

Information sheet

Make or break

Bottle strength and the manufacture of lighter weight wine bottles

This information sheet has been prepared as part of WRAP's (Waste & Resources Action Programme) GlassRite Wine project. One of the objectives of the project was to encourage further lightweighting of wine bottles, thereby reducing the tonnage of glass entering the waste stream and improving resource efficiencies.

One of the major concerns within the wine sector is 'If a wine bottle is made lighter and thinner, will it not be weaker and therefore break more easily?' To address this concern, an assessment was carried out by Glass Technology Services (GTS) which demonstrated that lighter, thinner bottles can be manufactured to a strength equal to that of more commonly used heavier bottles. Modern techniques, such as Finite Element Analysis (FEA) are also discussed as an option for optimum bottle designs.

Why do glass bottles fail?

Glass bottles fail when sufficient stress is applied to the container, creating a crack. Glass flaws can be introduced into glass bottles during manufacturing. Some of these flaws are due to poor process control e.g. thin walls; others are due to contaminants being introduced into the furnace, such as broken ceramic which can end up embedded in a bottle's sidewall or base. Inspection processes usually detect these flaws before the bottle leaves the factory.

Common stress inducers

In normal use, glass containers will be subject to a variety of stresses which could act on a glass flaw to produce breakage. These stresses include:

- Impacts: knocks from filling and general use;
- Squeezing: sideways pressure from rollers on filling lines;
- Loading: vertical pressure from stacking;
- Residual stress: internal manufacturing stresses that should be removed by annealing;
- Bursting: internal pressure from carbonated drinks; and
- Thermal: rapid expansion due to hot filling.



The safe manufacture of lighter weight glass wine bottles

Glass manufacturers are confident in their ability to reduce the weight of bottles whilst retaining, and in many cases improving, structural strength. The lightweighting process is viewed as the natural outcome to the application of new and improved technology in the manufacturing process. In recent times significant advances have been made in design, forming, inspection and testing techniques - all of which have contributed to the safe production of lighter glass containers. A brief description of some of these improvements is given below.

Improved design capabilities

The contribution to the lightweighting process of computer-assisted design (CAD) tools has been significant. Several software packages are now available. Some consider the actual forming process and how the glass moves during forming, which helps the designer direct more glass into potential weak spots; others consider the performance of the finished container.

Finite element analysis (FEA) enables the designer to model the strength implications of any design feature and reduce the need for producing prototype glass bottles for testing and subsequent bottle redesign that may be necessary.

Improved manufacturing process control

Glass manufacturers can never achieve perfect glass distribution within a mould and must incorporate a safety factor to ensure that glass thickness does not fall below a safe level. Today's manufacturers have much more control over the forming process, in determining both the amount of glass required for a bottle and the distribution of glass in a mould. The use of Narrow Neck Press and Blow (NNPB) processes has resulted in better glass distribution in the mould.

Improved inspection and testing technology

Every container produced is subject to a range of quality checks during the manufacturing process. Technology based on high speed imagery is able to identify and reject any manufacturing faults including thin walls. Containers are also routinely tested to destruction to assess impact resistance, vertical load and bursting pressure. This testing ensures that any lightweighted bottles meet the same exacting standards that were applied to its heavier predecessor.

Real time in-situ monitoring

Developments in telecommunications and data logging now enable the glass manufacturer to gather information about the stresses a glass bottle is subjected to in the supply chain. One such system, Sensor Wireless, involves producing a perspex replica of a bottle within which are installed various sensors. The model records impact and temperature information which can be used to refine the design of the bottle or identify where stress points occur in production, filling and distribution.

Performance of lighter weight wine bottles

As a means of demonstrating that lighter wine bottles can be manufactured to a comparable strength to their heavier counterparts, GTS assessed the performance of 3 existing 75cl wine bottles.

The bottles chosen had varying wall thicknesses and weights ranging from 360g to 475g.

The performance of the bottles was compared by using Finite Element Analysis (FEA). The bottles were also subjected to standard impact testing as would be applied in normal manufacturing procedures.

Test results for stress and impact load showed that the thicker bottles were stronger, but most importantly that the 360g bottle fell comfortably within the allowable stress, impact and load levels. What was most apparent was that the design and shape of the bottle contributed more towards points of weakness than wall thickness.

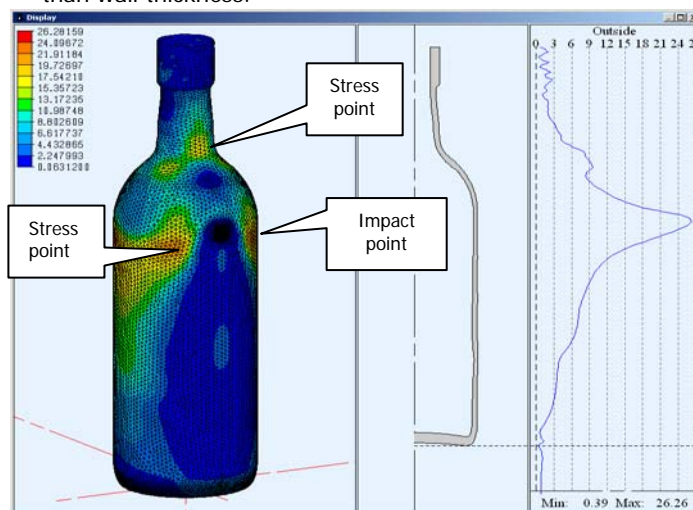


Figure 1: Results of impact loading on the outside surface of a wine bottle weighing 360g.

Conclusions

Modern manufacturing methods allow glass manufacturers to produce wine bottles that are significantly lighter than was previously possible, without compromising safety. As the demand for and actual use of lighter bottles increases supply and specification will improve.

Further information

Find out more about lightweighting and how WRAP can help your brand and business by visiting www.wrap.org.uk/retail

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