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THREE-DIMENSIONAL SIMULATION OF A THERMOPLASTIC POLYURETHANE INJECTION MOLDING WITH A METALLIC INSERT: GATE LOCATION AND COOLING SYSTEM OPTIMIZATION

M. Camila Quintana(*), Federico Rueda, Patricia Frontini

Instituto de Investigaciones en Ciencia y Tecnología de Materiales (INTEMA), Universidad Nacional de Mar del Plata, Mar del Plata, Buenos Aires, Argentina.

(*)*Email:* cquintana@fi.mdp.edu.ar

ABSTRACT

This work study the insert injection moulding process of a dowel holder, which is a rubber-made machine element used in the production of concrete railway sleepers. The flow path of polymer melt and its temperature distribution predicted by CFD software Moldex3 were evaluated to compare which of two possible gate location would lead to optimal bond strength between insert and part. An additional objective was to analyze the efficiency of two possible cooling channel configurations (parallel or serial). Simulation results show that a gate location closer to the insert would lead to lower air trap formation and higher melt temperature around insert. Serial channel layout has higher efficiency and allows to achieve a uniform temperature distribution along the piece.

Keywords: injection moulding simulation, part insert, thermoplastic elastomer.

INTRODUCTION

Dowel holders are machine elements used in the production of concrete railway sleepers. Its main function is to keep the dowels in position during the concrete casting. These parts are made of a thermoplastic elastomer, overmolded on a metallic insert. The main requirements for dowel holders are: good elastomer-to-insert bonding - that implies minor amount of weld lines formation and air trap- to prevent tearing during the un-molding stage and precise dimensions to be easily screwed and to prevent cement leakages to the dowels. Thus, the specific goals of performing injection molding simulation of this case are:

1-Evaluate flow path and temperature distribution around part insert, weld line formation and air trap, predicted by Moldex3, to decide which of two possible gate location will lead to optimal bond strength between insert and part.

2-Evaluate temperature distribution along the piece and cooling channel efficiency, predicted by Moldex3, to decide which of two possible cooling channel configurations (parallel or serial) will lead to optimal part quality, i.e. with lower total displacement or warpage and shorter cycle time.

RESULTS AND CONCLUSIONS

Figure 1 and 2 displays respectively the gate locations and cooling systems analysed. To achieve optimal bond strength, melt temperature level must be higher as possible (the upper limit is polymer degradation temperature). Also, flow path length must be minimized and potential residual stresses around the gate must be avoid [1]. Simulation predicts that the melt temperature at the time it contacts the insert is slightly higher for gate location 1 (230°C for location 1 and 228°C for location). Also, for gate location 1, the flow path length is shorter: injected from gate 1, melt contacts the insert al 0.02 whereas injected from gate 2, it does at 0.09 s.

Weld line and air trap predictions are shown in Figures 3 and 4 respectively. Efficiency predicted by simulation for the cooling channels layouts analyzed is display in table 1.

Considering the higher amount of air trap and being melt temperature the most important factor determining bond strength between part and insert, gate location 1 is choose as the optimal one.

Even the exterior temperature of the part at end of cooling is similar for both cooling channels configurations (slightly higher for parallel cooling channels), the temperature distribution is more uniform along the piece for serial cooling channels. For this reason and for its higher efficiency, serial cooling configuration is choose as optimal one.

Fig. 1 - Gate location analyzed

a) b)

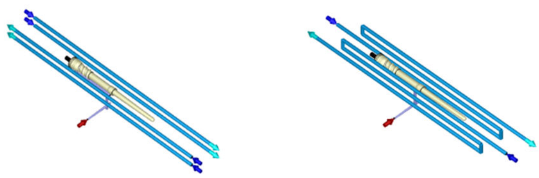

Fig. 2 - Cooling channels configuration analyzed:
a) Parallel b) Serial

a) b)

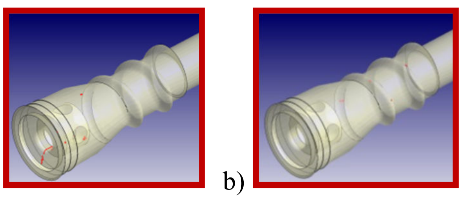

Fig. 3 - Weld line predicted for: a) gate 1 b) gate 2

a) b)

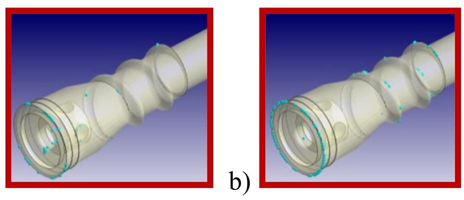

Fig. 4 - Air trap predicted for: a) gate 1 b) gate 2

Table1. Efficiency of cooling channel configurations

Type of cooling system	Min. Efficiency (%)	Max. Efficiency (%)
Parallel	22	27
Serial	49	50

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