

## **RESEARCH REGARDING THE INFLUENCE OF THE THERMAL CONCEPT OF THE MOLDS ON THE QUALITY AND PRODUCTIVITY OF THERMOPLASTICS INJECTION PARTS**

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**Key words:** mould, temperature, thermoplastic, injection, deformation.

**Abstract** This work square up to the sizing channels of temperature for injected mould having one or more composite mould.

It is presented the necessary determination in order to actuate the length of the cooling channels, also it is theoretically and graphically presentation to the way of optimal lay out to the system temperature.

In this work it is presented the a case study a PP plane pieces, being obtained into a mould injection having only one nest where is dignified the temperature of the mould.

### **1. GENERAL CONSIDERATIONS**

The quality of a product obtained by thermoplastic injection and not only depend on several factors, one of the most important factor is undoubtedly provided by the mold cooling. Temperature sizing system is undoubtedly a complex issue so that the literature on certain difficult questions can find answers satisfactory technical equations of heat are known, their solutions are the computers or computer technical tables, however the right solution is often a complex issue for all manufacturers of molds, because calculations are required on the length, diameter channels cooling mode location, temperatures and fluid flow Temperature.

Nest mold walls are heated at a rate similar to the mass injection of molten material, thus there is a greater temperature difference between mold and cooling water, with a stronger cooling effect.

### **2. TEMPERATURE OF LENGHT CHANNELS CALCULATION**

Calculate amount of heat transferred from a mold injected parts formula:

$$Q = \frac{3600}{t_T} m(i_2 - i_1); \quad (1)$$

- $t_T$  – injected cycle [s];
- $m$  – mass injected parts [Kg];
- $i_2$  – enthalpy at the entrance to mold plastics [KJ/kg];
- $i_1$  – enthalpy materialului plastic la demulare [KJ/kg]; [4]

If you consider that the amount of heat that is discharged in full by slowing the flow of the equation can be written as follows:

$$Q = Sk(T_2 - T_1) \quad [W] \quad (2)$$

where:

- $S$  – channel surface Temperature [ $m^2$ ];
- $k$  – overall coefficient of heat exchange [ $kJ/m^2h^0C$ ].
- $T_2$  – the temperature of injected material [ $^0C$ ];
- $T_1$  - Temperature temperature [ $^0C$ ];

Transmission coefficient is calculated with:  $\frac{1}{k} = \frac{1}{\alpha} + \frac{\delta}{\lambda}$ ; (3)

where [2]:

- $d$  – part and distance between cooling channel [m];
- $\alpha$  – convection coefficient of fluid [ $kJ/mh^0C$ ];
- $\lambda$  – coefficient of thermal conductivity of mold material [ $kJ/mh^0C$ ];

Circuit transmission coefficient is calculated in temperature:

$$\alpha = 19,37 + 0,27T_i V_T^{0,95} \text{ [kJ/mh}^0\text{C];} \quad (4)$$

- $T_i$  – temperature input circuit moderation [ $^{\circ}\text{C}$ ];
- $V_T$  – temperature output circuit [ $\text{kg/m}^2\text{h}$ ];
- $r$  – coolant density [ $\text{kg/m}^3$ ];

Flow is calculated as:

$$V_T = 10^{-4} w \rho \text{ [kg/m}^2\text{h];} \quad (5)$$

Use the fluid velocity in channel  $w \geq 2300\text{m/h}$ .

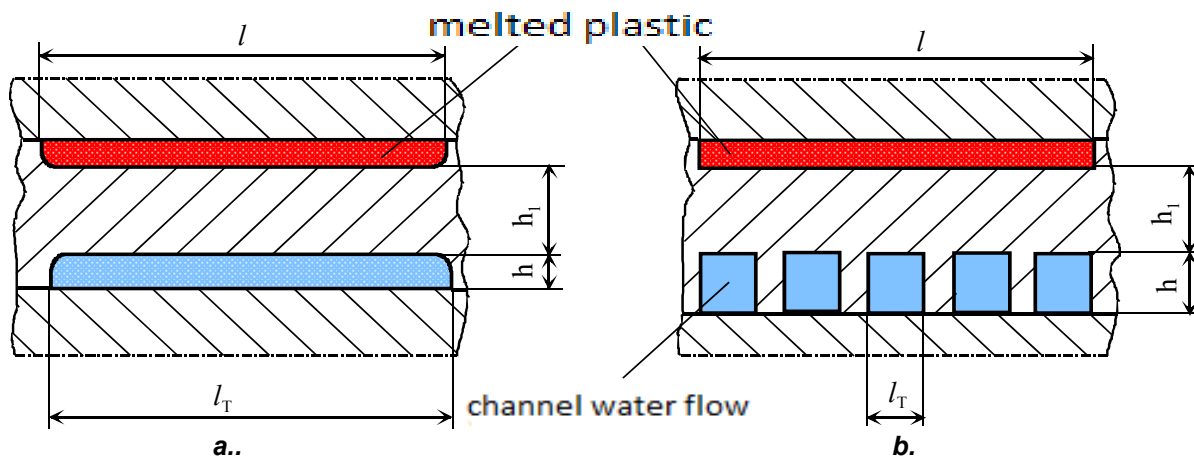
Channel length is calculated  $l = Q \frac{\frac{1}{\alpha} + \frac{\delta}{\lambda}}{\pi \cdot d_c (T_2 - T_1)} \text{ [m]; [4]} \quad (6)$

### 3.LOCATION TEMPERATURE 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.

Figure 1 shows a variant of the channel location of moderation.

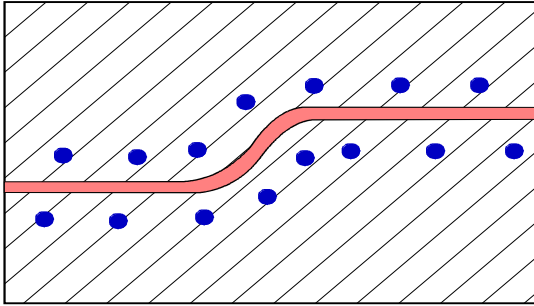


**Fig.1. Methods of locating channel temperature [4]**  
**a – ideal of physical; b – technically optimal;**

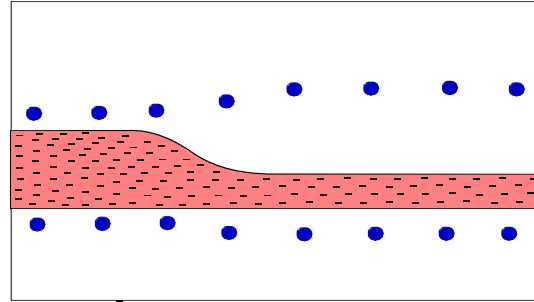
Tempering best physically is if the channel width of moderation should be the width piece injected (fig.1.a), but for reasons of rigidity, high injection pressures due to technical optimal replaced with a solution. After studies have concluded that section square channels are the most optimal. In practice however, the solution uses facilities due to implementation of channels is that of moderation performed circular channels by drilling is recommended in this case  $h_1 = (2 \dots 3) \cdot d_c$ ,  $d_{c,1} = \max 3d_c$ .

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: [2]

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.)



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



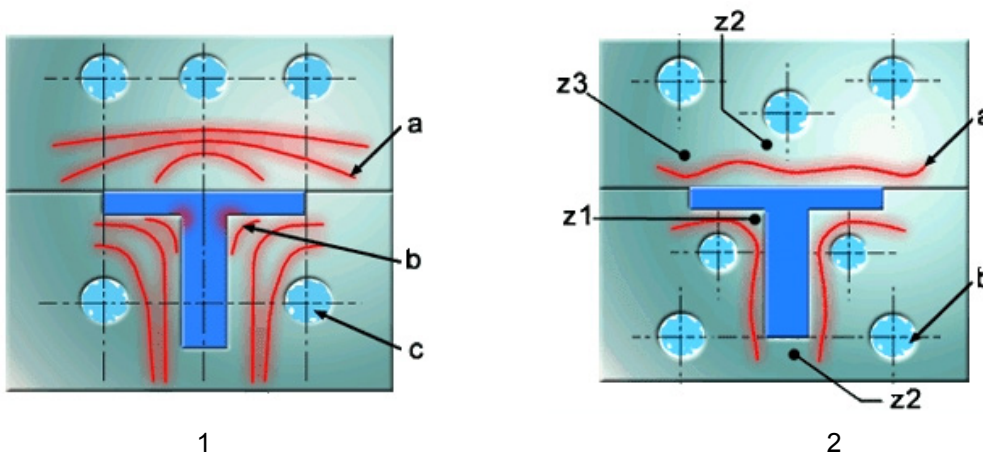
**Fig.3. Ideal location of cooling channels in one piece with variable thickness. [2]**

Holes for cooling channels must be in principle a diameter of 2.5 times the wall thickness of the product, but not less than 5 mm. Distance between holes for cooling channels and the mold walls to practice values of 2.5 - 3D (hole diameter). For injection process that develops pressures greater than 500 steel bars is taken into account to ensure the necessary rigidity. Designing physical channel is subject to moderation sometimes nests mold geometry, the ferries and the core, the planes of separation and the injection mold throwers. This together with the fact that the majority of injected parts were variations of wall thickness, corners, bosses, edge stiffening causes hot spots on the surface of injected parts. Recommended for disposal:

1. Temperature near the channel ribs, as close to the hot zone;
2. Temperature increase in the number of channels [3]

In variant -1 (Fig. 4.) Is observed more isothermal (a) indicates that the mold temperature variations and even hot points (hot) (b) cycle time may increase and subsequent deformation after injected parts. These drawbacks were eliminated through optimal arrangement of circuits for moderation in variant-2 where we have a single isotherm (a) and multiple channels of moderation (b) of different sizes and different placement. If it increases the distance between channels moderation nest mold surface temperature will be more uniform and will increase during injection of plastic melt.

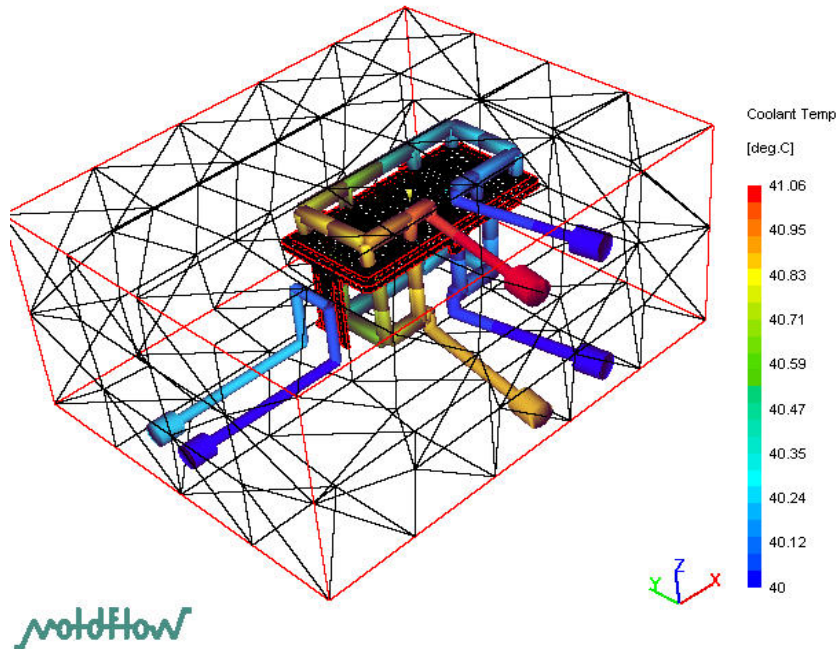
If the counter is decreased too much distance between channels by slowing heat melt the plastic injection mold in the nest will be removed too quickly and therefore will cause too much temperature variation of flow fronts which can lead to quality problems injected parts.



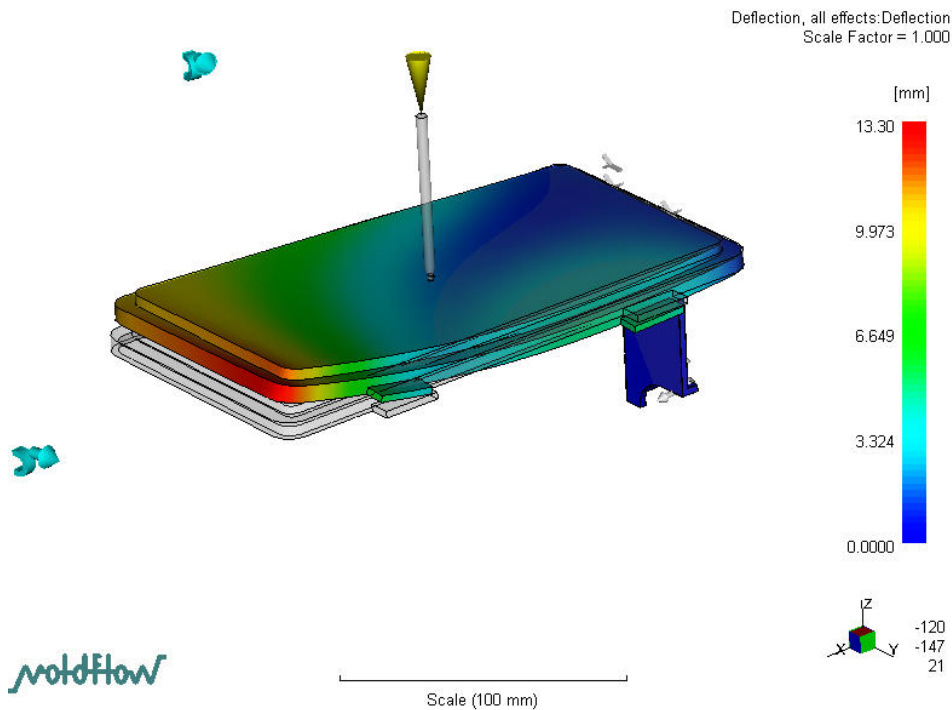
**Fig.4. Variations of temperature circuit layout of the injection mold: 1- incorrect design, 2 – ideal.**

### 3. CASE STUDY

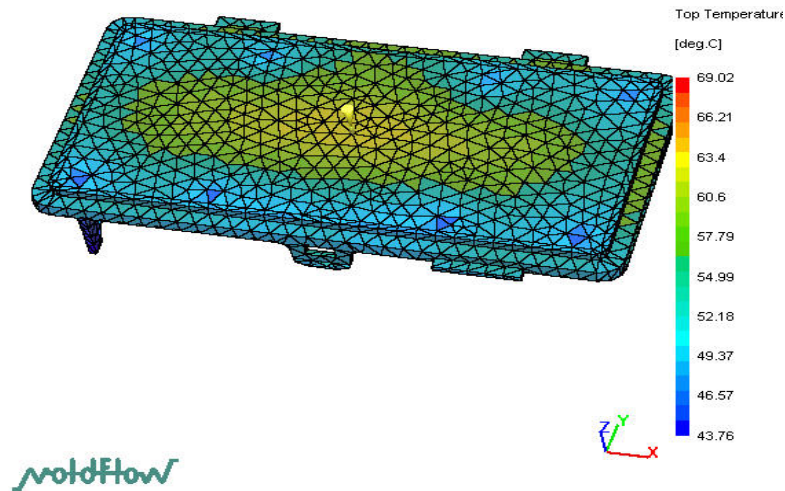
It presents a case study conducted in polypropylene flat-shaped product that is injected into a hot mold steel nozzle with a single nest. In Figures 5 and 6 is a circuit placement a moderation, ie, deformations occurring in part because design of the system of moderation.



**Fig.5. Chart changes in water temperature fixed die (nest).**



**Fig.6. Total strain diagram of the song.**



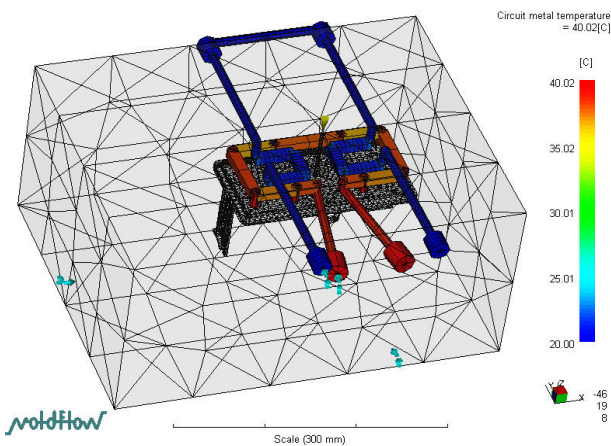
**Fig.7. Representation temperature play.**

Following studies carried out in 3D modeling and simulation using Moldflow software and practical experiments conducted, it was found that made no moderation system ensures relatively uniform temperature on all surfaces of the two die, because the central area due to the presence hot nozzle flow and lack of cooling melt temperature is higher. Location moderation system is shown in figure 5.

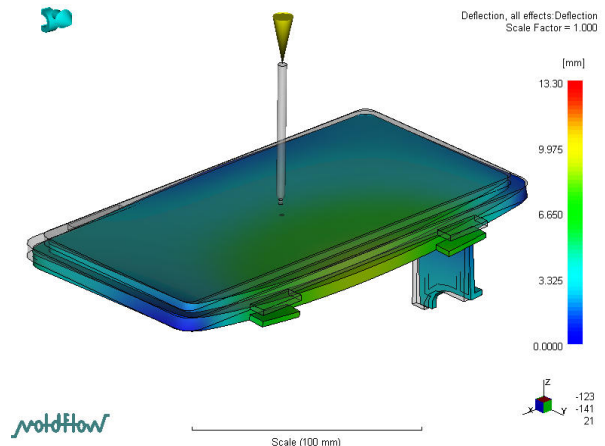
Studies show that in this area requires additional circuit location, which apparatus mold temperature, the temperature variation having direct influence on the quality of the finished product, which in most cases lead to relatively large residual strain, particularly directions Ox and Oz

In figure 6, the deformations have occurred in part after the mold release phase. clearly seen where the influence of mold temperature.

To address these shortcomings have made an additional cooling circuit in the central area where the temperature was high due to the presence nozzle means (fig.8.) Running through their channels to obtain a more turbulent water flow, which increases flow significant cooling efficiency, which leads to uniformity of temperature in mold temperature is reflected clearly in play. Deformations play as shown in figure 9 are reduced to near zero.

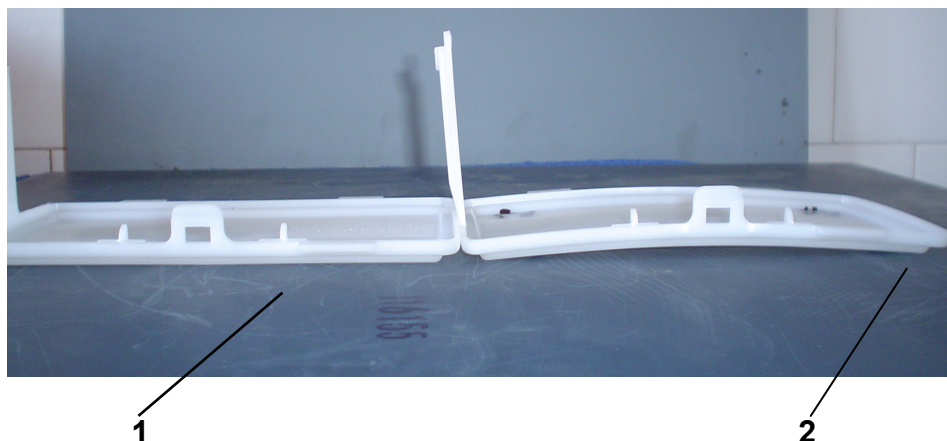


**Fig.8. Representing new system of moderation of fixed semimatriței (nest)**



**Fig.9. Total distortion of song chart**

Figure 10 is presented in two parts which are observed actual deformations influenced moderation system.



**Fig. 10. Representation piece injected with the two systems of moderation  
1- good song (new system of moderation), 2-piece deformed (old system Temperature);**

#### **4. CONCLUSIONS**

Module sizing and placement of circuits Temperature (cooling) to contribute significantly to the quality of the mold dies, because the temperature during the injection process is the main factor that influence the quality of the finished product.

If an improper location of cooling holes there is a danger that, due to uneven cooling of the part injected occur in certain area internal tensions within the play. Higher temperature only in certain cases can make some quality improvements, in turn decreases the efficiency of the process, due to large cooling time leads to lower productivity. Lower temperature leads to rapid degradation of the melt, in order to obtain a homogenous structure with a weak lens. Heat deflection temperature is due to great differences between the two surfaces play, in which case it acts as a bi-metal blade leading to different thermal contraction.

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