Original article

Institution of MECHANICAL ENGINEERS
Journal of PROCESS MECHANICAL ENGINEERING

Multi-shaped tool wear study during rotary ultrasonic drilling and conventional drilling for amorphous solid

Proc IMechE Part E:
J Process Mechanical Engineering
0(0) 1–10

DOI: 10.1177/0954408918776724
journals.sagepub.com/home/pie
SAGE

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Abstract

Float glass, which is a hard and brittle material, is generally machined and drilled using rotary ultrasonic machining and conventional drilling to create products such as solar panels, metrological instruments, etc. But researchers are facing serious issues with regard to tool wear and opting for best shape of tool for the drilling purpose. In this study, blind holes are made on float glass specimen using rotary ultrasonic drilling and CNC conventional drilling process with the aid of multi-shaped tools. The opted tools are namely hollow abrasive tool, pin-pointed conical tool, flat cylindrical tools, and concave circular tool. The entire experimental work is accomplished by considering industrial conditions. Multi-shaped tool's weight is computed at three stages i.e. (a) fresh tool, (b) after rotary ultrasonic drilling, and (c) after conventional drilling to analyze the overall tool wear. Apparently, micro-studies are used to investigate the phenomena of lateral and end face tool wear while creating blind holes at these three stages. It is revealed that the concave circular tool achieved a minimum percentage of weight loss i.e. 4.92% after conventional drilling and 1.96% after rotary ultrasonic drilling process, which could be preferred for drilling purpose followed by the hollow abrasive tool.

Keywords

Rotary ultrasonic drilling, multi-shaped tools, tool wear, micro-study, conventional drilling

Date received: 22 November 2017; accepted: 11 April 2018

Introduction

Float glass has huge potential in solar panels, metrological instruments, and automobile sector, owing to its thermal wear resistance and chemical properties.[1] Hard and brittle material like glass is widely machined using rotary ultrasonic machining (RUM) and CNC conventional drilling (CD). Most of the research study is carried out to achieve efficiently drilled component and optimum working parameters. Yet, researchers are facing crucial hitch relevant to tool wear and opting for best shape of tool for the drilling purpose. Conventional diamond drilling process is generally used for glass drilling. However, during float glass drilling few inadequacies are needed to be sorted out.

RUM is a hybrid process that generally aids in drilling holes in advanced ceramics and glass. Its material removal mechanism is a combination of ultrasonic machining and traditional grinding. It was found in some studies that RUM provides superior material removal rate, improved surface finish, better hole creation, and lesser cutting force, which results in lesser pressure on tool increasing tool's life in comparison to other processes, for instance diamond drilling and other traditional methods (such as ultrasonic machining).[2–8]

Zeng et al.[9] worked on the RUM process, where the hollow abrasive drill tool was equipped with metal bonded diamond abrasives. In another study, tool wear and its failure monitoring were considered during the RUM process.[10] Digital microscope and sensors were used to examine the actual tool wear.[11] Jain and Pandey[12] discussed about the tool wear occurred during drilling operation by micro-rotary ultrasonic machining. It was mentioned that the metal-bonded tool has the least wear occurrence tendency, as tool is fabricated with a combination of diamond abrasive and sintering-type metal powder. It was found that the size and thickness of grains of hollow diamond tool showed inverse effect on the tool wear. Factors such as vibration amplitude, spindle speed, and

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