Effect of increasing abrasion on properties of a glass ceramic

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Introduction

Glass ceramics are currently being considered for use as the strike-face in transparent armor systems. In this study, Schott Robax® glass ceramic was subjected to increasing levels of abrasion to determine the effect of abrasion damage on its equibiaxial flexure strength and optical properties. It was expected that if glass ceramics were subjected to abrasion, the equibiaxial flexure strength would decrease while the optical properties would be quantifiably impaired. This drop in strength could cause the glass-ceramics to fracture prematurely which would be detrimental in situations where the glass ceramic is used in a transparent armor system. Through ascertaining the influence damage has on the strength and optical properties of glass ceramics the quantified results can be compared to glasses subjected to similar damage in similar studies. The results of this project will ultimately be used to help determine the glass type to be used in armor systems.

Materials and Methods

Schott Robax® glass-ceramic plates of dimensions 150 × 150 × 6 mm were tested under varying levels of abrasion. Glass ceramics were produced by creating glass through standard glass-making procedures, shaping, and reheating the glass at a higher temperature. This controlled the crystallization of the interior of the glass instead of allowing spontaneous surface crystallization, which characterized the interior of normal glass.

The Robax plates were dimensionally analyzed to determine their exact edge lengths and plate thicknesses. Each plate was cleaned thoroughly and the initial haze value, which was formally defined in the American Society for Testing and Materials D1003 (2013) as the percentage of transmitted light that deviates from the incident beam by more than 2.5 degrees on the average, was measured with a Haze-gard plus.

The experimental conditions the plates were exposed to included increasing levels of abrasion. Ten Robax plates, and ten borosilicate float glass plates were abraded for 0, 150, 300, 600, 1200, and 2400 cycles respectively. The plates were secured with a jig (seen in Figure 1) that held the plate steady while abrading and 250 grams of 12-grit alumina zirconia abrasive were poured evenly onto the plate in the jig. A modified Bayer Taber® tester (seen in Figure 2) oscillated the jig back and forth to induce abrasion on the surface of the plate with the abrasive material. The jig oscillated back and forth for a certain number of cycles and once the abrasion duration was finished, the plate was removed from the jig, cleaned

Materials and Methods (cont.)

thoroughly again, and then the final haze value was measured. Finally, the equibiaxial flexure strength test was performed on the abraded plates following the standardized procedures with an Instron frame (ASTM C1499-09, 2009) to determine the maximum amount of stress that the glass was able to sustain when subjected to increasing load until fracture (set up shown in Figure 3).

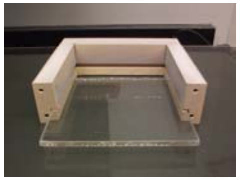
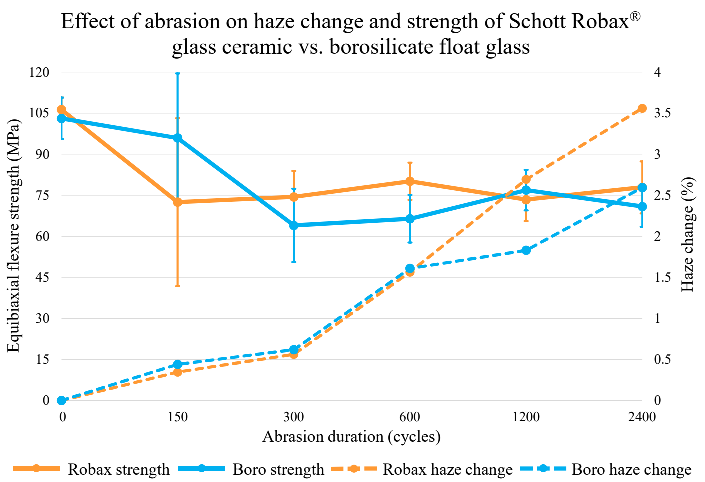


Figure 1 (left, top): Fabricated wooden jig configured to secure a 6” × 6” × 0.25” glass plate during the process of abrasion.

Figure 2 (left, bottom): Modified Bayer Taber® tester used to induce abrasion damage upon the glass specimen by oscillating laterally with the specimen secured in it.

Figure 3 (right): Instron frame set up to perform the equibiaxial flexure strength test on a Schott Robax® glass ceramic specimen.

Results



Graph 1 (above): Graph plotting effect of increasing abrasion on strength and haze change of Schott Robax® glass ceramic and borosilicate float glass (J. Murdock, personal communication, October 28, 2016) with the horizontal axis log scale of base two and error bars of one standard deviation.

Results (cont.)

The average haze change and equibiaxial flexure strength were calculated for each group of ten Schott Robax® plates, and the data were plotted in Graph 1 in a double *y*-axes graphs. Additionally, strength data for the borosilicate float glass by Jake Murdock (personal communication, October 28, 2016) was plotted. The strength and haze values were displayed on the vertical axes as the dependent variables, while the number of abrasion cycles were displayed on the horizontal axis as the independent variable. The change in each as a result of the increase in abrasion cycles was plotted, with the natural variation accompanying the strength for each group of ten plates depicted using the error bars.

Conclusion

The purpose of this project was to study the effect of abrasion on the optical properties and strength of Schott Robax® glass ceramic and compare it to other glass types where similar damage was induced. This was part of a larger study that aimed to identify the glass or glass ceramic to be used in transparent armor systems. It was evident that as abrasion increased, the haze of the Robax increased with a range of 3.56. This was similar to the haze change values for the borosilicate float glass, which were attributed to the increase in abrasion cycles inducing flaws on the surface of the glass. The equibiaxial flexure strength of the Schott Robax® experienced a significant decline when initial abrasion was introduced at 150 cycles. Research by Patel, Schoenstein, Swab, Thies, & Wright (2013) found that after soda-lime-silicate and borosilicate glasses were exposed to a 1 N scratch, the equibiaxial strength dropped 25–60%, which supported the Robax data. By quantifying how increased abrasion affected glass ceramic properties, the collective results could be comparatively used for continued study of all glass types. Ultimately, the results of this study will lead to the development and identification of the bullet resistant glass or glass ceramic used in transparent armor systems.

References

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