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A Melt Replication Process to Create Plastic Products with Precise Surface Micro Patterns and High Optical Transparency Applied to Display Parts and µ-TAS

H. Ito (a), K. Yakemoto (a), K. Kishida (a),T. Shiroganeya (a), T. Shigeishi (a), A. Naitou (a) and I. Satoh (c)
(a) Machinery Research Laboratory, The Japan Steel Works, Ltd.,J-736-8602, Japan
(b) Development Planning Department, The Japan Steel Works, Ltd.,J-236-0004, Japan
(c) Department of Mechanical and Control Engineering, Tokyo Institute of Technology,J-152-8552, Japan

In this study we developed a new melt-replication process to fabricate thermoplastic products with 3-dimensional geometry, thin wall, large area, precise micro-patterns and high optical-transparency, and proved experimentally and theoretically the validity. Furthermore, we discussed the applicability to display parts and µ-TAS (Micro-Total Analysis Systems), and compared its superiority to conventional injection-molding and imprinting processes.

In the first stage of this process, a thin molten polymer layer thicker than 100µm was coated on the large surface area of a metal mold with micro-patterns. In the next stage, the polymer layer was compressed under the pressure less than 10 MPa, optimally controlling cooling temperature profiles. A molten polymer was directly and instantaneously filled into very fine patterns on the surface of the metal mold without any drops in temperature. Then molded products with the homogeneous replication of the micro-patterns were obtained. In this process, fountain flows and the polymer solidification of surface-layers were hardly observed during both coating and compression. This resulted in lower residual-stresses, minimal birefringence, and higher optical-transparency for molded products.

From our experiments using PMMA(Polymethylmethacrylate) and COP(Cyclo-Olefin Polymer), we could directly obtain products with the thickness of 100µm under the compression-pressures less than 10MPa. Particularly, in the case of a metal mold with 150mm square, and with fine line patterns of 50 µm depth and 20µm width on the surface, we could achieved replication ratios of more than 94% at 5.2MPa. Furthermore, in the case of a lot of holes with the diameter of 20µm and the depth of 50µm, high replication ratios of larger than 95% could be attained.