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VIRTUAALIMESSUT • EM-KONE • COBOTIT • KIERRÄTYSVALMENTAJA • LASER TEXTURING

Laser texturing allows for reducing injection cycle time by 15%

Summary: *A defined laser texturing of a mould insert has demonstrated positive effects on the productivity when applied in combination with the DuPont grade Zytel® HTN51G35HSL NC010, which is a PPA polymer containing 35 % glass fibers. A validation test under production conditions has shown that a surface topography tuned with laser texturing (provided by GF Machining Solutions) has an anti-adhesive effect and allows for a potential gain of 5 seconds cooling time, which corresponds to a cycle time reduction from 33 to 28 seconds or a 15 % productivity increase.*

The EUREKA project Super-Moulds is co-financed by Innosuisse (Switzerland) and the Innovation Fund Denmark and unites 11 Swiss and Danish partners. The aim of this almost five-year project (initiated in 2017) is to quantify the influence of polymer material, mould geometry and mould surface treatment on the overall productivity of plastic injection moulding. Sytematic demoulding tests have been performed and the ejection force has been measured as a function of time using a specially designed test tool that is equipped with a force detector. The test tool was mounted in an Arburg 270C Allrounder 500-250 press. The maximum force and the integral value of the force curve are used as criteria to quantify the influence of a given test parameter. The maximum ejection force corresponds to the peak value of the curve, and the integral value of the force curve multiplied by the ejection speed corresponds to the energy necessary for demoulding the part.

In the initial phase of this project, industrial end-user companies have been approached and concrete test geometries have been defined. Figure 1 shows the original set of mould inserts and the conceived study geometry for a specific case. For this star-shaped geometry the DuPont grade Zytel® HTN51G35HSL NC010, a PPA polymer containing 35 % glass fibers, has been defined as the reference polymer.

A series of tests was made using star shaped cores made of K110 Böhler Steel (1.2379) and using seven different polymers. A series of cores was modified by laser texturing strategies to obtain different surfaces to be tested in real injection processes. Here, the laser textures are described by their corresponding surface roughness (S_a). The roughness scale was chosen to cover surfaces with low values of Sa (0.5 – 0.9 µm). Although the surface topography cannot be defined only by its roughness value, a trend was observed.

Figure 1 Left: Original star-shaped inserts of the production mould. **Right:** Test insert for studying the effect of surface treatments on the demoulding properties. All parts are made in stainless steel (1.2379).

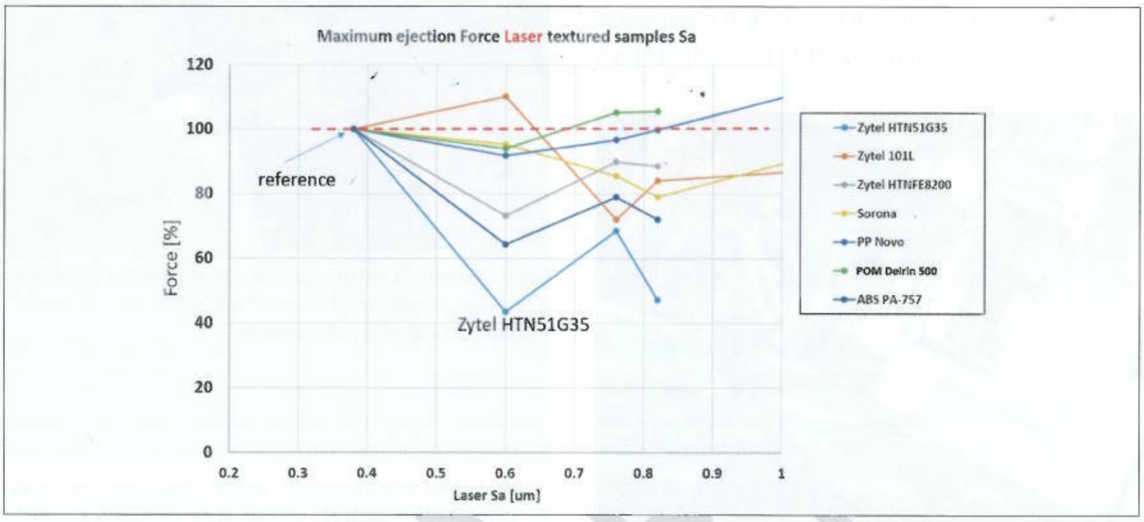

Figure 2: Ejection force depending on surface roughness.

For the majority of the polymers, the results reveal a minimum in ejection force around S_a = 0.6 µm. The laser textured cores were further investigated by surface contact angle analysis to determine the surface energy. It was found that with increasing roughness, the surface energy decreases, which presumably leads to lower adhesion between the polymer and the core surface. On the other hand, increasing roughness gives rise to interlocking between the core surface and the polymer and hence an increase in the static friction.

From these two general trends, the effect of surface roughness can be summarized as follows:

S_a < 0.5 [µm]	High adhesion.
0.5 < S_a < 0.9 [µm]	Combination of both lower adhesion and lower friction.
S_a > 0.9 [µm]	High friction.

According to these results and depending on the polymer, the impact of the laser textures varies from a 10 % increased ejection force to a 60 % reduction as compared to the untextured reference. In particular, a random laser blasting pattern of S_a = 0.6 µm was the best performing surface treatment in combination with the DuPont grade Zytel® HTN51G35HSL NC010 PPA grade (Figure 3). In this case, laser texturing gave rise to a reduction of the initial peak force by 60 %.

After the injection tests, an end-user validation test was carried out under production conditions. Inserts fitting to the production mould were fabricated and then textured by laser using the identical parameters as for the most performant test insert. For the validation tests, reference plastic parts were produced using the standard injection parameters. In a second phase, the cycle time was systematically reduced by decreasing the cooling time. Standard quality control tests (one example shown in Figure 4) were conducted to evaluate the minimum allowable cycle time for which the geometric tolerances of the produced plastic parts were met.

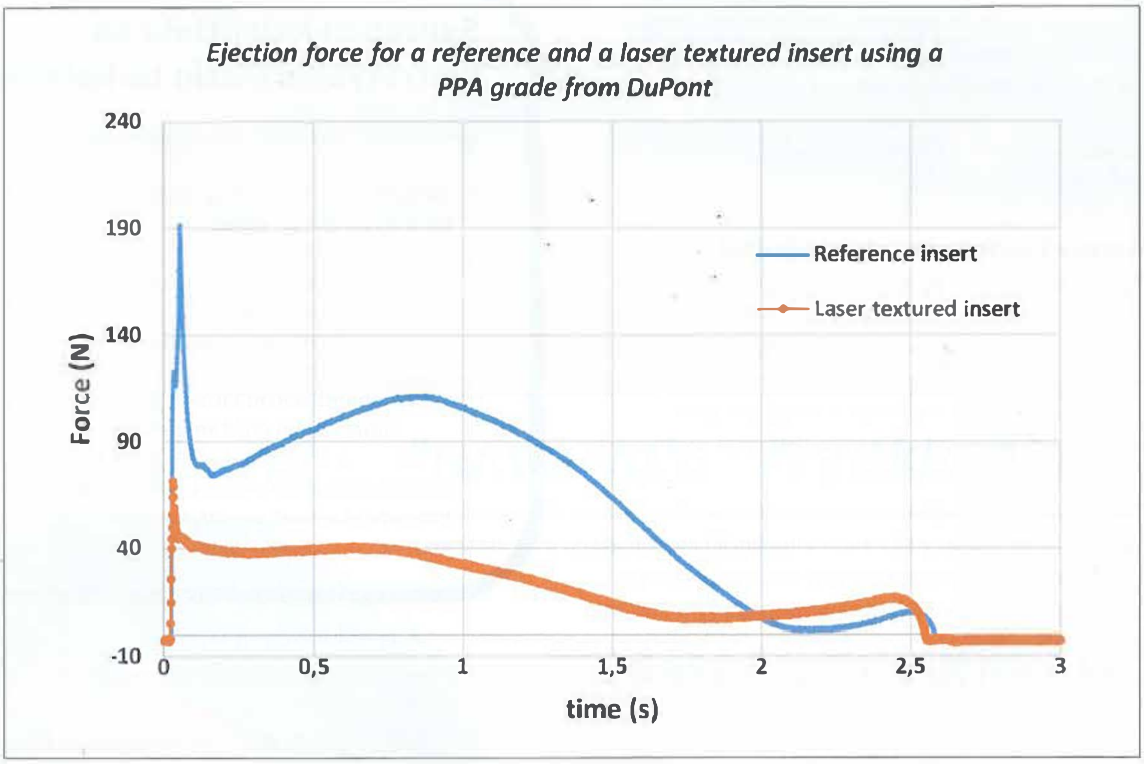

Figure 3: Ejection force versus time curve for a reference insert, which has been polished in the direction of demoulding, and a laser textured insert (S_a = 0.6 µm). The initial peak indicates the combined effect of static friction and adhesion and the integral under the curve (multiplied by the ejection speed) corresponds to the energy necessary to demould the part. For both parameters, the laser textured insert was the best performing. The test was performed with DuPont grade Zytel® HTN51G35HSL NC010, a PPA polymer containing 35 % glass fibers.

Figure 4: Example of a key quality control test of the star shaped axis of the plastic part. The plastic parts produced using the laser textured inserts fulfilled this quality criterion, even after reducing the cooling time by five seconds.

The validation test showed that the cooling time can be reduced by 5 seconds when the laser textured insert is used instead of a standard surface-finished insert. Thus, the total injection cycle time could be reduced from 33 seconds to 28 seconds, corresponding to a productivity gain of 15 %.

Contact information:

Ejection force measurements and validation test: Stefan Hengsberger, Haute école d'ingénierie de Fribourg, HES-SO University of Applied Sciences, Switzerland, email: stefan.hengsberger@hefr.ch

Project Management (Super-Moulds): Sascha Louring, Danish Technological Institute, email: salo@teknologisk.dk