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DISCONTINUOUS COOLING IN INJECTION MOLDING PROCESS

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Abstract: The paper presents an method to improve the injection molding process, through the discontinuous cooling of the mold. Mold temperature have an important influence over the shrinkage and warpage of injection molded piece, requireing a low temperature, but in the same time this temperature infuence the flow of melt inside the mold, requireing a high temperature. This method using an pulsed cicle for cooling water inside the mold. This method can be used only in the case of long time cicle and long pieces.

1. General consideration.

The shrinkage and warpage of the injection molded piece is determineted by the injection pressure, packing pressure, cooling time, melt temperature and mold temperature, acording with formula:

$$C_V = \frac{1 + \alpha_v^{kpi}(T_m - T_M)(1 + \frac{4}{\pi} \cdot \frac{1}{e^{C_2 tr}})}{\alpha_v^{kpi}(T_m - T_M)(1 + \frac{4}{\pi} \cdot \frac{1}{e^{C_2 tr}})} \quad (1)$$

Were : α_v – the coefficient of thermal expansion,
k_{pi} – correction coefficient of α_v with injection pressure,
T_m – melt temperature,
T_M – mold temperature,

$$C_2 = \frac{a\pi^2}{S^2} = ct. \quad (2)$$

a- thermal diffuzivity,
S- thickness of moulded piece,

The shrinkage and warpage of the injection molded piece decrease with decrease of mold temperature, figure 1,

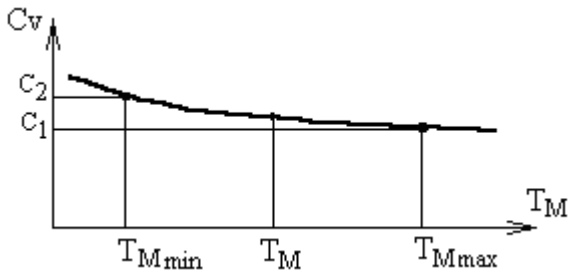

Fig.1. *The graphic of the shrinkage variation of injection molded piece with mold temperature.*

But, in the same time, for a good flow of the melt inside the mold, especially in case of long pieces with small thickness, the mold temperature must to be high, to evitate the frozen of melt, and stop the flow.

Continuous cooling use a constant flow of cooling liquid, at a constant temperature, and keep the mold temperature constant. The design of the cooling sistem determinate the cooling time and the quality of injection moulded piece. The cooling system must to be designed such the quantity of heat brought into the mold by the melt to be dissipated as qiuckly as possible without the temperature of the mold surface fall below the flow temperature.

Heat quantity given up from melt is taken by mold, cooling liquid and environment.

The cooling time is given in acording with formula :

$$t_r = \frac{s^2}{a\pi^2} \ln \frac{4(T_m - T_M)}{\pi(T_p - T_M)} \qquad (3)$$

where: -s – thickness of molded piece,[m]

-a- thermal difuzivity, [$m^2 s^{-1}$]

-T_m- melt temperature, [K]

-T_M- mold temperature, [K]

-T_P- piece temperature in open moment of mold, [K]

The grafic variation of shrinkage and warpage with cooling time is present in figure 2

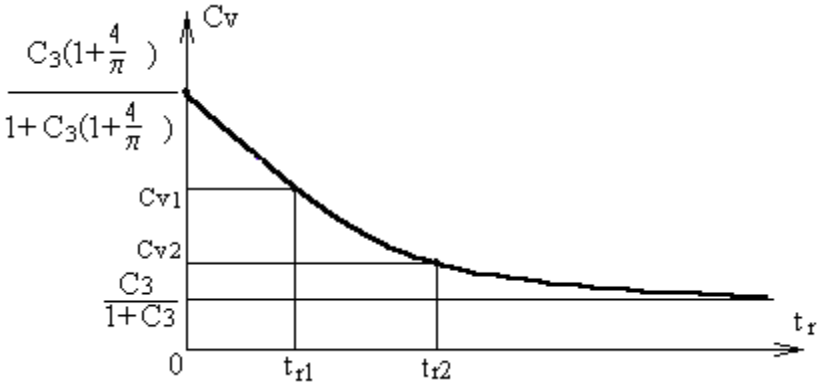

Fig.2. *The graphic of the shrinkage variation of injection molded piece with cooling time.*

Mold temperature have an important influence over the shrinkage and warpage of injection molded piece, requireing a low temperature, but in the same time this temperature infuence the flow of melt inside the mold, requireing a high temperature.

The idea of discontinuous cooling is to cause an extensive cooling of the mold and melt in first part of the injection cycle, following by a warm up of mold temperature for a good flow of the melt.

The method of discontinuous cooling is present in figure 3. For an good flow of melt inside the mold, especially in case of long molded pieces, and low thickness is necessary to have a high temperature of injection mold, In discontinuous cooling a valve opens the cooling liquid flows inside the mold. The moment for opening of cooling liquid is when the injection pressure stop and packing pressure start. The time for cooling on is more little like closed mold time, because the mold have an thermal inertion. The variation of piece

temperature, cooling time and mold temperature is present in figure 3. Cooling time can start together with packing pressure because the melt cooling in contact with mold wall.

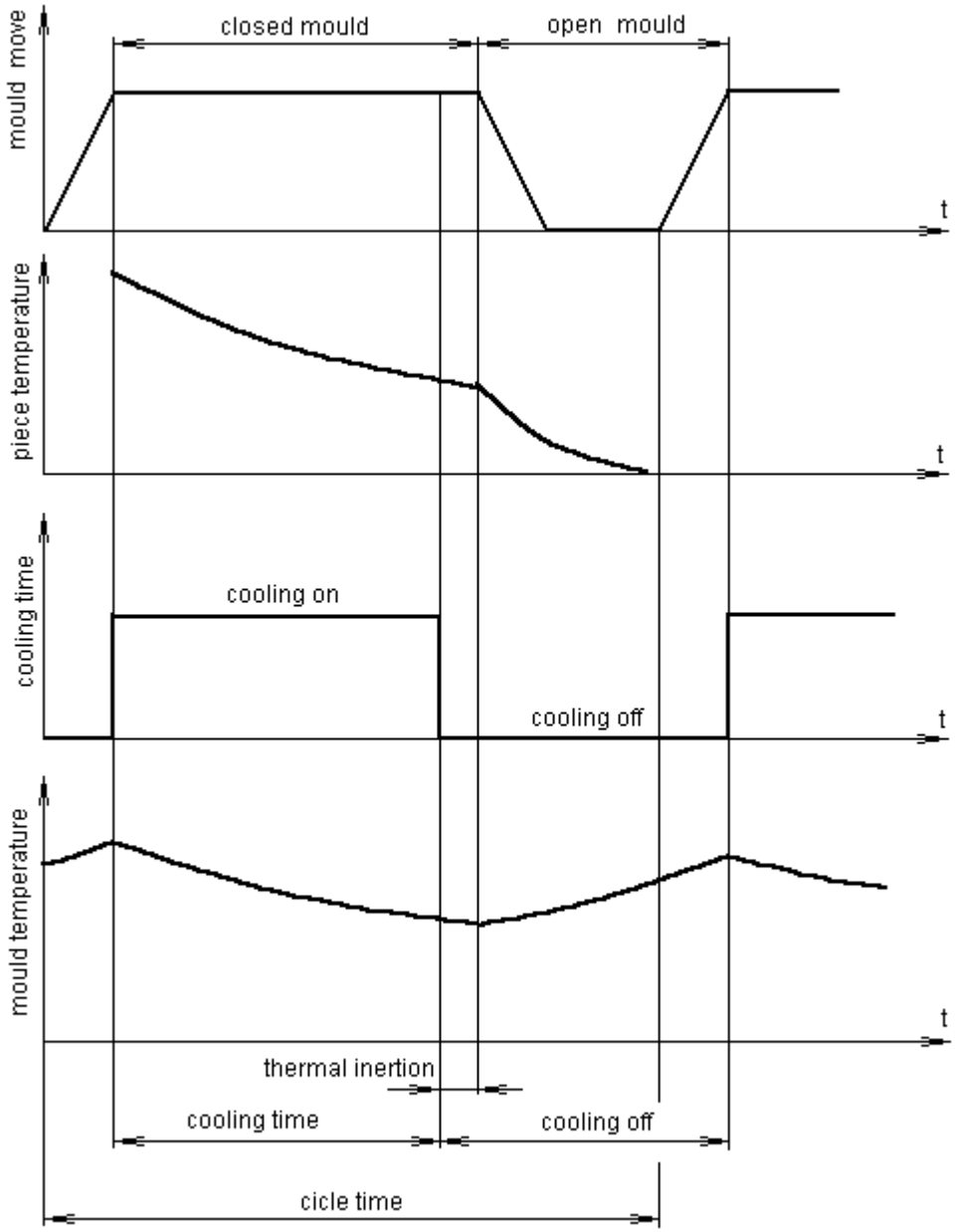

Fig.3. *The method of discontinuos cooling.*

In our experiments we use continuous and discontinuous cooling for a technical piece, same mold, and compare the dimensional changes in this two cases. In table 1 are present the injection parameters.