World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:16, No:06, 2022

Mechanical Characterization and CNC Rotary Ultrasonic Grinding of Crystal Glass

Authors : Ricardo Torcato, Helder Morais

Abstract : The manufacture of crystal glass parts is based on obtaining the rough geometry by blowing and/or injection, generally followed by a set of manual finishing operations using cutting and grinding tools. The forming techniques used do not allow the obtainment, with repeatability, of parts with complex shapes and the finishing operations use intensive specialized labor resulting in high cycle times and production costs. This work aims to explore the digital manufacture of crystal glass parts by investigating new subtractive techniques for the automated, flexible finishing of these parts. Finishing operations are essential to respond to customer demands in terms of crystal feel and shine. It is intended to investigate the applicability of different computerized finishing technologies, namely milling and grinding in a CNC machining center with or without ultrasonic assistance, to crystal processing. Research in the field of grinding hard and brittle materials, despite not being extensive, has increased in recent years, and scientific knowledge about the machinability of crystal glass is still very limited. However, it can be said that the unique properties of glass, such as high hardness and very low toughness, make any glass machining technology a very challenging process. This work will measure the performance improvement brought about by the use of ultrasound compared to conventional crystal grinding. This presentation is focused on the mechanical characterization and analysis of the cutting forces in CNC machining of superior crystal glass (Pb ≥ 30%). For the mechanical characterization, the Vickers hardness test provides an estimate of the material hardness (Hv) and the fracture toughness based on cracks that appear in the indentation. Mechanical impulse excitation test estimates the Young's Modulus, shear modulus and Poisson ratio of the material. For the cutting forces, it a dynamometer was used to measure the forces in the face grinding process. The tests were made based on the Taguchi method to correlate the input parameters (feed rate, tool rotation speed and depth of cut) with the output parameters (surface roughness and cutting forces) to optimize the process (better roughness using the cutting forces that do not compromise the material structure and the tool life) using ANOVA. This study was conducted for conventional grinding and for the ultrasonic grinding process with the same cutting tools. It was possible to determine the optimum cutting parameters for minimum cutting forces and for minimum surface roughness in both grinding processes. Ultrasonic-assisted grinding provides a better surface roughness than conventional grinding.

Keywords : CNC machining, crystal glass, cutting forces, hardness
Conference Title : ICMPT 2022 : International Conference on Materials Processing Technology
Conference Location : Copenhagen, Denmark
Conference Dates : June 09-10, 2022