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AN INNOVATIVE RAPID THERMAL CYCLING SYSTEM TO IMPROVE THE REPLICATION CAPABILITY OF INJECTION-MOULDED MICROSTRUCTURED SURFACES

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Achieving the required accuracy in the replication of microstructured surfaces by injection moulding is challenging because the polymer solidifies as soon as it touches the cavity surface. Maintaining the cavity surface temperature above the polymer glass transition during the filling stage prevents material freezing, thus improving microfeatures replication. On the other hand, the heated mould needs to be rapidly cooled down to avoid an increase in the cycle time. A very high cooling power is therefore necessary in order to lower the part temperature and to allow the component ejection as soon as possible. In this work an innovative rapid thermal cycling system, based on the use of open-cell aluminium foam, is proposed. A piece of metal foam was placed just under the cavity surface and a regime of forced convection was realized by water flowing through the foam at a controlled temperature. During the injection phase, hot pressurized water flowing through the metal foam keeps the cavity temperature above the glass transition temperature. The material fluidity remains high for the whole filling stage, avoiding undesired material freezing and favouring the filling of the microfeatures. Once the cavity is completely filled, the cooling phase starts by switching the used fluid from hot to cold water. The high heat transfer efficiency provided by the open-cell aluminium foam allows a very fast decrease of the mould temperature. To evaluate the improvements on the microfeature replication quality and the thermal cycling efficiency of the system, experimental tests were conducted. Moulding tests were carried out using a microstructured mould, with microfeatures characterized by high aspect ratio in order to highlight the benefits of the rapid thermal cycling. The degree of replication of the surface microstructures obtained using the proposed thermal system was compared with what is achievable by the standard injection moulding process.