Non-destructive testing of the glass strength in flat glass with indentation induced cracks by Nonlinear Acoustic Wave method

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Glass is a unique but unfortunately brittle material whose strength is primarily limited by the presence of cracks on the surface [1]. The strength of glass is limited by the fact that very high stresses arise at the crack tips when subjected to tensile load. In principle, without the presence of surface cracks, glass would have a strength far exceeding many other structural materials, *e.g.*, steel. The size and the distribution of surface cracks vary greatly, which results in the strength of glass exhibit a great variation and thus requires that large safety margins must be applied for glass in practical applications, *e.g.*, when used as a load bearing building material.

Today, there are no methods to determine the strength of flat glass non-destructively. Instead, the strength is determined by different experimental methods requiring >10 samples for sufficient statistics. This procedure requires both lots of glassy materials and time. The future aim is to investigate if the use of nonlinear acoustic waves (NAW) could be an alternative for developing a standardized design strength value. Developing a non-destructive inspection method for determining the glass strength is a scientific breakthrough that will have a great industrial impact for the sustainable development of glass manufacturing.

With the use of NAW it is possible to detect and quantify the defects in materials [2,3]. The nonlinear waves are transmitted through the object and the nonlinear effects, caused by the defects in the material, corresponds to the level of damage in the material. This work present result from samples containing relatively precise defects. The defects were created using a microindenter with a sufficient load to cause indentation induced cracking in the glass. The indentations were created using a Vickers diamond tip in the middle of commercial 4 mm float glass samples of the dimensions 10x10 cm^2. The applied loads were 0.5N, 1N, 2N, 5N and 10N. The "damage value" of the sample series was then quantified using the NAW technique. The fracture strength of the samples was correlated destructively using a conventional ring-on-ring setup.

The results show that there is a clear correlation between the indenter load, the damage value from the NAW inspection and the fracture strength. We noted that the standard deviation for the ring-on-ring tests for the 1N, 2N, 5N and 10N was low while the 0.5N and the reference samples presented a high standard deviation. A possible explanation for this observation is that for 0.5N not all indents give radial cracks but in some cases the indentation produces only plastic deformation. The main conclusion from the research is that is possible to detect realistically large defects in glass using the non-destructive NAW method and these defects cannot be seen with the naked eye. Moreover, the results can be directly correlated with the strength of glass [4].

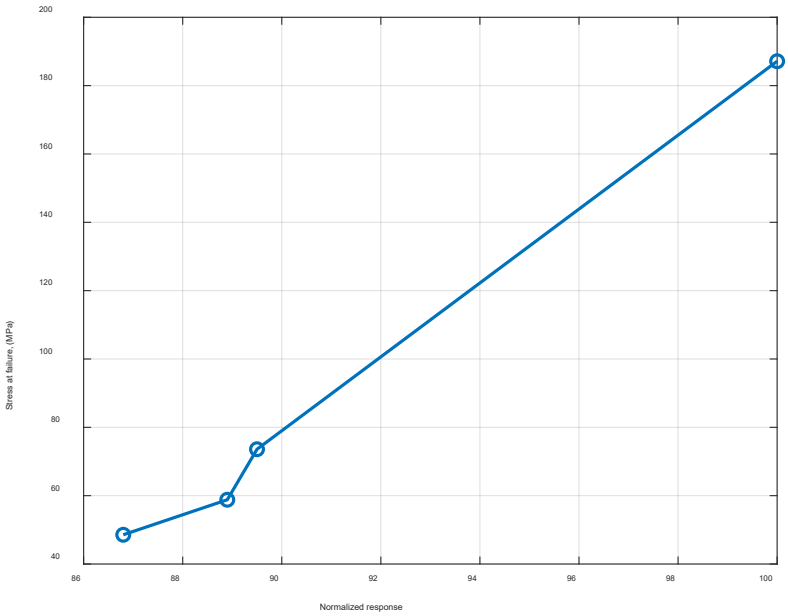

Figure 1. Average stress at fracture from the ring-on-ring test as a function of the inverse normalized damage value from the NAW measurements.

References

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