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The influence of the thermoplastic injection molding on the molding degree of crystallinity

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The results of the tests of the influence of the thermoplastic injection molding on the moldings degree of crystallinity have been presented. The tests of a degree of crystallinity and a crystallites mean size in a chosen region of the molding have been performed. The results obtained from the experiment have been compared to the ones from computer simulation of the injection molding process.

1. INTRODUCTION

The tests of the degree of crystallinity of moldings obtained under different values of the injection time were performed. The degree of crystallinity was determined with the X-ray diffraction analysis method. X-ray tests were performed with use of the SEIFERT XRD 3003 T - T X-ray diffractometer. Filtered radiation of the copper anode lamp was used; radiation length $\lambda_{CuK\alpha}$ = 0,15418 nm. Working parameters of the lamp were as follows: U = 40 kV, I = 30 mA. The tests were performed in the angles range 2Θ from 8° to 60°, measurement step was 0.1°, and the time of the impulses counting 5s.

On the basis of the obtained experimental data and using the software package DHN – PDS (DHN – Powder Diffraction System) the degree of crystallinity was calculated.
Wunderlich's equation was used to calculate the degree of crystallinity S_k:

$$S_k = \frac{I_k}{I_k + b \cdot I_a} \cdot 100 \tag{1}$$

where:
I_k – field under the reflex from the crystalline phase,
I_a – spectrum field of the amorphous phase,
b – factor of proportionality.

Using the X-ray tests and the Scherrer's equation made it possible to calculate the crystallites mean sizes in the direction perpendicular to the given family of the crystal planes (hkl) [1]:

$$L_{hkl} = \frac{k_s \lambda_s}{\beta_s \cos \Theta_{hkl}} \tag{2}$$

where:
k_s – Scherrer's constant (0.9 – 1.0), λ_s - wave length of the radiation used, Θ_{hkl} - deflection angle, β_s - width of the diffraction line in the middle of its high.

2. RESULTS AND DISCUSION

In figure 2 the results of the x-ray tests of the degree of crystallinity are presented. In the upper part of the picture the moldings with the places of drawing the samples are shown. The tests enclosed moldings obtained by variable values of injection time (ranging from 0.1-3s), injection temperature 280 °C and the injection rate 113.2 mm/s. Gradual increase in the degree of crystallinity with the increase in injection time up to the value of 1.5s was observed. Further increase in the injection time caused smaller dynamic of the degree of crystallinity increase with the tendency to reach the steady value. In figure 1 the dependence of crystallites mean size and the injection time is presented. The calculation were performed for specimens shown in figure 2.

The results of the calculation indicate the occurrence of relatively large crystallites in samples for short injection time. It may be caused by the occurrence of the clusters of small crystallites situated very close to each other. With the increase in injection time these crystallites gain possibility to move away in the space and become detectable by the measurement apparatus as separate objects. The increase in crystallites mean size was observed for injection time values above 1.5s.

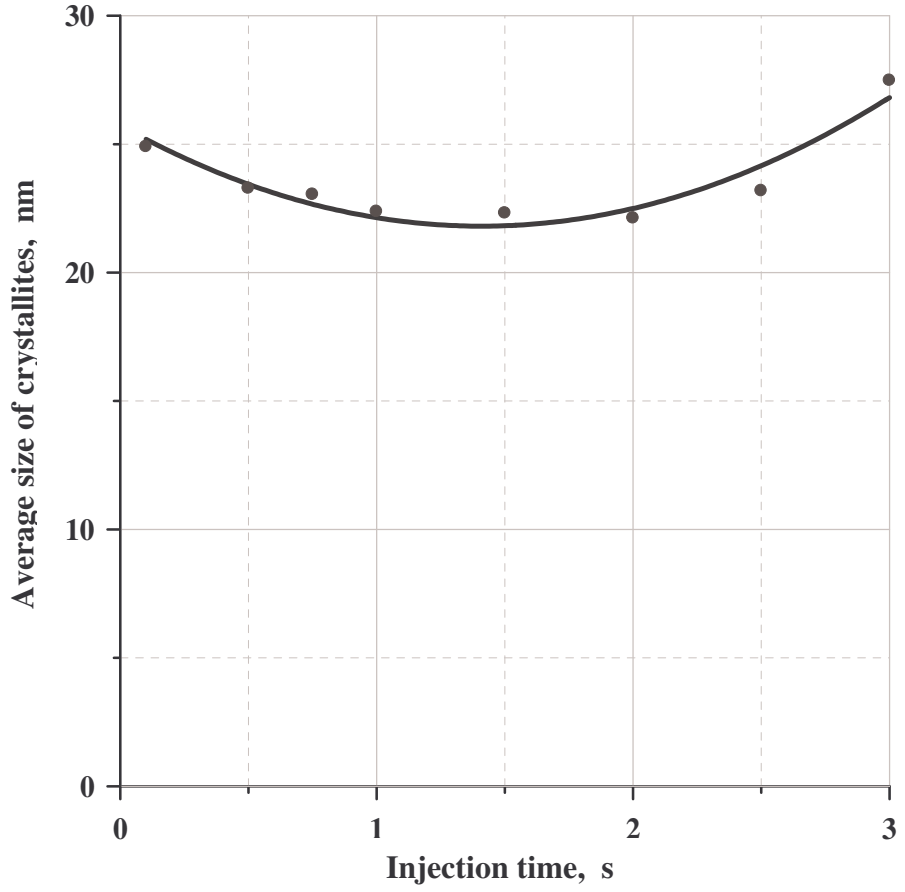
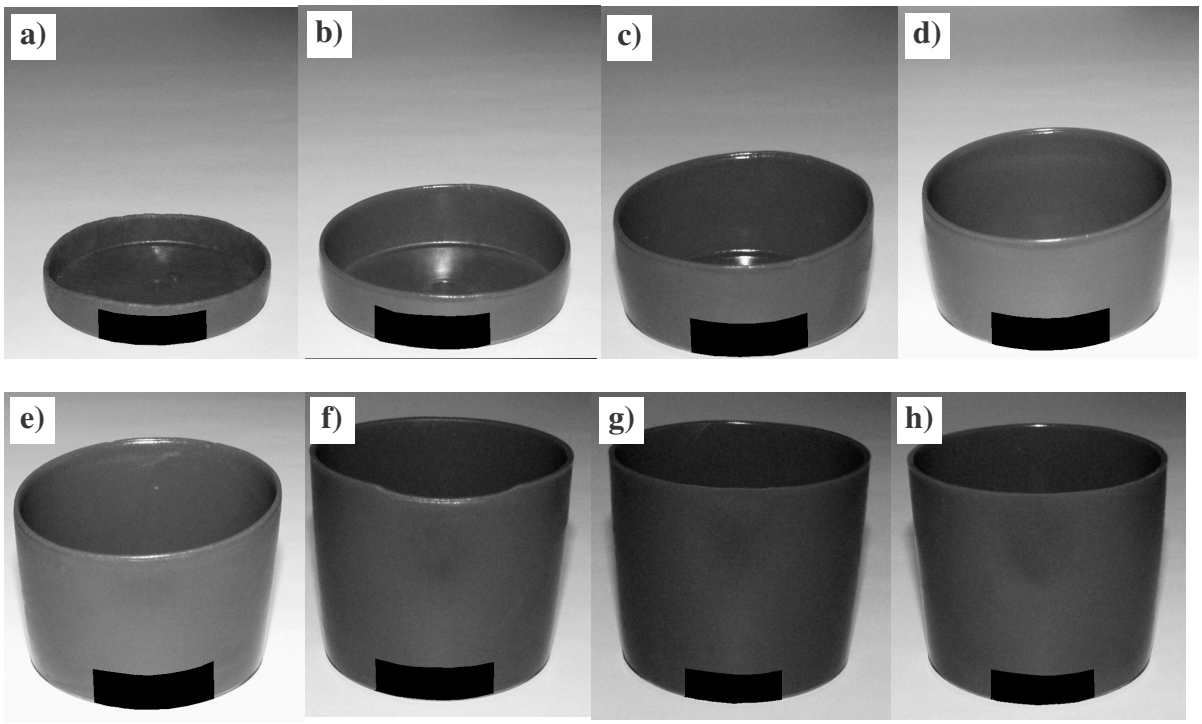


Figure 1. Relationships between crystallites mean size and injection time



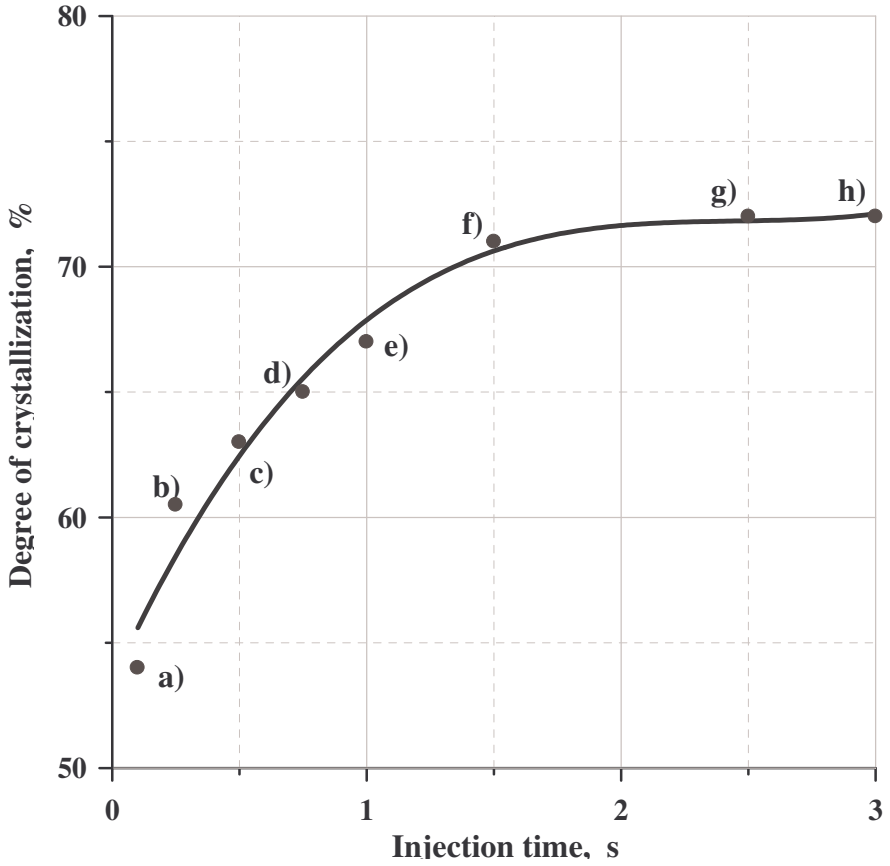


Figure 2. The results of the X-ray tests of the degree of crystallinity (places of drawing the samples for X-ray tests are marked black)

In order to confront the results of the degree of crystallinity tests and the ones obtained from numerical calculations the plot of the dependence of the thickness of solidified material layer near the mold walls on time was made. The results are shown in figure 3.

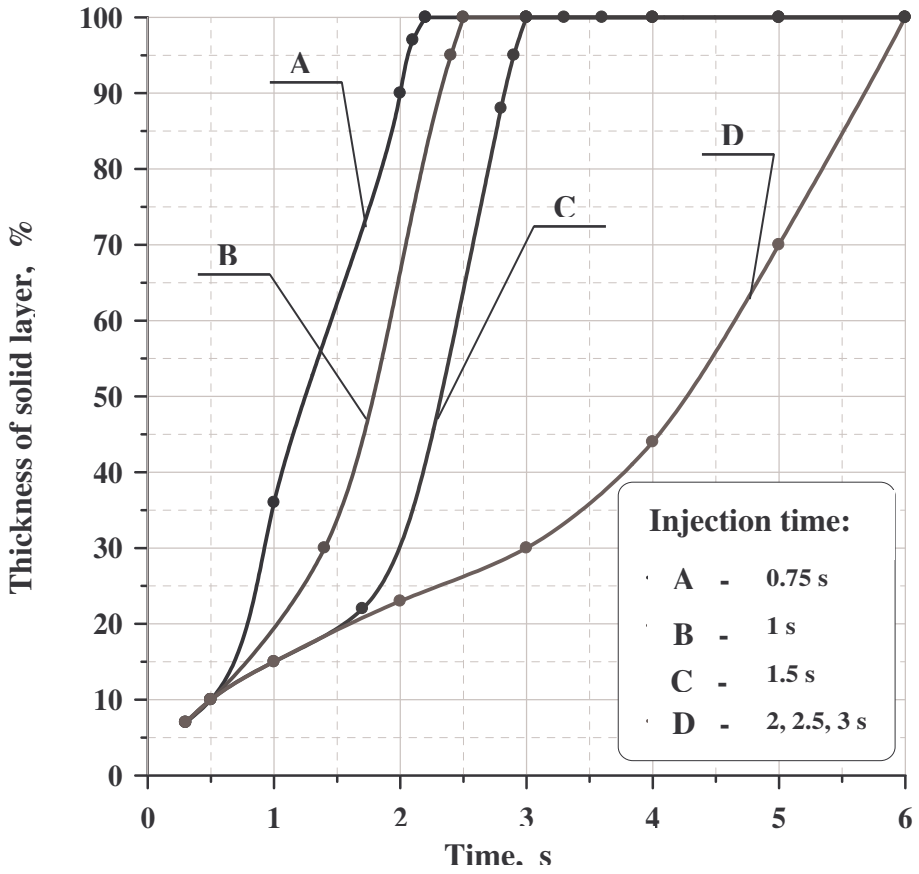


Figure 3. The dependence of the thickness of solidified material layer on time

The decrease in a rate of building up the thickness of a solidified material layer near the mold walls with the increase in injection time was stated. Particular decrease in this rate was observed for injection time value higher than 1.5s. For injection time value 2s and higher the runs were nearly identical. The discussed results reflect in the results of the degree of crystallinity tests. It can be stated that a rate of building up the thickness of a solidified material layer is inversely proportional to the degree of crystallinity.

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