# Lightweight glass technology: weight reductions and surface coatings

Henning Meyer
Hermann Heye, Obernkirchen (Germany)

## 1. Introduction

The discussions that have been under way already for a long time concerning environmentally-friendly packaging, in connection with the packaging regulations and the establishment of the DSD (Duales System Deutschland) have given a great impetus to the development of lightweight glass containers. Many who did not foresee the necessity for a reduction in weight have now been forced by the DSD charges to catch up on developments that had long been latent. These developments have notable advantages for the environment, for consumers and for business.

Heye-Glas has been a pioneer in the field of lightweight glass technology for more than a quarter of a century, and now sees its efforts fully endorsed. Very recently, weight reductions in glass containers on the market have been achieved, which would not have been thought possible even a short while ago.

## 2. Technology for manufacturing lightweight glass

The lightweight glass technologies developed by Heye-Glas offer considerable reductions in weight and thereby savings in raw materials and energy as well as in DSD charges. A view of achieved and expected reductions in wall thickness by different manufacturing processes and surface protecting treatments is given in figure 1.

The success of the Heye technology is based on achieving a very regular and reproducible wall thickness distribution in the forming of glass containers. The thinnest part of a container determines its strength. A poor distribution of wall thickness is therefore the reason for a high weight, since the average wall thickness must be increased in order to guarantee that there will be a certain set thickness at the thinnest point.

The first step was accomplished by the development and improvement of the narrow neck-press-blow NNPB process, which is followed today by the Heye Advanced NNPB Process (HAP) for IS machines. That includes all those measures and components that contributed to improving the reproducibility of the process. The intensive involvement of Heye-Glas with the process has led

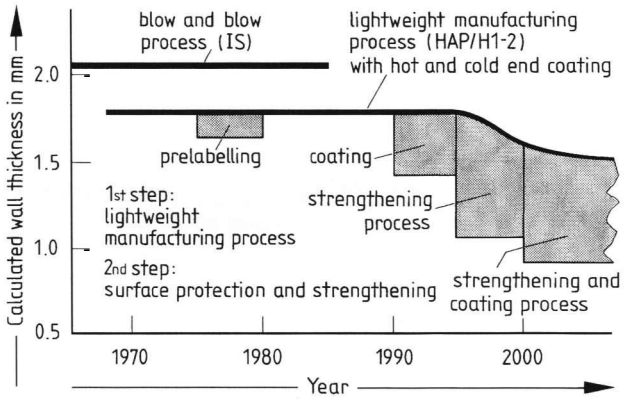


Figure 1. Achieved and expected reductions in wall thickness by lightweight manufacturing of glass containers.

Table 1. Examples of weight reductions for jars produced by the H1-2 process

| jar capacity in ml | glass weight in g | | weight reduction in % |
|---|---|---|---|
| | up to now | from now on | |
| 580 | 315 | 190 | 40 |
| 370 | 185 | 130 | 30 |
| 370 | 200 | 140 | 30 |

to a whole series of developments in IS machines and related matters, which has made possible better control, even at the highest production speeds.

In a parallel manner to the HAP for narrow-necked containers, Heye-Glas has developed a special lightweight glass technology for wide-necked containers, involving the use of the H1-2 production machine developed in-house.

Using this process, Heye-Glas produces, for example, everything from ultra-light glass containers for small sausages (table 1) to protective glass bulbs for energy-saving lamps.

## 3. Examples of weight reductions achieved

Table 2 shows some examples of weight reductions for various types of glass containers, which achieved savings of up to 40% in some cases. As was stated in section 1.,

Table 2. Examples of effected weight reductions by the Heye lightweight technology

| article | glass weight in g | | weight reductions | |
|---|---|---|---|---|
| | up to now | from now on | in g | in % |
| 1.0 l soft drink bottle | 480 | 400 | 80 | 17 |
| 0.33 l soft drink bottle | 165 | 145 | 20 | 12 |
| 1.0 l wine bottle | 555 | 390 | 165 | 30 |
| 0.7 l spirits bottle | 600 | 350 | 250 | 42 |
| 0.7 l spirits bottle | 450 | 315 | 135 | 30 |
| 1.0 l spirits bottle | 650 | 450 | 200 | 31 |
| 1.0 l juice glass | 370 | 265 | 105 | 28 |
| 0.75 l vinegar bottle | 420 | 250 | 170 | 40 |
| 325 ml packaging glass | 220 | 130 | 90 | 41 |
| 580 ml packaging glass | 315 | 190 | 125 | 40 |
| 1285 ml packaging glass | 580 | 350 | 230 | 40 |
| 720 ml packaging glass | 325 | 250 | 75 | 23 |

Table 3. Examples of weight reductions for jars (soft drink bottles) produced by the Heye advanced NNPB process

| jar capacity in l | glass weight in g | | weight reduction in % |
|---|---|---|---|
| | up to now | from now on | |
| 1.0 | 190 | 315 | 18 |
| 0.33 | 140 | 200 | 17 |

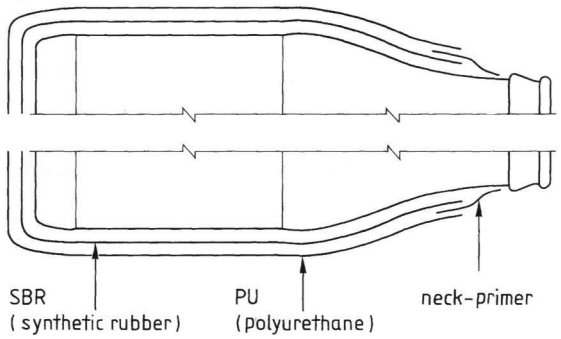


Figure 2. Two-layer coating shown on a glass bottle (Glas-Pact process).

the demand for reductions in weight has enormously increased recently. For instance the weight of returnable soft drink bottles had to be reduced from 480 to 400 g. An additional example is given in table 3. A further progress of this development is highly likely. Reductions in weight also lead to changes in the external appearance since the capacity must be retained in any case. Consequently the form of packaging (palette utilization, distribution, etc.) changes together with the machine technology at the bottling plant (guides; conveyors; starwheel; etc.). Thus the demands on the technology, process control and quality assurance in the manufacture of the bottle increase.

In particular, additional care must be taken with bottles for carbonated drinks to ensure that the reduction in weight does not reduce their strength and thereby reduce the safety level.

Walls of less than 1 mm thickness require special surface treatment to guarantee sufficient strength and to allow further weight reductions.

## 4. Basic technology for increasing the strength of glass

The strength of glass depends very strongly on the condition of the surface of the glass. The tensile strength of new glass fibres is around 200 times greater than, for instance, the strength of a returnable bottle after numerous round trips. This is due to the different number of scratches and microcracks in the surface. External forces cause large mechanical stresses at the tips of microcracks. These stresses can substantially exceed the theoretical strength of about 10 000 MPa. For this reason the compressive strength is around 10 times greater than the tensile strength.

Increasing (or maintaining) the original strength can be achieved by two different methods:

a) avoiding or healing surface defects by applying a protective coating, or

b) producing compressive stresses in the surface by chemical procedures or thermal toughening.

### 4.1. Examples of bottles with surface coating

Currently, returnable bottles with an alkali-proof polymer coating are being launched on the market. In addition, other processes, that will still take a long time to develop, are emerging. As an example, a description of compressive stress coating produced by the sol-gel process is given in section 4.2.

#### 4.1.1. Alkali-proof polymer coating for returnable bottles

In Germany there are two processes for coating returnable bottles, which will be introduced into the market shortly.

a) Glas-Pact
This process was developed jointly by PLM Glashütte Münder, Bad Münder (Germany), and Heye-Glas. Two layers – synthetic rubber (SBR) and polyurethane (PU) in an aqueous solution – are applied by a dipping process (figure 2).

b) Geracote
A process that was put into operation by Gerresheimer Glas, Düsseldorf (Germany), and Oberland Glas, Bad Wurzach (Germany). A single-layer polyurethane coating is applied by a roller system.

Both processes produce an alkali-resistant and strength-retaining coating so that the bottle can be reused as often as normal returnable bottles. Further advantages are, firstly, protection of shards if the bottle breaks, and secondly, the possibility to reduce the weight to the level of that of normal nonreturnable bottles. In this way, it is possible to overcome the disadvantage of the heavy weight of the returnable bottles and containers currently used.

Due to these developments, normal returnable 920 g soft drink glass bottles now have to compete with a coated bottle with a weight of about only 400 g.

## 4.2. Coating with the sol-gel process

The sol-gel process opens up opportunities for producing a glass layer without the need to go through a melt phase. Using hydrolysis and condensation reactions to form a gel via a sol (which contains glass components in solution) at relatively low reaction temperatures, followed by thermal solidification, leads to a new form of glass of a certain composition.

Selection of a suitable sol-gel system can be used to determine in advance the heat expansion coefficient to form a strength-enhancing compressive strength layer on the surface.

Heye-Glas is working on this development with well-known research facilities. It will, however, take some time until this coating system is ready for sale.

0794R005