Injection Moulding optimization of nanostructured components using surface fingerprint

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The Injection Moulding of micro/nano structured components, often requires multiscale optimization in order to ensure the replication of the features embed in the parts. Depending on the geometrical properties of the structures, mostly the size and the aspect ratio and the material properties, a different set of parameter has to be found for the process optimization [1].

The concept of fingerprint has been extensively used in order to find correlations between process parameters settings and a response function that generally refers as localized selected features of the sample component [2]. The approach is adopted in this case for the optimization of the Injection Moulding process parameters. Four different factors (Injection Velocity, Holding Pressure, Mould Temperature, Melt Temperature) are varied according to a full factorial two levels design.

The specimen under investigation embeds a single diffractive optical elements (DOE) manufactured using ultra-sound assisted machining to a 1005 ± 2 nm measured pitch. Using a laser scanning confocal microscope, the replicated components made of Acrylonitrile butadiene styrene (ABS), were measured on a unique location for all the replicated samples and compared to the master steel insert.

Two different fingerprint analysis are proposed to feed two regression models. The first one combines the dominant spectral frequency response and its amplitude, calculated using the Fast Fourier Transform function (FFT) (as shown in Figure 1a). The second one uses the mean squared root amplitude error calculated on the residual images from master insert and polymer part topographies (as shown in Figure 1b). The amplitude error is calculated using the surface roughness amplitude parameter *Sq*.

The results indicates that both the method conduce to different regression models. For the first analysis, the most significant parameters is the Holding Pressure (as shown in Figure 1c). While for the second one the mould temperature plays a major importance (as shown in Figure 1d). The polymer shrinkage is addressed to be the cause for replicating the dominant frequency response function of the texture. On the other hand, the Sq model is depended mostly on Mould Temperature as it suffers the incomplete replication of waviness and form errors of the machined insert.

This study shows that two process fingerprints can lead to different injection moulding process optimal conditions for the same measured part geometries. Depending on the size scale of the feature, one of the regression model proposed can be used to predict injection moulding quality output.

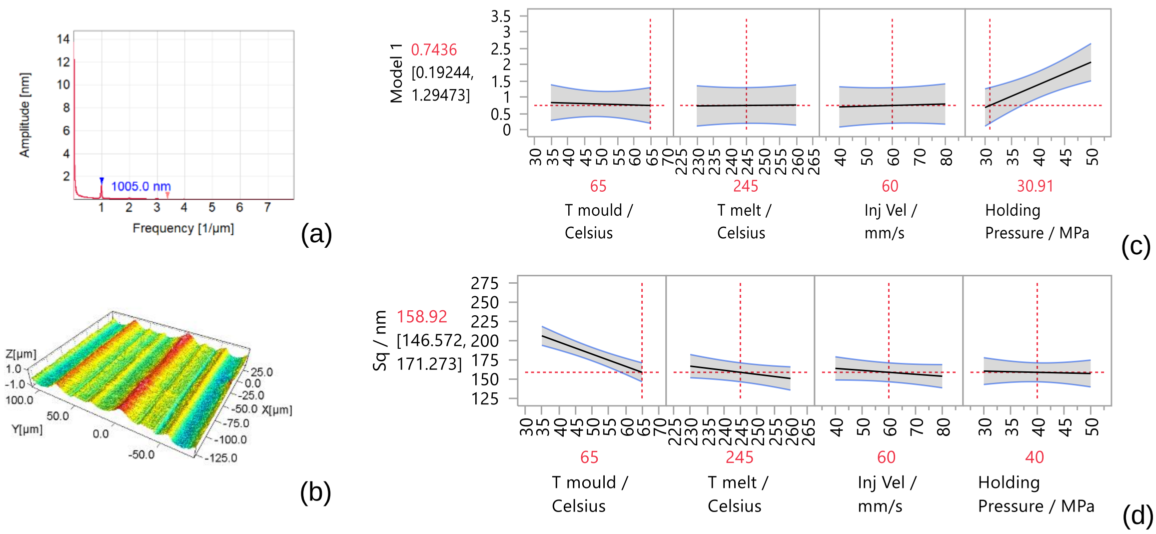

Figure 1: FFT response (a) and its prediction model (b) and residual topography sample (c) and related model based on its amplitude (d).

References

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