Deflectometry for surface inspection and shape fidelity analysis for manufacturing and polishing of safety spectacle molds

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A non-contact deflectometric measurement technique for injection molding tools is being proposed. Global shape deviations and local surface quality is derived from target surface comparisons and curvature measurements. Deflectometry is a suitable tool for quality control of safety spectacles before and during the injection process.

Introduction

Work with possible chemical, thermic or mechanical hazards requires protection with safety spectacles [1]. Most of the spectacles are plastic optics, produced by injection molding techniques. Optical testing of the molds is difficult before or during the injection process, despite the high importance of optical quality [2]. Poor optical quality caused by deficient steel molds can only be detected by optical testing of the molded parts. Outworn mold shapes and surfaces are the main reason for poor optical quality and rejection in optical testing. The purpose of this study was to implement 3D phase measuring deflectometry (PMD) for shape fidelity tests of (bi)spherical and full form mold surfaces. The scope of this work is to present the ability of PMD to detect mold defects and mold outwear for personal protective eyewear.

Material and Methods

The setup is based on a phase measuring deflectometer (3D-Shape GmbH, Erlangen, Germany), equipped with 3 cameras. Two cameras (f' = 16 mm) are used for absolute position measurement in space (standardized PMD – Sensor) with a field of view (FoV) of 80 x 80 mm^2 [2]. The third camera (f' = 8.5 mm) was used for full form molds with a FoV of 150 x 150 mm^2. Analysis of the objects surface was reviewed by GOM Inspect (GOM mbH, Braunschweig, Germany) and SoftPMD (Max Planck Research Group, OSMIN, Friedrich-Alexander-University of Erlangen-Nuremberg, Germany). The analysis is based on target surface comparison by substraction of a predefined or best-fit sphere with target radii constraint to point out global differences from the target shape. Additionally, two spherical full form molds were measured and evaluated by curvature maps. A classical best-fit analysis was used for detection of local deviations for both sides of the cavity.

Results

The statistical evaluation included deviation from the target shape (distance) by descriptive statistics (range, mean, standard deviation). Characteristic variables for the global and local fits are the integrated values (integrated absolute distance). Figure 2 and 3 show the results of the full form best-fit evaluation.
Both left sides had uniform elevated deviations on the edge, especially the ejector side. The mean curvature map of the NS full form mold illustrates visible elevations caused by expansion of mounting bores of about 200 nm (Figure 4).

Figure 5 and 6 show the extracted distance parameters for shape fidelity analysis of the bispherical mold series. Three nozzles sides had bumps and local surface errors, except 2 NS, due to a higher integrated absolute distance. They were additional tested by best-fits, e.g. Figure 7a. Two of four ejector sides had max/min deviation under 3 µm. For example, the false color plot of 1 ES mold conducts good shape fidelity with insignificant local errors (Figure 7b).

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**References**

