C12 Breakage Characteristics of Glass Drinking Vessels and Consequent Injury Potential in "Glassing" Attacks

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After attending this presentation, attendees will gain awareness of typical breakage patterns of a representative selection of glass drinking vessels found in bars and pubs, and understand the particular conditions in which they occur.

This presentation will impact the forensic science community by providing a detailed account of the failure of drinking glasses, and thus giving an indication as to whether or not an alleged account of a glassing assault is likely to be valid or not.

The failure of glasses is dependent upon a complex function of: (1) flaws that are either inherently present or due to handling damage in/of the glass; (2) the glass' thermal history and, hence, the extent of residual stress present; (3) the magnitude and distribution of areas of individual stress concentrations due to loading; and, (4) the mechanical properties of the glass itself. Since nearly all commercial glasses are soda-lime silicates, the mechanical properties of glass can be assumed to have negligible effect.

Figure 1 shows a Finite Element Analysis (FEA) simulation of a pint glass subject to impact. Areas of high stress concentration are likely to serve as the origin of failure but more vulnerable areas of the glass (i.e., the rim) are likely to be the source of the most severe flaws. Failure occurs when the critical fracture toughness is exceeded. Where a large flaw is found, the energy necessary to cause fracture is low and a claim of accidental breakage and consequent injury may have merit.

The introduction of tempered glasses over the last two decades has led to an increase in glass safety by causing the glass to break into smaller and blunter fragments. A rapid cooling treatment of the glass surfaces from the glass transition temperature causes a mismatch of fictive temperatures throughout the glass wall thickness, leading to compressive stresses at the surfaces and a balancing tension stress in the core of the glass. Since glass will only fail in tension and usually from a surface flaw, the magnitude of compressive stress can be added directly to the inherent glass strength. The combination of the additional force required to cause fracture and the release of the residual stresses causes a far more dense fracture pattern.

However, the level of temper possible is dependent upon the thickness of the glass and it is found that thinner parts of the glass (i.e., closer to the rim) store far less stress and resulting fragments there are similar to that of annealed (residual stress-free) glass. This can be seen in Figure 2.

Not only does the level of residual stress vary up and down the height of the glass, but also around its diameter. This can be measured using an automated polariscope that interprets the degree of retardation of light due to stresses in the glass. A prediction of residual stress can also be made by analyzing the distribution of wall thickness, which is aided by the use of CT imaging.

This presentation will show a range of characteristic breakage patterns produced by varying types of glasses, and illustrate what factors must be incorporated into the production of a safe pint glass.

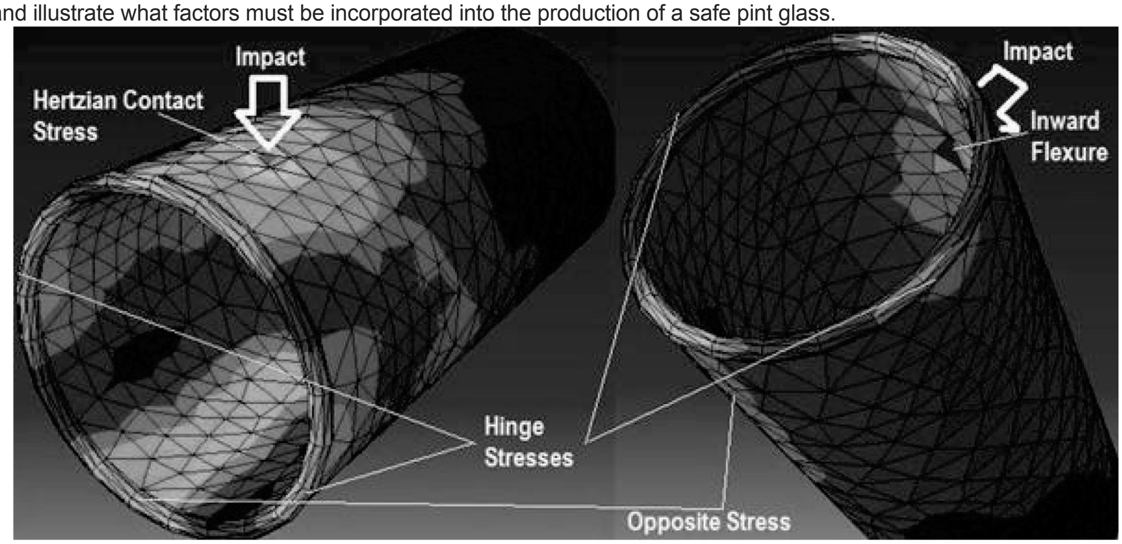

Figure 1 — Finite element simulation of stress distribution on a straight-walled pint glass due to impact. Left image shows the Von Mises stress distribution, right image shows first principal stresses.

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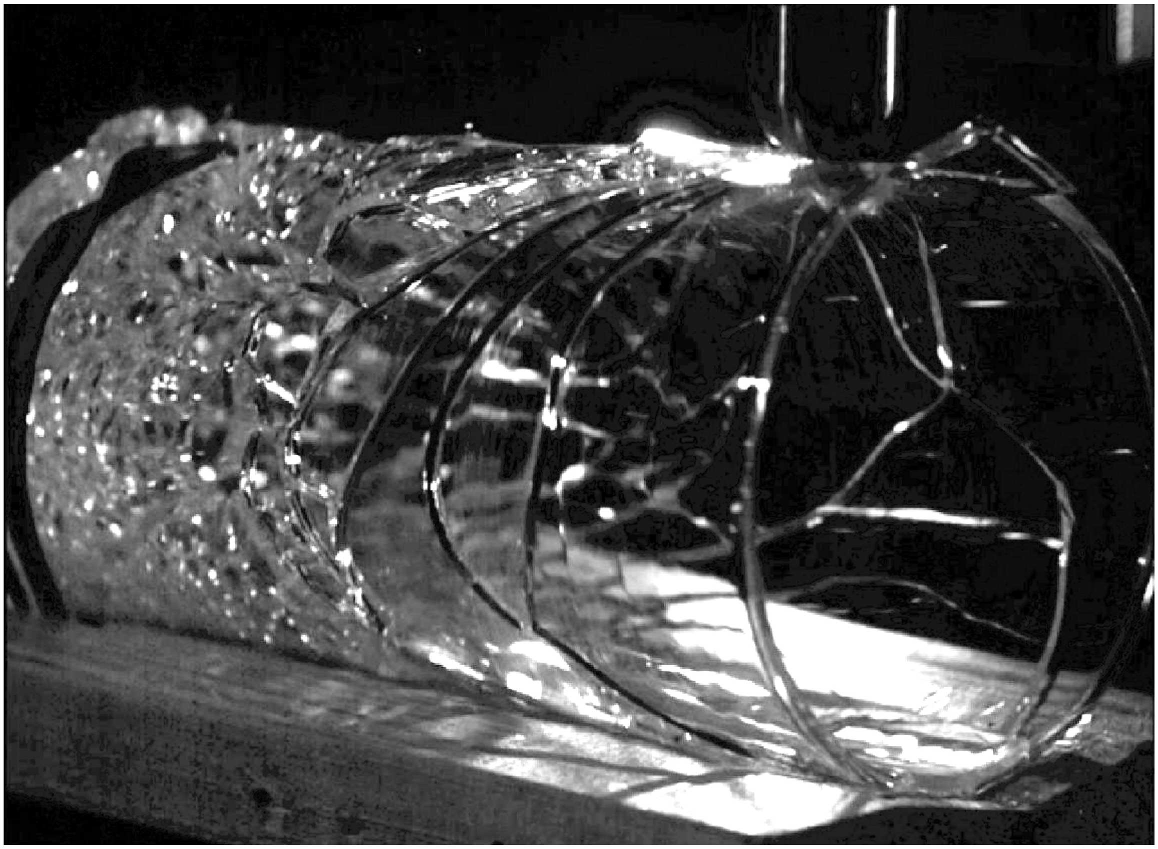

Figure 2 — A frame taken from high-speed video footage of a tempered glass fracture. Near the base of the glass, the toughening process is effective and the glass breaks into small shards. For this glass, toughening is less effective closer to the rim, resulting in larger and sharper shards.

Glass, Glassing, Fragment

 ** Presenting Author*