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True 3D and Fully Transient Mold Temperature Simulation of a Rapid Heat Cycle Molding Process

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The objective of the proposed research is to develop a novel fully transient, three-dimensional rapid thermal response heating and cooling analysis architecture for injection molding. The quality characteristic of molded part, such as weld line, flow mark, exposed fibers and poor surface transcriptions, greatly depends on thermo-mechanical history of the molding process. But it can be overcome by having a high mold temperature. The Rapid Heat Cycle Molding (RHCM) Process was introduced to shorten the required cycle time by heating the mold with high temperature steam in its filling and packing phase, and chilling the mold with low temperature coolant in its cooling phase. Due to its excellent balance in product performance and production cost, RHCM has gained a lot of attention in plastic injection molding industry recently. The conventional cooling analysis programs apply the cycle-averaged theory to minimize the required computation time and memory requirement. However, the cycle-averaged theory is no longer applicable to RHCM as its mold temperatures are far different in filling/packing and cooling phases. Due to this fact, a fully transient, three-dimensional molding heating and cooling analysis architecture is presented. (1) The coolant temperature variation and steam condensation in cooling channels, and (2) fully transient heat transfer coupling between cavity, mold, and cooling channel are considered in the presented analyses. The mold and cavity temperature response with time are also simulated. The comparison of the required cycle time, molding pressure, flow stress of RHCM process with those of the conventional process will be presented. This new algorithm also helps improve the warpage prediction accuracy of those processes with extended cooling time and constant coolant temperature, such as high precision molding and optical part molding.