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Characterization of chipping and tool wear during drilling of float glass using rotary ultrasonic machining

Ankit Sharma*, Vivek Jain, Dheeraj Gupta

Department of Mechanical Engineering, Thapar University, Patiala 147001, India

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ABSTRACT

Float glass's utility is emerging continuously; major application of float glass is in solar panel and architecture glass. However, the researchers are still bearing drilling problems i.e. chipping near hole's exit corner and tool wear. Therefore, this study has carried out a designed experimental investigation while drilling float glass by Rotary ultrasonic machining (RUM) process. The authors have made an attempt to estimate the relationship between selected machining parameters i.e. feed rate, vibration amplitude and tool diameter with the chipping amount at hole exit. The core objective is to reduce the chipping by optimizing the opted machining factors. The novelty of this work is a measurement of chipping using coordinate measuring machine (CMM). It is revealed that the least volume of chipping is estimated as 3.81 mm^3. The best parametric combination to obtain the least amount of chipping volume is considered as the first level of feed rate (F1), the third level of vibration amplitude (A1) and the first level of tool diameter (TD1). This study investigates the tool wear occurs at three different drilling stages. Tool (6 mm diameter) has carried out least amount of weight loss i.e. 4.78%. The tool which contains the least surface area (integrated lateral and end face) in contact with the workpiece sample has created minimum weight loss.

1. Introduction

The innovation in the utility of float glass is still needed to explore, because of its exceptional features such as wear resistance, chemical and thermal characteristics. The key application of float glass is in solar concentrators, automotive glass and solar panel [1]. In spite of that, the researchers are still facing machining and drilling issues, which are directly related to its practical application [2]. It was pointed out in some research study that due to high hardness and brittleness, conventional machining processes such as CNC milling machine, water jet machine, and ultrasonic machine are not fascinating efficient outcomes [3–5]. Instantly, researchers are working towards precise machining, surface quality and produce limited tool wear [6,7]. Presently, chipping occurred near drilled hole periphery majorly characterize the hole quality of a float glass [8]. Chipping is the critical hindrance during drilling process to generate high-quality holes with least tool wear [9]. Consequently, manufactures of float glass generally aimed at emerging new machining techniques exemplify as laser beam machining, rotary ultrasonic machining to amplify the hole quality [10,11].

Rotary ultrasonic machining (RUM) process is mainly aided to machine hard and brittle materials [12,13]. It is a hybrid machining process which consists of the material removal mechanisms of diamond grinding and ultrasonic machining [14–17]. The key characteristics of RUM process are fine surface finish with a lesser amount of cutting force, superior hole accuracy and lesser tool pressure [18,19]. It was found that during RUM process, the drilling force is reduced by 23% in comparison to conventional drilling and thus the hole exit quality also enhanced [20–25]. Wang et al. (2016) worked with the conical drill using RUM process to decrease the chipping at hole exit quality [26]. In another study, rotary ultrasonic machining (RUM) is taken place on BK7 and K9 materials. It was noticed that at 40 to 80% ultrasonic power, cutting forces and edge chipping size are decreased [27]. Another researcher did an investigation on the edge chipping reduction using quartz glass by rotary ultrasonic drilling. It was observed that the decrease in cutting force has directly reduced the crack size. Edge chipping has significantly influenced by the brittle material's toughness [28]. Lv et al. [29] demonstrated a high-frequency vibration based mechanism based on hole entrance chipping in RUD process of BK7 glass. It was found that the ultrasonic superimposition leads to drastic improvement in the holes edge quality. Ning et al. [30] predicted a mathematical model based upon CFRP specimen to find the ultrasonic vibration amplitude at various combinations of input aspects during RUM process. It was found that the ultrasonic vibration amplitude is a significant key variable. It has a noteworthy impact on cutting force,

* Corresponding author.
E-mail addresses: ankit.sharma@thapar.edu (A. Sharma), vivek.jain@thapar.edu (V. Jain), dheeraj.gupta@thapar.edu (D. Gupta).

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