Symposium 16

Precision Injection Molding, New Molding Technologies

S16-299

The role of heat transfer in micro-injection molding

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Micro-injection molding is established as the key technology for the large-scale production of micro-sized parts. Yet, the details of the injection process on the micro-scale are not well understood. The examination of the flow patterns during the filling stage reveals that they resemble those of conventional injection molding; hence, it becomes apparent one feature that sets micro-injection molding apart from conventional molding is the rate of heat transfer and temperature profiles of the filling polymer and the mold. This work investigates, primarily from a modeling stand-point, the effect of heat transfer on the filling and packing stages. Three-dimensional transient simulations of coupled momentum and heat transfer during micro-injection molding of thermoplastics are performed using the commercial software FIDAP. Polymer melts were modeled with a generalized-power-law viscosity model (with temperature dependent thermal properties) and pressure dependent density. The micro-mold geometry has several challenging features from both a practical and computational perspective: high aspect ratio, sudden width change after the gate, and flow through micro-sized ribs. Through the simulations, the effect of the filling rate, melt temperature, cooling rate, and wall temperature on the flow and thermal history of the polymer are examined. The results shed light on the distinction between micro- and macro-injection molding and demonstrate how the rate and spatial distribution of heat transfer set the optimal mold temperature, determine the production-cycle time, and predominantly control the mechanical properties of the final product. Comparison with material characterization studies of molded parts on the same systems will also be presented.

S16-1128

Combined flow visualisation and ultrasonic techniques for characterisation of the micromoulding process.

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Micro-injection moulding (micromoulding) and high speed, thin wall injection moulding provide environments where deformation rates, thermal gradients (both spatial and time dependent) and pressures can be many times higher than those typically encountered in conventional injection moulding. Such conditions pose new challenges for understanding of the polymer flow behaviour and the subsequent development of constitutive equations for numerical simulation methods. There is a significant requirement for high quality experimental data for validation of these models, but such process measurements can be challenging due to limitations of current sensor technologies imposed by the very short injection times and the compactness and complexity of the mould tools. Work has been performed to develop and combine characterisation tools to enable further understanding of the micromoulding process. Sol-gel film ultrasonic sensors provide compact solutions for measurement of flow front position, cavity wall contact time and material consistency and are easily integrated into micromoulding tools. Flow visualisation using high speed camera technologies and transparent mould cavities allows imaging of polymer flow behaviour, shrinkage contours (using Newton's rings) and stress induced birefringence measurement. This work has developed a synchronised system allowing simultaneous process measurement using each of these techniques in tandem with conventional measurement devices such as cavity pressure sensors. This system provides a comprehensive data set describing the filling, packing and cooling behaviour of polymers within micromoulding cavity geometries. Data have been collected for a range of cavities and materials.

S16-181

Morphology and properties of polycarbonate/multiwalled carbon nanotube composites for different microinjection molding conditions

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The mechanical properties, electrical conductivity and morphology of polycarbonate/multiwalled carbon nanotube composites have been studied for different microinjection process conditions. The composites were obtained by diluting a commercial masterbatch containing 15 wt %MWCNT using a twin-screw extruder in optimized mixing conditions and at two different mixing temperatures, 210 and 250 0C. The specimens were then microinjection molded under different conditions using a micro-injection molding machine. The morphology of nanocomposite was investigated using scanning and transmission electron microscopy and atomic force microscopy. It was shown that for the samples prepared at 210 0C the nanotubes were dispersed individually in the matrix and there were only a few aggregates; however, the distribution was not acceptable. For samples prepared at 250 0C, many aggregates were found, but the distribution of nanotubes was much better with no preferred orientation in the extrusion direction. The microscopic analyses of microinjected parts, however, revealed that the nanotubes were all well dispersed individually, distributed and oriented when using nanocomposites prepared at 210 0C. For samples prepared at a mixing temperature of 2500C, most of the nanotubes were pulled out from the matrix, suggesting low interactions between the nanotubes and the matrix. It seems that the drastically high shear rate found in microinjection molding contribute strongly to the nanotube distribution and high degree of alignment. Electrical measurements indicated a significant increase in the electrical percolation threshold after micromolding. The threshold rises from 2 wt % before molding to about 7-10 wt % of MWCNT after molding depending on molding conditions. The Young modulus and toughness also increased considerably with the MWCNT content, although the increases were found to depend strongly on the injection conditions.

S16-213

Manufacture of Thermoplastic Elastomers Tubes by Water Assisted Injection Molding Technology

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The objective of this study was to manufacture thermoplastic elastomer tubes by a novel water assisted injection molding method and to experimentally investigate the effects of various processing parameters on the molded parts quality. Styrene-ethylene/butylene-styrene (SEBS) compounds based thermoplastic elastomers were used for all the experiments. Experiments were carried out on a lab-developed water assisted injection-molding system, which included a water pump, a water injection pin, a water tank equipped with a temperature regulator, and a control circuit. After molding, the lengths of water penetration as well as the hollowed core ratios in molded tubes were measured. The effects of different processing parameters on the lengths of water penetration were determined. It was found that the shrinkage rate and the viscosity of the elastomer materials, and the void shapes of the hollowed cores mainly determined the water penetration lengths in molded products. In addition, a comparison has been made between the parts molded by water assisted injection molding and gas assisted injection molding. It was found that water assisted injection molded parts mold parts with less residual wall thickness distributions along the water channel. The cycle time for water assisted injection molded parts was shorter than that of gas assisted injection molded parts.

S16-230

Ultrasonic micro hot embossing of thermoplastic polymers

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Ultrasonic hot embossing allows fabrication of polymer micro structures with low investment costs. A polymer film is micro patterned by locally melting with ultrasound and molding from a master tool. The entire process is completed in a few seconds. With the same machine micro channels were sealed with a specially designed tool. The fabrication process is demonstrated by manufacturing micro devices such as passive micro mixers, micro flow sensors, and corrugated membranes by ultrasonic hot embossing and welding. All micro devices have been proven to work properly. Besides this, a molded interconnection device (MID) was manufactured by ultrasonic hot embossing. An aluminum film was coated with a polymer layer and locally welded to another polymer film. The edges on the tool had been designed such that the metal was cut around the conductor paths generated. A transponder was manufactured this way within a few seconds and showed a clear resonance frequency at 2.5 MHz.

S16-354

A study of micro replication by compression injection molding

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The replication of polymeric microstructures on a flat surface is not easily carried out by conventional injection molding because of their micro-sized dimensions and stringent tolerances of most applications. On the other hand, injection compression molding is an established process for the manufacturing of optical storage media like compact discs (CD) or digital versatile discs (DVD) with grooves and pits at the micro-scale. However, the flow behaviour of melts in micro cavities remains not well understood and challenging. The difficulties arise mainly from two sources: lack of adequate filling because of premature freezing-off of features with very small thicknesses and excessive deformation during ejection due to high friction at the polymer-metal interface. In this work, a study of the effect of process parameters on the replication of various microstructures on a flat disk using compression microinjection molding is carried out. A commercial micro-injection molding machine has been used in the study. Two optical grade polymers (PMMA and COP) and various mold inserts with embedded microstructures were used. The dimensions of the microstructures on inserts and molded parts were measured with a confocal profiler PLμ from Sensofar. A transcription ratio was defined to assess the quality of the replication. Correlations between the variations of the process parameters and the development of the microstructure during injection compression molding were identified using design of experiment. The above issues and typical results will be discussed.

S16-456

New Developments in Micro Injection Moulding - Multi-Component Technology

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With standard micro injection moulding becoming more and more established in practical manufacturing, special variants are attracting increasing attention. Especially the approaches on multi-component micro injection moulding have to be mentioned: As handling and assembly are difficult especially in micro technology, methods to reduce mounting efforts are of high economic importance. By merging of shaping and mounting procedures in one step economic progress as well as new material combinations and products of high functional integration can be obtained. An interesting approach for the fabrication of metal (or ceramic) micro components is the combination of 2-component injection moulding and metal deposition by electroforming. To produce 2-component polymer templates, first, an electrically conductive base plate is generated by injection moulding of conductively filled polymers. In a second injection moulding step microstructures consisting of insulating plastics are mounted on these plates. The quasi-infinite conductivity gradient of such 2-component templates allows controlled electroplating starting at the base plate only, so that defect-free metal micro components can be achieved. The interactions not only between the insulating/conductive polymers but furthermore between plastics and galvanic deposition will be described. The whole process developement of this procurement chain is supported by the German Research Society (DFG) within the Research Group 702.As a further variant of micro injection moulding, the development of the so-called MicroPIM process facilitates a large-scale series fabrication technology for metal and ceramic micro components. Combined with multi-component technology, an interesting new approach for micro manufacturing is obtained, i.e. the realization of magnetic/non-magnetic or conductive/non-conductive material combinations by two-component MicroPIM. The proces w

S16-485

Correlation between flow-induced orientation and tensile strength of injection-molded polystyrene processed via dynamic melt manipulation

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This study investigates the effect that dynamic melt manipulation based injection molding has on the locally induced molecular orientation and tensile strength of injection molded polystyrene (PS). Melt manipulation refers to a process where the polymer melt is purposely manipulated during processing beyond the extent normally encountered in conventional injection molding (CIM). The specific melt manipulation process investigated in this paper is vibration-assisted injection molding (VAIM). To implement the VAIM process, a conventional injection molding machine is augmented by oscillating the injection screw (in the axial direction) during the injection and packing phases of the molding cycle. The localized final molecular orientation and morphology that results dictates the resultant product response. Typically improved mechanical properties are observed. Here, the effect of uniaxial flow-induced orientation has on the mechanical properties in the flow direction (MD) and transverse direction (TD) of injection molded products was investigated. Three different molecular weights of PS were incorporated into the study to note the difference in mechanical performance. Methods, processing conditions, and mechanical test results for PS by CIM and VAIM are described. Smaller test specimens machined along the gage length of larger molded specimens showed dramatic tensile strength increase in the regions of higher melt manipulation, further supporting the promise of this novel processing methodology. Moreover, a high correlation exists between the tensile strength and relative orientation, depicted as retardation, of the samples.

S16-642

A novel fabrication method for various nickel mold inserts using anodic aluminum oxide for nano structure molding applications

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Recently, nano structures are attracting much interest in the research fields of biomimetics, tissue engineering, photonic crystals and so forth. Since such nano structures are commonly fabricated using high-cost and low throughput procedures like e-beam lithography, it has been of great difficulty to make large area mold inserts having nano structures with various sizes. In this regard, the present study proposes a novel fabrication method for nickel mold inserts, for nano structure molding applications, of which procedures are flexible, cost-effective and large area applicable. The procedures are based on anodic aluminum oxide (AAO) and nickel electroforming techniques. The former enables us to fabricate an AAO template of closely-packed nano dimple or pore structures of various sizes, while the latter provides a strong mold insert from the AAO template. Particularly in the nickel electroforming process, surface passivation technique is introduced if necessary, which allows fabrication of both negative and positive patterns from the single AAO template. Due to the flexibility of the whole procedures, one can introduce additional processes for their own purposes, for example, a micro structure patterning which enables fabrication of micro/nano combined structures. So achieved various nickel mold inserts can be readily employed for polymer replication processes such as an injection molding and hot embossing, allowing comprehensive investigations on the nano structure molding processes.

S16-854

Multi-component technique: Hybrid primary forming of plastics/metal-composites

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Whilst metals and plastics in traditional engineering normally compete with each other, hybrid technology can combine the advantages of both materials. Although, nowadays, various technologies are capable of producing plastics/metal-composites, they all have disadvantages in common due to several manufacturing steps and limitations in productivity or the level of achievable geometrical part complexity. In addition, the material groups are regarded separately. Particularly, the injection moulding process for plastics and the die casting process for metals are treated in a completely isolated way within each group. One approach to overcome the disadvantages described above, which is currently examined at the Institute of Plastics Processing (IKV) at RWTH Aachen University within the scope of Cluster of Excellence "Integrative Production Technology for High-Wage Countries", is to combine the injection moulding of plastics and die casting of metals to create a new hybrid primary forming process with one mould and one machine with regard to the production of plastics/metal-composites. Combining primary forming of plastics and metals two in principle different approaches exist with regard to the sequence of injection of the two different materials: the injection of plastics in a first step followed by the injection of metal and vice versa. The first process can be associated with the combination of plastics injection moulding and die casting of low-melting metal alloys for e. g. plastic parts with conductive paths. The second process can be associated with the combination of the high-pressure-die-casting process with the injection moulding of plastics in one mould and machine which is to be realised to produce metal/plastics hybrid-parts. A selection of promising results concerning the combination of plastics injection moulding and die casting of low-melting metal alloys is presented in this paper.

S16-906

FILM INSERT MOLDING AS A NOVEL WELD-LINE INHIBITION AND STRENGTHENING TECHNIQUE

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Weld lines in injection-molded parts have been one of the major causes of premature failures due to the concentration of stresses at these regions. A novel method of inhibiting or strengthening the weld line is proposed by using the film insert molding technique. The higher thermal insulation caused by the film insert has not only eliminated the v-notch at the surface of the molding, which is characteristic of the weld line, but has also improved the overall weld line strength to the extent of having similar properties to the bulk. A correlation was also found between the substrate-film interaction and mechanical properties of the weld line.

S16-916

Development of High Transcription and High Cycle Micro Molding Technologies Using Rapid Local Temperature Control Systems

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For the growing needs of high precision and high cycle micro- molding technologies, especially in the field of optical devices, we propose a rapid local temperature control system with micro heaters. The system potentially possesses the ability which can achieve the higher transcription rate and the short cycle time for the molding due to the suppressing growth of a surface skin layer on a metal mold in consequence of improving flowability of the resin by heating small volume locally. In this paper, effectiveness of the rapid local heating on the cases of a press molding and an injection molding is demonstrated. Using micro heaters, fabricated by Si-MEMS process, attached just under the metal mold with small patterns, higher transcription rate of 99 % and short pressing time of 1/60 (10 sec.) were achieved compared to the case of high-frequency induction heating for the press molding of the V-groove with the height of 100 microns. On the other hand, high transcription rate and short cycle time of 40 seconds were also carried out by the rapid local temperature control system for the injection molding of 10-level optical gratings with the minimum features of 6 microns with each structural height of 1.5 microns. Beside, the replicated heights and morphologies of the molded products were investigated both cases of rapid local temperature control system and the case of AMOTEC system which can be applied the highly pressurized carbon dioxide gasses as a plasticizer to the molten resin on the injection molding. For the rapid local temperature control system, there were some advantages for the filling rate into the holes of 5-10 micron diameter with high aspect ratio. Last but not least, this system has competitive edges of production not only for the reduction of the cycle time but also for the power consumption during the molding process greatly.

S16-994

Pressure-Dependent Properties of Cemented Carbides Based PIM Composites

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Cemented carbides (CC) are powder metallurgical liquid phase sintered composites, where hard and wear resistance of tungsten carbide component and ductility of metallic phase predestines their applications in the tool manufacturing industry. Powder Injection Moulding (PIM) of CC represents highly efficient processing route in comparison to die pressing or cold isostatic pressing. However, introduction of polymer binder as a temporary medium enabling processing of powder materials via injection moulding together with its tailoring to powder characteristics requires complex rheological study. Since the effect of temperature is considered automatically, the pressure influence is still obeyed in the flow simulation programs. Our previous studies of pressure-affected flow properties of highly filled polymeric materials intended for PIM reveal the following observations: pressure sensitivity coefficients of both - polymer binders and their composites with filler - are dependent on temperature, and sensitivity of filled systems to pressure is not linear function of filler concentration, exhibiting minima at certain loading level. Further, the pressure dependence of PIM compounds varies strongly with powder characteristics, especially particle size and particle size distribution. The reasons of such behaviour are unclear. Since it has been shown the direct correlation between pressure-dependent viscosity and free volume for pure polymers, in this study pressure-dependent viscosity data from modified capillary rheometer are related to the pVT characteristics with the similar focus.

S16-1240

Frozen-in Birefringence, Anisotropic Shrinkage and Luminance in LGP Moldings: Simulation and Experiment

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A computer code based on a CV/FEM/FDM technique, a nonlinear viscoelastic constitutive equation and orientation functions, was developed for one- and two-dimensional simulation of the filling, packing and cooling stages for injection molding of a light guide plates (LGPs) made of optical grade polycarbonates (PCs). The stress- and strain-optical coefficient functions of PCs were determined by means of a newly developed rheo-optical instrument and were used to predict the residual thermal birefringence. The measured temperature dependent viscosity data of the PCs were used in conjunction with the constitutive equation to simulate the LGP injection molding process. Extensive measurements of various components of birefringence and anisotropic shrinkage in the LGP moldings were carried out. Simulations of these quantities in the LGP under various processing conditions were performed to understand processing effects on the flow and thermally-induced birefringence and anisotropic shrinkage. The numerical results were compared with experimental measurements at various processing conditions. The luminance of LGP moldings was found to be significantly affected by the depth of melt filling of the V-grooves. To determine the depth of melt filling of the grooves, measurements were carried out at different locations. The measured positions were selected according to the melt front propagation. The degree of melt filling was found to be strongly influenced by molding conditions and related to the layout of the V-grooves. The depth of melt filling of grooves was mostly completed during the cavity filling stage.

S16-178

Pressure and Temperature Behavior of Thermoplastic Polymer Melts During High-pressure Expansion Injection Molding

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The development of expansion injection molding as new cutting-edge technology for producing thin plastic parts has raised questions about polymer melt behavior in the process of rapid high pressure compression and expansion. To be able to investigate those phenomena, the new in-line injection molding machine mounted measurement system has been developed, able to work under high pressures and temperatures encountered during industrial production. Measuring nozzle equipped with hydraulically driven closing bolts and contact fast response pressure and infrared temperature sensors enabled us to measure the compression of polymer melt in the measuring channel at different starting conditions. Also the expansion out of the measuring slit has been investigated and analyzed. Results presented for high impact polystyrene (HIPS) and polyamide 6,6 show, that polymer melt temperature rise is linearly dependent of compression pressure as well as it is dependent of compression speed. Comparable effect of temperature fall has been recorded during the polymer expansion, resulting in no noticeable loss of dissipation energy during this reversible process. During melt compression, pressure, volume and temperature have been measured and compared with modified 2-domain Tait equation of state. Curve fitting analysis to manufacturer's material data show that measurements fit well with the model, even at very high compression speeds. Pressure fall in the nozzle during the expansion has also been investigated.

S16-253

Gas Pressure Exertion on Part Surface During External Gas-Assisted Injection Moulding for Improvement of Rib-Induced Sink Mark and Shrinkage

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External gas-assisted injection moulding (EGAIM) was applied for improving surface quality of flat ABS part with rib design. Sink mark for the rib of the same width as the part thickness can be reduced from 21 µm to 2.5µm. To achieve the same shrinkage, EGAIM requires a 90-bar gas pressure whereas conventional moulding requires 400-bar packing pressure.

S16-404

Effects of processing parameters on the form accuracy of plastic aspheric lenses using a Be-Cu mold insert in injection molding process

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Recently, the plastic aspheric lenses have been widely used in many applications such as pick-up lens of DVD-ROM, f-θ lens, and camera lens, etc. Injection molding is the common method for the fabrication of plastic aspheric lens with high throughput and low cost. This study is devoted to investigating the effects of processing parameters on the form accuracy of molded aspheric lenses using a Be-Cu alloy mold insert. Four processing parameters, namely, mold temperature, melt temperature, packing pressure, and injection speed were chosen to investigate the effects of processing parameters on the form accuracy of molded aspheric lenses. The BeCu mold insert was machined by single-point-diamond-turning (SPDT). The plastic material used for the fabrication of aspheric lenses is cyclic olefin copolymer (COC). In this study, an experimental design (Taguchi's method) was also employed to investigate the effects of processing parameters on the form accuracy of molded aspheric lenses. Form accuracy of molded aspheric lenses and BeCu mold insert were measured by a form talysurf (Form Talysurf Series 2, Taylor Hobson, UK). The differences in the profiles between the mold insert and molded aspheric lenses were compared to evaluate the form accuracy.Results indicate that the mold temperature and packing pressure are the major factors affecting the form accuracy of molded aspheric lenses. Better form accuracy of molded aspheric lenses were obtained with higher mold temperature and packing pressure.

S16-604

Analysis of morphology and performance of micro dumbbell specimens manufactured by micro injection molding

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Injection moulding is one of the most important and versatile techniques to produce plastic parts with complex geometries. New innovations have been developed continually to offer special characteristics and benefits. The use of the injection moulding process in micro fabrication is one of these improvements. Microinjection moulding is a production technique that has several advantages namely, high productivity, production of parts with high complex geometries and the variety of materials used.Due to the miniature characteristics of the moulded parts, is essential a special moulding machine and auxiliary equipment to perform the tasks, such as injection, ejection, shot volume control, inspection and handling of the moulded parts.A Battenfeld Microsystem 50 injection-moulding machine was used to produce the micro dumbbell specimens. The length of the micro dumbbell is 18 mm and the cross-section of the middle zone is 1,2 x 0,3 mm2. The stress-strain behaviour allowed the evaluation of the mechanical performance of the injection moulded micro dumbbell specimens. The mechanical behaviour of the micro dumbbell samples was assessed through micro tensile tests at a velocity of 1 mm/min. These specimens were tested on a special equipment for miniature samples, "Micro-Tester", equipped with a load cell of 500 N. The yield stress values were obtained from these tests.For the morphology assessment, the micro dumbbell specimens were observed in a polarized light microscope. Polarized microscopes are employed in the assessment of spherulitic crystalline polymers and in the morphologic and orientation analysis of solid polymers.

S16-758

Study on correlation between mechanical properties of weld line and processing parameters in micro injection molding process of PP (Polypropylene)

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As a hot fabrication technology for micro scale parts, micro injection molding is getting more and more market attention. Improving mechanical properties of micro parts should be an important issue in micro injection molding process. The relation between the strength of weld line in micro injection molding parts and processing parameters is investigated. A visual mould with variotherm unit is designed and constructed, in which the micro tensile specimen with weld line are prepared. Polypropylene(PP) is used as the research material in this study, and 6 processing parameters are choose as investigating factors, which are melt temperature, tool temperature, injection pressure, packing pressure, demold temperature and injection speed. In order to get optimizing processing parameters and their significant order, Taguchi experiment method is applied in this presented study. And the prediction formulation of the strength of micro weld line is built up by multiple regression analysis based on Chebyshev orthogonal polynomial. The results show the influencing significant order of parameters from strong to week separately are tool temperature, melt temperature, injection speed, demold temperature, packing pressure and injection pressure. And the tolerance of micro weld line prediction formulation is lower than 20%, proved by confirmation experiment.

S16-852

Analysis on variothermal moulding processes to replicate micro-structured surfaces

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By integrating micro-structures, effects like self cleansing properties or the flow behaviour in tubes can be optimised. In order to achieve good results concerning the replication of micro-structures by injection moulding or injection-compression moulding, it is necessary to heat up the surface temperature close to the melting point of the polymer during cavity filling. Several approaches focusing on the replication of micro-structured surfaces are currently examined at the Institute of Plastics Processing (IKV) at RWTH Aachen University within the scope of Cluster of Excellence "Integrative Production Technology for High-Wage Countries". Within this paper investigations on one possible approach, the use of an external inductive heating respectively, are presented. A fully automated system composed of injection moulding machine, robot and inductor heating system which is extended by a touch less temperature measurement system was set up. A control algorithm allows to prescribe defined mould temperatures and to adjust the induction power. The experiments show that heat up rates of 60 K/s can be realised using induction heating. During the investigations different microstructures were tested including a LiGA honeycomb structure with a height of 100 µm and a mould insert structured by a laser beam. In order to qualify and quantify the replicated parts different techniques were used: Classical SE-, light- and macro-microscopy were used to identify the quality of the mould. A white light interferometer microscope was used to measure the replication depth. The experiments show that injection-compression moulding results in better replication of the microstructures compared to conventional injection moulding. The accuracy of the replication is generally increased when external induction heating is applied. Best results are achieved when using injection-compression moulding with induction heating.

S16-861

On the microstructure of HDPE micromoulded parts

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Microinjection moulding (µIM) appears to be one of the most efficient processes for large-scale production of thermoplastic polymer microparts. Compared to the conventional injection moulding process (IM), µIM has its own specificities [1,2]. Different studies pointed out microparts fabrication parameters to satisfy the dimensional and tolerances requirements [3]. Few results related to the effect of processing on the polymer's properties have already been published. This is the topic of this paper. The present study deals with quantifying the effect of µIM process on the microstructure of a High Density PolyEthylene (HDPE). The properties of the microparts (0.15mm thick) are compared with conventional injected parts (1.5mm thick). Possible chemical changes in the structure of the polymer such as degradation during processing are evaluated. These effects reported elsewhere [4] are studied by means of gel permeation chromatography (GPC) and spectroscopic techniques. Physical changes into the material are also investigated by analysing the polymer morphology by means of differential scanning calorimetry (DSC) or WAXS measurements. Differences in the crystalline phase of micro- and macroscopic parts are observed and related to the different processing conditions used. Thus, it is assumed that thermomechanicalconditions induced during µIM lead to specific arrangement of the polymer chains [4].[1] J Giboz et al, Journal of Micromechanics and Microengineering, 17, 96-109, 2007.[2] M T Martyn et al, SPE ANTEC Proceedings, 2002.[3] B Sha et al, Journal of Materials Processing Technology, 183, 284–296, 2007.[4] V Kalima et al, Optical materials, 30, 285-291, 2007.

S16-980

Fabrication of mold insert and product of microfluidic chip by micro electrical discharge machining

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We report fabrication of mold insert and product of microfluidic chip with micro electrical discharge machining (µEDM). A stainless steel mold insert of microfluidic chip is manufactured by µEDM. Morphology, chemistry, surface roughness and structure of the surface of mold insert have been characterized by scanning electron microscopy and atomic force microscopy. The microchannel of microfluidic chip has 70µm width and 50µm depth. After the process finishes the mold insert, the microchannel of molded microfluidic chip replicates from the metal mold insert by micro-hot embossing molding. Different processing parameters (Embossing temperature, embossing pressure, embossing time, and de-molding temperature) for the properties of COP film of microfluidic chip have been discussed. The results show the most important parameter is the embossing temperature for replication properties of molded microfluidic chip. The de-molding temperature is the most important parameter for surface roughness of the molded microfluidic chip. Key words : µEDM, Mold insert, Microfluidic chip, Surface roughness, Replication

S16-983

Injection moulding of micro featured parts

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We will present details on the injection moulding of parts with micro features. By this we mean parts with outer dimension on the order of centimetres but with structural details between 0.1 and 100 µm. On the lower end of the scale we present injection moulding of optical gratings, where the features are similar in size to the wavelength of visible light, namely 0.3-0.7 µm. The functionality of the grating is completely dependent on the grating being replicated with the correct wavelength and amplitude. The product must also be planar, e.g. with less than 10 µm curvature over 1 cm. At the other end of the scale, we have been moulding a lab-on-a-chip system where the smallest details are channels with width 50 µm, but where a very high degree of accuracy is required for the application of the chip. This is especially true for the burst valves, where a liquid droplet is stopped at a channel widening because of capillary forces. The tuning of the pressure drop over the valve is made partly by changing the filet radius of the burst valve corners.

S16-1187

As-molded shrinkage on industrial Polypropylene–EPR Copolymer injection molded parts: experiments and analysis

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The phenomenon of shrinkage in injection molding is particularly relevant in semi-crystalline polymers. Despite of this, if compared with the considerable effort spent by researchers to investigate (both experimentally and theoretically) the evolution of shrinkage and thermal stresses in amorphous polymers, the relevant research work is scarce for semi-crystalline polymers. This is probably due to the fact that the phenomenon is strictly related to the evolution of crystallinity, which is per se quite difficult to be predicted. In fact, modern approaches to the phenomenon of dimensional accuracy in injection molding link the evolution of shrinkage from the moment of first solidification to a force balance between restraining and constraining forces which sets in inside the mold before ejection. Such as approach needs a complete understanding of what happens inside the cavity during the molding cycle.In this work, with reference to a simple rectangular cavity, the complete evolution of shrinkage from the instant of first solidification inside the mold to some minutes after demoulding was followed for a typical multiphase industrial polymer, i.e., an industrial polypropylene-ethylene-propylene rubber (iPP-EPR) copolymer with a small percentage of talc. The influence of holding pressure and time, and geometric constraints on linear shrinkage was explored. Experimental results were compared with predictions for shrinkage obtained by a code developed at the University of Salerno, which takes into account crystallization kinetics.

S16-1360

The Effect of Process Parameters on the Crystallinity of HDPE in Thin-wall injection molding

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Processing parameters plays an important role in the structure-property relationship of semi-crystalline plastics in thin-wall injection molding. In this study, rectangular thin flats with dimensions of 12mm×5mm×0.8mm, were injected under different melt temperatures(215-195-175°C) while other processing parameters kept constant. Flats were sliced specimens every 60µm along the thickness direction. The non-isothermal crystallization DSC curves were gained by simultane thermoanalyse (STA). The results show that the crystallinity and skin-core structure are dependent on the injection molding processing conditions. With the increasing of distance from skin layer, the heat of crystallization rises from 199.6 J/g to maximum 244.7 J/g at sub-skin layer and then decreases to 148 J/g at the core layer. The crystallinity gets to the maximum at the gat and decreases rapidly along the flow direction. Key Words: thin-wall injection molding; semi-crystalline plastics; non-isothermal crystallization; process parameters