GLASS DESIGN
MODELLING SOFTWARE
ELFEN GD
INTRODUCTION

Elfenglass Design (GD) is a suite of numerical modelling programs which are designed to provide glassmakers with decision support system tools to aid in the design, production and quality control of glass containers. The programs combine the latest numerical technology and years of glassmaking measurements and experience to provide practical, representative simulation tools that glassmakers can use and benefit from.

Elfenglass Design (GD) may be used to simulate the forming process of round glass containers on an IS machine from gob load through parison forming, invert and final blow to mould open.

BENEFITS OF THE SOFTWARE

Implementation of the package within a company’s design and production procedures will enable the users to:

» Create “virtual prototypes” of new containers prior to physical trials, thus reducing the number of expensive and time consuming trials required

» Perform lightweighting trials on existing containers

» Provide virtual teaching/training on production techniques without downtime on production lines

» Assess effects of changing parison, plug and plunger shape

» Investigate the influence of process conditions and glass composition upon final container shape,

» Assess the effects of changing parison, plug and plunger shape,

» Perform lightweighting trials,

» Assess the effects of mould cooling on the forming process.

The joint research programme was a blend of numerical modelling developments, experimental measurements and considerable trialling by the partners.

ELFEN GD has its origins in joint research with IPGR*. The joint research programme was a blend of numerical modelling developments, experimental measurements and considerable trialling by the partners.

The ELFEN GD suite has three main modules:

ELFEN GD Forming

ELFEN GD Forming has been designed to simulate the forming process of glass containers from gob delivery through parison formation, invert and final blow until mould open. The types of forming process modelled include BB, PB and NNPB.

ELFEN GD Design (Static)

This module analyses the integrity of containers subjected to head loads and internal pressure loads. Assessment of a container’s integrity can be made by comparing the predicted results against experimentally determined failure stress curves.

ELFEN GD Design (Dynamic)

GD Design (Dynamic) analyses the integrity of containers subjected to impact loads, such as filling line collisions.

KEY FEATURES

» Simulation of forming processes: blow blow (BB), press and blow (PB) and narrow neck press and blow (NNPB)

» Stress analysis of containers for head loads, internal pressure and impact loads

» Failure prediction based on comparing predicted stress results against specified failure stress levels.

» Graphical user interface has pre and post processors with data input using glass industry terminology

» Interfaces to CAD packages for transfer of tooling geometry

» Results of forming analyses can be transferred directly to the stress analysis modules

The ELFEN GD Forming module has been designed to allow the professional engineer/designer in the glass container manufacturing industry to improve quality and efficiency. The software can be used to:

» Predict the glass thickness distribution in the final product under a variety of conditions

» Perform “virtual prototyping” of new containers,

» Perform lightweighting trials,

» Investigate the influence of process conditions and glass composition upon final container shape,

» Assess the effects of mould cooling on the forming process.

The software is used to simulate the forming of round containers using BB, PB or NNPB technology. The processes are modelled from the delivery of the gob to the blank mould through parison formation, invert, run down and final blow.

The numerical models incorporate state of the art technology to correctly represent the physics of the glass behaviour and the process conditions so that the simulations can capture the response of the forming process to:

» Glass composition

» Process timings

» Gob temperature

» Mould and air temperature

» Viscosity and shear thinning effects

The ELFEN GD Forming module is an easy to use integrated package aimed at those working in the glass industry. The data required for each analysis is input via a customised graphical user interface, using terms that the glass industry understand and data which is readily available to the glassmaker.
Data Input

The pre-processor has been set up to accept the required simulation data in industrial terms under six categories:

- Factory Settings (Glass properties)
- Process Data
- Container Geometry
- Glass Data
- Blank Setup
- Mould Setup
- Machine Timing

Most of this data will be readily available to the user.

Geometric Data

The geometry required is:

- Blank,
- Mould,
- Neckring,
- Plug/plunger.

These are imported from CAD as DXF or IGES.

Gob Data

The gob data comprises:

- Gob weight
- Gob temperature,
- Initial positioning of the gob within the blank mould.

Temperature Data

The distribution of temperature on the blank, mould and plug/plunger influences the heat transfer from the glass during forming. Temperature distributions are defined by specifying temperatures at user-selected points on the blank, mould and plug/plunger. Data may be obtained from any convenient method, such as probes or infra-red cameras. The ability to specify temperature distributions also enables the user to assess the effect of changes in temperature distribution, e.g. from a proposed change to the cooling system before it is implemented.
Timing Data
Timing data is required for each event in the processing sequence on the IS machine, e.g. blank close off, invert on. This data is entered from the machine logging sheets in degrees, points or seconds. This data can be entered individually for each container, or imported from an existing project or standard library.

Process Data
The process data includes:
- Counter blow pressure (BB)
- Plunger force (PB)
- Final blow pressure
- Vacuum on final blow (optional).

Glass Properties
ELFEN GD Forming allows the user to set up and store glass property data sets on a “factory, furnace, line” basis. The correct line is then simply selected within the pre-processor. This ensures that within a company several users will utilise a consistent set of material data. An unlimited number of factories and lines may be created, thereby accommodating users who have several production sites.

Three default property sets are included in the software, for flint, green and amber glass. Users may also create their own via the User Interface.

Viewing Results
Post-processing Capabilities
The post-processor has been designed to enable the user to assess and interpret the results of the forming simulation efficiently and with ease by providing the following viewing facilities:

Graph Plots
A graph of glass wall thickness can be plotted at selected times throughout the process, with the facility to overlay measured container thickness data or design thickness data. Temperature graphs for the external and internal surfaces can also be produced, along with a graph of plunger displacement, for PB/NPB containers. Graphs can be exported to textfiles and overlaid in other projects.

Parison Plots
The parison plot is a composite plot which shows superimposed parison shapes at three stages - blank open, reheat and run down.

Animations
Colour animations of the forming process may be produced in AVI format and replayed independently of the ELFEN-GD Forming module.

Tracking Points
This is a facility which allows the user to select a number of points on the outside of the parison which are tracked to their final position on the container. The paths of the tracking points selected in the pre-processor are displayed as coloured lines superimposed on the parison shape and blow mould.
Container Information
The glass weight, brimfull capacity, corkage diameter and other data can be requested.

Colour Screen Plots
Presentation of the results, at selected times throughout process, in the form of colour plots of the following:
- Shape of parison/container
- Temperature distribution of the parison/container

Report Generation
Reports containing graphs and mesh/contour plots can be output to a Postscript file, which can be sent directly to a Postscript printer or to almost any other printer via widely available third party printing software.

Prediction of Wall Thickness Distribution

Parison Plot

Tracking Points
The ELFEN GD Design (Static) module is designed to help glass container manufacturers and associated companies predict how containers will withstand head and pressurisation loads. Stress distributions may be predicted on both the inner and outer surfaces, for any round or non-round container.

Implementation of the package within a company’s design and production procedures will enable the users to:

- Assess the initial designs of container profiles based on design wall thicknesses
- Monitor the stress resistance of manufactured containers from measured wall thicknesses or thicknesses predicted by ELFEN GD Forming

The zoning data is used in the post-processor when displaying target stresses in the container. The zones are identified automatically by the software from the geometric data. An overlay representing the target (maximum allowable) stress level for each zone may be superimposed, giving indications of potential failure at a glance. A set of default templates is available. The user can also construct their own and include them in the post-processor.

Mesh and Contour Displays
The user may display:
- Container shape
- Contours of maximum tensile stress
- Contours of maximum tensile stress as a percentage of the failure stress in each zone.

Target Stresses
To assess the integrity of a container, the stresses predicted by ELFEN GD Design (Static) need to be compared against failure stress limits. However, the strength of a container varies all over and depends greatly upon its handling from take out to packer, particularly at the hot end.

Areas of the container which are defined as having different failure stress levels, e.g. shoulder, bearing surface, are referred to as zones.

Graphs
The graph facilities enable the user to display graphs of tensile stresses on the internal or external surface of the container, for head loading, internal pressure or a combination of the two. Output in tabular form is also available from the graph facility. Graphs can be exported to textfiles and overlaid in other projects.

Tip Angle and Velocity
The tip angle and velocity are calculated and can be displayed as graphs related to the container perimeter. This allows for the fact that non-round containers will have tip angles which vary with the local radius.

Container Information
The glass weight, brimfull capacity and other data can be requested.

Report Generation
Reports containing graphs and mesh/contour plots can be output to a Postscript file, which can be sent directly to a Postscript printer or to almost any other printer via widely available third party printing software.
Overview
The ELFEN GD Design (Dynamic) module is designed to help glass container manufacturers and associated companies predict how containers will withstand impact loads. Stress distributions may be predicted on both the inner and outer surfaces, for both round and non-round containers.

ELFEN GD Design (Dynamic) is capable of analysing containers under a variety of dynamic (and static) loading conditions, and will report the maximum stress values induced in the container. The dynamic loads available are designed to simulate real situations such as line collisions, and standard test procedures such as the pendulum test.

Implementation of the package within a company’s design and production procedures will enable the users to:

- Assess the initial designs of container profiles based on design wall thicknesses
- Monitor the stress resistance of manufactured containers from measured wall thicknesses.

The ELFEN GD Design (Dynamic) module is an easy to use package comprising pre and post processors and analysis package. The data required for each analysis is input via a graphical user interface in terms that the glass industry understands and using data that is readily available to the glassmaker.

Data Input
The ELFEN GD Design (Dynamic) pre-processor provides a user-friendly interface through which all the necessary data may be entered. The data required for a ELFEN GD Design (Dynamic) analysis comprises:

- Container geometry
- Loading data

Container Geometry
The geometry input consists of the internal and external profiles for 2D containers (round only), or full 3D surfaced geometry for any shape container. These are imported from CAD as DXF, IGES or STL.

Loading Data
The dynamic loads comprise:
- Pendulum test
- Line Collision
- Drop impact

Auxiliary items such as the v-bar, hammer and baseplate for the pendulum test are generated automatically by the software, taking into account the container size and shape.

Viewing Results
The failure of containers subject to impact loads is initiated from the internal or external surfaces (providing no flaws or inclusions within the glass are present). Thus the evaluation of a container’s integrity within ELFEN GD Design (Dynamic) is based on the maximum tensile stresses occurring on the outer or inner surface.

The post-processor has been designed to enable the user to assess and interpret the results of the stress analysis efficiently and with ease.

The maximum tensile stress distribution may be viewed in the post-processor in both graph form and as contour plots. The stresses are shown as time-independent stresses, i.e. maximum stress occurring at all positions on the container surfaces at any time during the analysis.

Graphs
The predicted results may be viewed in the form of graphs of stress distributions along user-selected vertical sections through the container. Graphs of maximum tensile stresses on both inner and outer surface may be plotted. Graphs can be exported to textfiles and overlaid in other projects.

Contour Plots
The maximum tensile stress distributions are viewed as contour plots on to a 3D container shape.

Tip Angle and Velocity
The tip angle and velocity are calculated and can be displayed as graphs related to the container perimeter. This allows for the fact that non-round containers will have tip angles which vary with the local radius.

Report Generation
Reports containing graphs and mesh/contour plots can be output to a Postscript file, which can be sent directly to a Postscript printer or to almost any other printer via widely available third party printing software.
Overview
Rockfield Software Ltd offer high quality customer services to complement ELFEN GD, ensuring that users can perform all their modelling tasks smoothly and efficiently, and obtain maximum benefit from the software. A comprehensive range of services is available including:

- Training
- Consultancy
- Maintenance
- Software Updates
- Post Sales Support
- Product Installation

Post Sales Support
Post sales support is an important part of any software product and Rockfield are committed to providing a first-class, friendly service, to ensure that users receive expedient solutions to any queries or problems that arise when modelling with ELFEN GD. Since the support staff have extensive experience in the modelling of glass container forming, FE systems in general and computer hardware, quality hot-line support is available in the following areas:

- Functionality queries
- Modelling advice
- Modelling trouble-shooting
- Software errors
- Hardware queries
- FE theoretical information

To provide a quick and convenient access to the support desk, various modes of contact are available:

- E-mail
- Telephone

To shorten the turn-around time of certain types of queries, project files may be sent to Rockfield via e-mail.

Training
Training courses can be held on-site or at Rockfield’s offices and cover the following topics:

- An introduction to ELFEN GD functionality
- Application of ELFEN GD to industrial problems
- Data gathering and validation
- Assimilation of ELFEN GD into the Design Procedures

Typically, the costs and durations of the recommended product training course are as follows:

<table>
<thead>
<tr>
<th>Module</th>
<th>Duration (Days)</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELFEN GD Forming</td>
<td>2</td>
<td>2,200</td>
</tr>
<tr>
<td>ELFEN GD Design (Static &amp; Dynamic)</td>
<td>1</td>
<td>1,100</td>
</tr>
</tbody>
</table>

Travel time for courses held at a Client’s site will be charged at £750 per day.

ELFEN GD Supply Schedule
A ELFEN GD licence entitles the holder to use the purchased modules for a full calendar year from the date of supply. Each licence includes:

- User manuals
- Software media
- Software support
- Maintenance
- Updates

Software Updates
ELFEN GD is continually being enhanced with improvements to existing features and the incorporation of new capabilities. These enhancements are driven by customer feedback and demand or by funded developments. For more information on the latest updates please contact Rockfield.

Maintenance
A maintenance service is provided to minimise and overcome any inconvenience caused in the unusual event of software non-conformities being encountered. This service is fast and efficient since the software is developed in-house and the program developers are on-call to give expert advice on work-arounds and to correct the product.

Consultancy
On occasions where users require an analysis to be performed and they do not have the manpower resources or the knowledge in-house, Rockfield can undertake this task on a consultancy basis.

Computer Platforms
ELFEN GD has been designed to run on a PC platform. The recommended minimum specification is given below.

- PC Workstations
- Monitors: Colour 1280x1024 resolution
- Processor: 1GHz or faster
- Memory: 2 Gb (Min)
- Operating System: Windows

Typical Run Times
(Based on 3GHz PC with 4Gb RAM)
- GD Forming: 5 mins
- GD Design (Static): 10 s (round) - 10mins (non-round)
- GD Design (Dynamic): 15-60 mins
ELFEN GD Licences
ELFEN GD is supplied on payment of an annual licence fee for each module used (minimum licence period is normally one year). This ensures that all users have the latest version of ELFEN GD and that they are fully supported. For up to date costs please contact enquiries@rockfield.co.uk

Multiple Licences
Licence fee prices are for a single PC.
A licence to use ELFEN GD on additional machines, at the same site, is charged as a factor of the primary licence:

- 2nd & 3rd CPU  50%
- Additional CPU’s  25% each

Flexible Licence costs are available on request.