THEORETICAL CONSIDERATION AND EXPERIMENTAL RESEARCHES REGARDING THE INFLUENCE OF HOLDING PRESSURE OVER THE SHRINKAGE OF INJECTION MOLDED PIECE.

CHIRA Dan, RUS Alexandru
University of Oradea, dan.chira@rdslink.ro

Key words: injection moulding, holding pressure, shrinkage,

Abstract. Injection molding process the injection and compacting phase of the melted material. During the second phases over the melted materials is applied an injection pressure, and after this, the packing pressure. The packing pressure can be development up to various values by the hydraulic system, result different values of compaction of melted material, resulting different values for the injection molded piece mass.

1. THEORETICAL CONSIDERATIONS.

In injection molding process the holding time follow the fill time, t_i, figure 1. During the holding time, t_h, is apply the holding pressure, with purpose to introduce an supplementary quantity of melt inside the mold, for compensation the diminution of volume due the cooling. Is necessary to keep the holding pressure until the gate freeze. To remove quickly the holding pressure, equivalent with an small holding time, without the gate freeze, allow to the melt to flow back from the mold. Result an diminution of injection molded piece mass, with negative influence over the shrinkage and warpage, existing an correlate between the mass and shrinkage and warpage. In the same time, a too long holding time lead to unjustified energetic consumption.

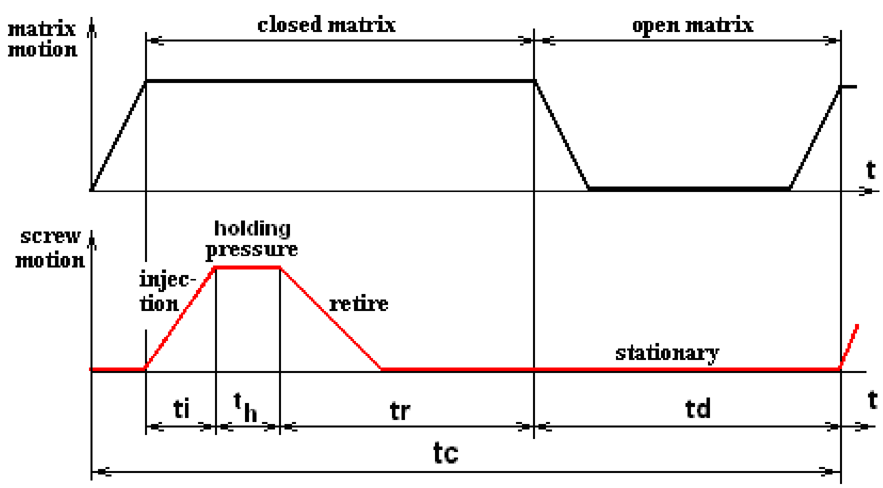

Fig. 1. Grafic of matrix and screw motion in injection molding process: t_i- injection time, t_h- holding time, t_r – cooling time, t_d- demulation time, t_c –cicle time,

The holding pressure follows after the filling phase, when the maximum pressure, P_{imax}, has been reached. In figure 2 is presented the graphic of pressure variation inside the cavity of mould. The injection pressure should rise approximately in a linear gradient during the filling time. When the filling phase has been completed the melt is compacted to ensure the contours of molded piece, and compensates the thermal contraction of thermo-plastic material. The melt start cooling near the wall of cavity, the run section is little, viscosity increase and inhibits the pressure transfer inside the mould. When the gate of the mould is frozen, the melt can't flow back from the mold, and the screw can be retire.

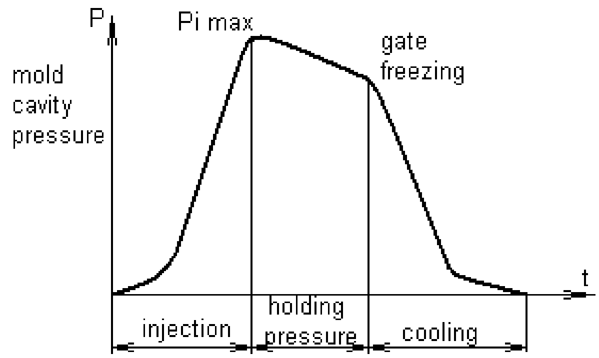

Fig.2. The graphic of inside mould cavity pressure variation.

The different characteristics of the amorphous and semi-crystalline thermoplastic materials make no difference in filling phase, but this have different viscosities and coefficient of thermal expanse. Semi-crystalline thermoplastics, such polyethylene (PE), polypropylene (PP), polyamide (PA), etc., need more much melt added in to the mould to compensate the volume contraction, and so to prevent high shrinkage and warpage. In this case is necessary to increase the injection pressure, holding pressure and holding time. Amorphous thermoplastics, such as polystyrene (PS), acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), polyvinylchloride (PVC), etc., during the holding pressure the mold cavity pressure drops to atmospheric pressure in same time with piece temperature.
The shrinkage of injection moulding piece is define as a decrease of the volume of plastic melt due the cooling. Holding pressure succeed to injection pressure, and have influence over the dimensional and geometrical accuracy of injection moulding piece.
The shrinkage is influenced by injection mould process parameters in accordance with next relation:

$$C_V = 1 - \frac{V_p}{V_m} = 1 - \frac{\dfrac{V_m}{1+\alpha_v^{k_{pi}}(T_m - T_o)}}{V_m} = \frac{\alpha_v^{k_{pi}}(T_m - T_o)}{1+\alpha_v^{k_{pi}}(T_m - T_o)} \qquad (1)$$

Where:

α_v- coefficient of volume dilatation, indicate the influence of temperature over the melt of thermoplastics materials,

k_{pi}- coefficient that indicate the influence of injection and holding pressure over the coefficient of volume dilatation,

T_m- melt temperature,

T_0- ambient temperature,

In figure 3 is present the theoretical graphic of shrinkage variation with holding pressure.
An extremely important theoretical issue with direct implication upon the practical aspects of the injection process, is the variation of injection piece mass with holding pressure. The variation of relative density of the melted material with the injection pressure is given by the relation:

$$\rho_{spTPi} = \frac{\rho_o}{1+\alpha_v^{k_{pi}}(T_m - T_o)} \quad [\frac{kg}{m^3}] \qquad (2)$$

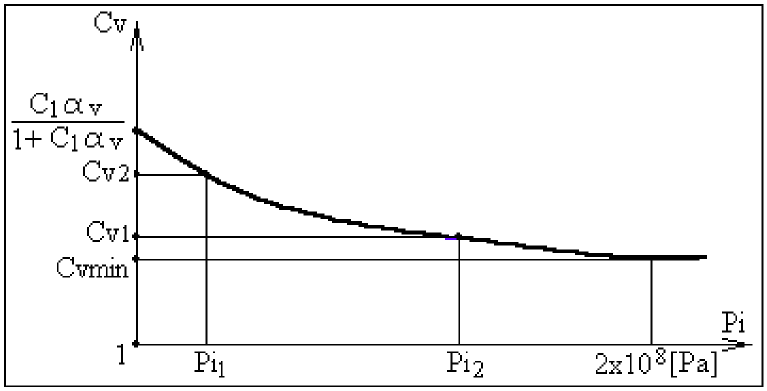

Fig.3. The graphic of shrinkage variation with holding pressure.

The mass of injection molded piece is given by formula:

$$m_p = \rho_{spTPi} \cdot V_c \quad (3)$$

Where V_c is the volume cavity inside the mould at mould temperature. The variation graphic of the injection piece mass with the injection pressure is presented in figure 4.

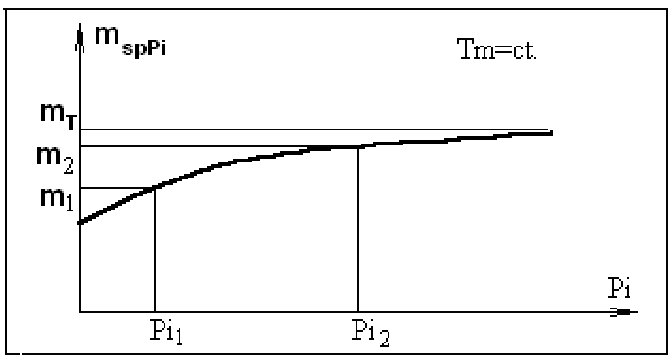

Fig.4. The graphic of the injection piece mass variation with injection pressure.

2. EXPERIMENTAL RESEARCHES.

Our experimental researches were targeted to confirming our theoretical sup-positions referring to the mass of the injection molded piece, as they are featured in first part.

For experimental researches setting up on the injection molding machine the following condition: a continuous regulating of the injection pressure with the help of the proportional hydraulic elements featured; a regulation of the injection pressure so that, by the end of the injection process, it equals with the holding pressure; the injection of the melted material is to be carried out at a constant injection speed. We are setting on injection machine value for packing pressure from 600 to 1200×10^5 Pa, and for cooling time three series: 28 s., 38s. and 48 s. In figure 5 is present the graphic of injection molded piece mass with injection pressure, equal with holding pressure, result after experimental injection.

In figure 6 is present the graphic variation of shrinkage with packing pressure. Experimental researches confirm the theoretical aspects, increase of injection molded piece mass with holding pressure and a diminution of shrinkage with holding pressure.

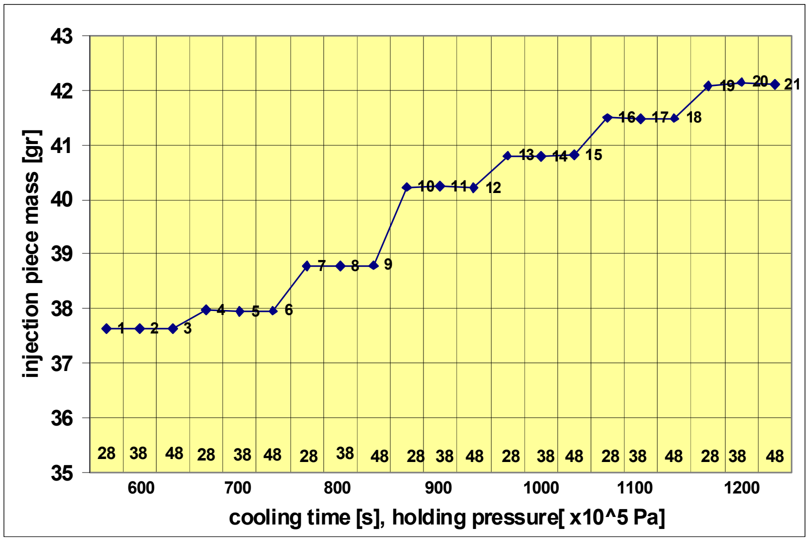

Fig. 5. The experimental graphic of the injection piece mass variation with holding pressure.

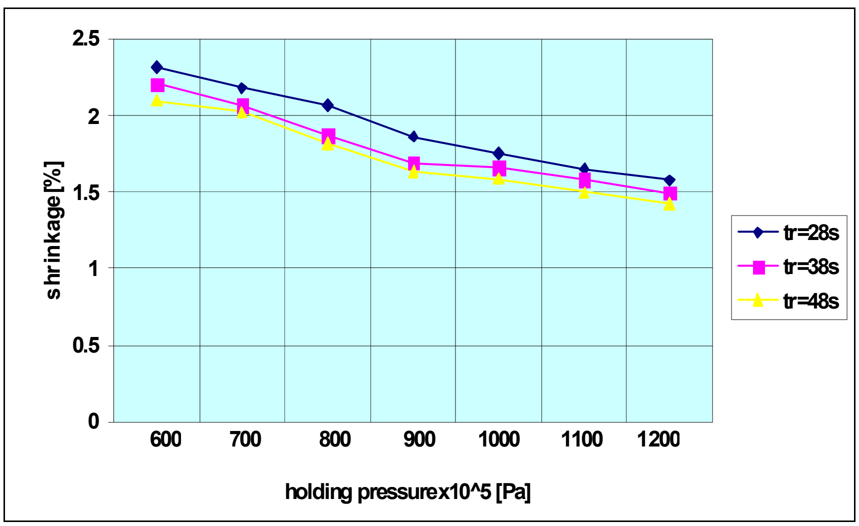

Fig. 6. The experimental graphic of shrinkage variation with holding pressure.

Bibliography:

1. Chira Dan, - Optimizarea comenzii maşinilor de injectat materiale termoplastice. Teză de doctorat. Universitatea din Sibiu. 2006.
2. Chira Dan, - The influence of temperature and pressure over the volume variation of plastic melt in dosing-melting stage in injection mould machine. Annals of Oradea University, Oradea, 2003.
3. www. kistler.com,- Fundamentals of mold cavity pressure measurment, 2010,