Experimental Study on Minimizing Edge Chipping in Glass Milling Operation Using an Internal CBN Grinding Tool

Mohd Sayuti Ab Karim a, Ahmed Aly Diaa Mohammed Sarhan a & Mohd Hamdi Abd Shukor a
a Centre of Advanced Manufacturing and Material Processing, Department of Engineering Design and Manufacture, University of Malaya, Kuala Lumpur, Malaysia


To cite this article: Mohd Sayuti Ab Karim, Ahmed Aly Diaa Mohammed Sarhan & Mohd Hamdi Abd Shukor (2011): Experimental Study on Minimizing Edge Chipping in Glass Milling Operation Using an Internal CBN Grinding Tool, Materials and Manufacturing Processes, 26:8, 969-976

To link to this article: http://dx.doi.org/10.1080/10426914.2010.530533

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.tandfonline.com/page/terms-and-conditions

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.
Experimental Study on Minimizing Edge Chipping in Glass Milling Operation Using an Internal CBN Grinding Tool

Mohd Sayuti Ab Karim, Ahmed Aly Diaa Mohammed Sarhan, and Mohd Hamdi Abd Shukor

Centre of Advanced Manufacturing and Material Processing, Department of Engineering Design and Manufacture, University of Malaya, Kuala Lumpur, Malaysia

Glass is one of the most difficult materials to be machined due to its brittle nature and unique structure as frequent occurrence of fracture and edge chipping during machining has to be avoided. To minimize edge chipping of the machined glass, which is common when cutting materials harder than 50HRC, adopting right parameters is required followed by additional effort and cost. This article presents experimentation in minimizing the edge chipping for glass milling operations using an internal cubic boron nitride grinding tool by optimizing the machining parameters. Taguchi optimization method is the most effective method to optimize the machining parameters, in which the most significant response variables affecting edge chipping could be identified. In glass milling operation, several machining parameters are considered to be significant in affecting edge chipping. These parameters include lubrication pressure and direction, feed rate, spindle speed, and depth of cut. The standard orthogonal array of L_16 (4^4) is used, while the signal-to-noise response analysis and analysis of variance methods are carried out to determine which parameters are statistically significant. Finally, confirmation tests are carried out to investigate the optimization improvements.

Keywords Chipping; CNC; Glass; Grinding; Machining; Milling; Optimization; Parameters; Taguchi.

Introduction

Glass is an amorphous (non-crystalline) solid material. It is typically brittle and often optically transparent. Glass plays an essential role in science and industry. The optical and physical properties of glass make it suitable for many different applications such as flat glass, container glass, optics and optoelectronics material, laboratory equipment, thermal insulators, reinforcement fiber, art, and many more. Examples of glassy materials include soda-lime glass, borosilicate glass, acrylic glass, sugar glass, muscovy-glass, and aluminum oxynitride [1]. However, soda-lime glass is the most prevalent type of glass. It is widely used and can easily be found on the market. In industry, this type of glass is the most commonly produced since it is easy to make with better-cost effectiveness compared to other types of glass [2]. In addition, it also has good mechanical properties in terms of hardness, refractive index, and melting temperature [3].

In the silicone industry, as an example, soda-lime glass has been used as a mould with very good precision in terms of dimensional accuracy even at high temperatures. While using a very high precision glass mould, the shape varieties of the silicone product lead to many different complicated shapes of glass moulds to be developed [2]. The computer numerical controlled (CNC) milling machine is possible to be used with a variety of parameters setup, making the machining process on the glass mould superlative compared to other machining processes. The capability of the CNC milling machine to make batch production would be a noteworthy advantage for glass machining. However, the application of grinding process on the CNC milling machine could be an ideal solution in manufacturing complicated special products, but the existence of edge chipping is a common problem when machining brittle materials. The edge chipping is defined as a form of typical machining-induced material edge damage. This type of damage happens due to high hardness and extreme brittleness of the material which is difficult to be avoided [4]. It is also known as the condition left when a brittle material fractures at the edges during machining and leaves an irregular, fractured surface. Glass, cast iron, and ceramics particularly display this condition [4].

A lot of effort has been made by researchers and manufacturers to machine these important brittle materials with minimum edge chipping. Edge chipping phenomenon in brittle materials can be reduced by decreasing the cutting forces during the milling process [5]. It is reported that the grinding wheel velocity can influence cutting forces and grinding temperature, consequently affecting edge chipping formation. A fundamental research has been conducted to investigate the machining parameters effect on edge chipping of brittle materials [6]. It was showed that the increasing in cutting speed could reduce edge chipping width. On the other hand, an experimental investigation of temperature in high speed deep grinding of partially stabilized zirconia has been conducted [7]. It has been reported that the high lubrication pressure is an important factor in reducing the cutting force and that would subsequently reduce edge chipping while machining brittle materials. The high lubrication pressure can also be used...