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CONTACTLESS ANALYSIS OF SURFACE OF POWDER INJECTION MOLDED PARTS

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ABSTRACT

This work reports on contactless control of surface quality of parts produced via powder injection molding technology. Surface properties derived for parts used in the weaving machines, where a smooth surface of the internal area is a critical factor, were related to the processing conditions of injection molding as well as debinding route. Further, the statistical analytical tools to quantify the results of surface analysis are described and discussed.

Keywords: surface, contactless scanner, quantitative analysis.

INTRODUCTION

Surface properties of parts produced via powder injection molding (PIM) technology result from combined influences of mixing, molding, debinding and sintering steps of the process. While the surface structure is often related to the sintering conditions, there is only limiting number of studies devoted to the effect of processing parameters during injection molding step, although they clearly dictate the uniform distribution of powder particles within polymer binder, where the main quality issue - separation of powder and binder resulting in inhomogeneous structure, occur (depending on shear rate).

In this study, alumina powder was compounded with a multi-component binder which is partially water-soluble. Compounded feedstock in a form of pellets was injection molded at molding conditions differing in (10±0.5) °C in molding temperatures 150 and 160 °C. In addition, two debinding routes - thermal and combined solvent/thermal removal were tested.

RESULTS AND CONCLUSIONS

The methods to observe surface properties on final parts (after polymer extraction and sintering) employed so far rely largely on electron microscopy or direct measurement of surface roughness parameters. In this study, a contactless 3D Chromatic Length Aberration (CLA) scanner has to be employed. Tested surfaces (Figure 1) were subjected to a height measurement over a rectangular area (1 x 1) mm with the scanning rate 100 μm/s and spacing 5 μm. Filtration of the scanning data was done with a help of Gaussian filter (0.25 mm) in accordance with ISO 4288.

A 3D data map was obtained as shown on the sample example depicted in Figure 1. The data supplied is of the form $z = \mathrm{f}(x,y)$, where z is the height of the profile, x stands for the position over the scanning direction, and y corresponds to the number of traces. First Interface

Detection (FID) was selected as a measurement mode. The software takes into account the height of the first interference (i.e. the upper border of the transparent interference represented by the first peak in the spectrum).

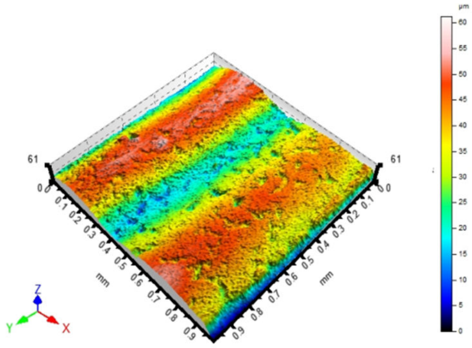

Fig. 1 - Example of surface reconstruction from contactless measurement

Surface mapping data was evaluated from the fracture planes (meaning conversion into series of profiles), where 200 profiles in both *x*- and *y*-axes were obtained for each sample. Surface parameters R_p, R_v, and R_a were treated with Anderson-Darlin normality test (α = 0.95) in accordance with ISO 4287.

According to this test, the normality of the data was denied on the confidential level 0.95 %. This means that the examined surfaces contain not only accidental inhomogeneities, which must be detected with a suitable statistical tool serving as a base for relation of surface properties to processing conditions.

Primary statistical evidence might be Box-Plot diagrams of R_p, R_v, and R_a showing considerable scatter of measured data.
Therefore, Kruscal-Wallis statistical approach has been selected as it enables simple analysis of data scatter. A zero-hypothesis expects that the particular surface roughness parameters (R_p, R_v, R_a) have the same median values in the sample groups.

Table 1 - Example of application of Kruscal-Wallis method

R_p evaluation	***P* value**	**H_0**
150°C parallel x 160°C parallel (solv/therm)	0 < 0.05	denied
150°C perpendicular x 160°C perpendicular (solv/therm)	0 < 0.05	denied
150°C parallel x 160°C parallel (therm)	0 < 0.05	denied
150°C perpendicular x 160°C perpendicular (therm)	0 < 0.05	denied

Kruscal -Wallis method confirmed on the confidential level 0.95 % (i.e. 5 % error) that the medians of selected samples do not vary at random. Instead, they are dependent on the processing conditions - in this case on molding temperature. Thus, the surface properties might be related to the processing conditions, and based on this knowledge, the process can be optimized.

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