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ScienceDirect

Procedia Engineering 184 (2017) 344 – 349

Procedia Engineering

www.elsevier.com/locate/procedia

Advances in Material & Processing Technologies Conference

Study on Injection Molding of Shell Mold for Aspheric Contact Lens Fabrication

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Abstract

This study aims to propose a method to reduce the shrinkage error of shell molds in the injection molding process. The shell molds are used for casting bi-aspheric soft contact lens with HEMA material. Moldex3D R13.0 is used to simulate and analyze the shrinkage of the front contact lens curve on the front shell mold in Z-axis direction. First, the design of experiment (DOE) method is applied to obtain the optimal setting parameters (melt temperature, injection velocity, and packing pressure). Amount of the shrinkage error is used to compensate the original design curve to improve the shrinkage error in the next simulations. The simulation result after compensation shows that the shrinkage error is reduced as 80.8%. The adding value to compensate the original design curve should be optimized to minimize shrinkage error. Result of this study can effectively improve the shrinkage error before fabricating the shell molds of the soft aspheric contact lens.

Peer-review under responsibility of the organizing committee of the Urban Transitions Conference

Keywords: Injection molding; Soft contact lens; Aspheric; Shrinkage Error; DOE method; Compensation

1. Introduction

A soft contact lens is a thin and soft lens worn directly on the corneal surface of the human eye. Soft contact lenses are can be used to correct vision, or for fashion or therapeutic reasons. The plastic type to make soft contact lenses usually contains 80% water. These contact lenses are commonly used because they provide a comfort to wear [1].

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Peer-review under responsibility of the organizing committee of the Urban Transitions Conference
doi:10.1016/j.proeng.2017.04.104

Recently, contact lens market grows very quickly due to the increasing number of people having eye disease such as astigmatism, presbyopia and myopia. In addition, many people wear soft contact lenses because of fashion. By the end of 2020, the commercial value is forecasted to reach US$13.50 billion [2-4].

In order to provide mass production with various contact lens types and low cost, the manufacturing process of soft contact lenses keeps an important role. Generally, the soft contact lens is made by cast molding method. The shell molds are two plastic convex shells made by injection molding process.

To cast the more complex surfaces of the soft contact lenses, the surfaces of the shell molds should be made more accuracy and smooth. Therefore, the geometric deformations in the manufacturing process of the shell molds should be reduced. In this study, the injection molding process for manufacturing polypropylene (PP) symmetric shell molds of the bi-aspheric soft contact lens is simulated to find the optimal injection parameters by Taguchi method [5-11]. Three two-level parameters i.e. melting temperature, injection velocity and packing pressure are analyzed to obtain the small z-axis shrinkage error. Then, the original front lens curve on the front shell mold is compensated to reduce this deformation. The optimal parameters and the compensated curve are imported to the injection machine to make the shell molds. This method can be extended to reduce the shrinkage error on the shell surfaces.

The rest of the paper is organized as follows: in Section 2, detail on the method is presented. In Section 3, results and discussion are given. In Section 4, some conclusions are obtained from this study.

2. Material and method

2.1 Material

The materials used in this study is PP (Polypropylene Globalene 6331) supplied by LCY Chemical Corp. Since this plastic provides a high thermal stability and a high flow property, it is easily filled into the complex shell mold shapes.

2.2. Injection molding simulation

The shell molds are designed based on the shape and dimensions of the soft contact lens. Fig. 1 shows the dimensions of a symmetric bi-aspheric soft contact lens with base curve of radius of 8.6 mm. The optical zone in the front lens surface includes two aspheric curves. The shell molds includes two parts: front shell mold and base shell mold in Fig. 2(a). Since the front lens curve of the soft contact lens requires high precision, the shrinkage of the front lens curve on the front shell mold should be reduced. The design of delivery system in injection molding process is presented in Fig. 2(b).

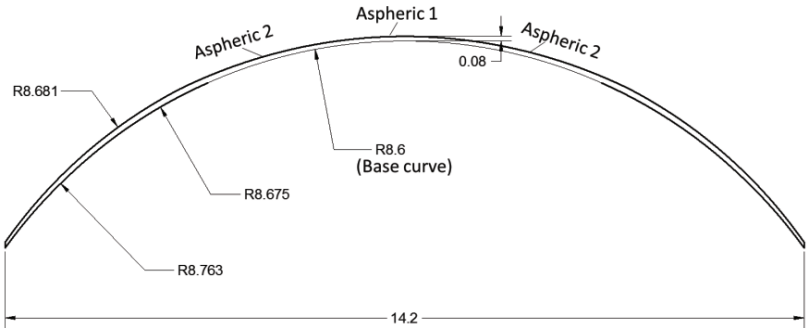

Fig. 1.The dimensions of the soft contact lens

Moldex3D software is used to simulate the filling stage of the shell mold parts and then to find the operational ranges of parameters. Three processing parameters chosen to investigate their effects on the shrinkage of the shell mold parts are selected as variables: melt temperature, injection velocity and packing pressure. Each studied parameter