Main recipient of such information are automotive, medical, precision and electronic industries.

REFERENCES

1. DuPont Polska, Wymiary detali podczas formowania i po jego zakończeniu, Vademecum Tworzyw Sztucznych i Gumy, nr 2, 2001 r.
2. Johannaber F., Wtryskarki, seria Przetwórstwo Tworzyw Sztucznych, Wydawnictwo Poradników i Książek Technicznych, Plastech, Warszawa 2000 r.
3. Kowalska B., Sikora R., The influence of the cooling time of the injection moulded parts on pVT behaviour, The Polymer Processing Society, PPS-17 Conference Proceedings, 21-24.06.2001, Montreal, Canada.
4. Minkina W. A., Rutkowski P., Wild W. A., Podstawy pomiarów termowizyjnych cz. I, Pomiary Automatyka Kontrola, nr I/2000, str. 7-13.
5. Möhler H., Knappe S., Focus on thermal analysis for polymers, NETZSCH-Gerätebau GmbH, Selb, 1998.