Forming glass containers: temperature, thermal exchange and viscosity

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Moulds, different processes and glass temperature

Forming glass containers involves the use of blank and blow moulds, with which heat is removed from the glass, along with diverse processes such as blow-blow, press-blow, NNPB, which give the final items their correct shape. Figure 1 shows the blow-blow process, during which the parison is formed inside the blank mould and then transferred from the neck ring arm inside the blow-mould. The temperature of the glass inside the mouth lowers considerably due to its contact with the plunger. If the plunger remains in the glass too long it can cause stress on the mouth. The neck ring mould must be suitably amortized and able to avoid possible oscillations of the parison, without touching the upper surfaces of the blow mould. An optimal distance could be 1.2 millimetres, but this distance can change as per the type and size of the mouth.

Glass temperature and behaviour

The temperature of the glass gob changes in just a few seconds, from 1200°C to about...
500°C in the container forming phase with IS machines. This temperature decrease is due to the thermal exchange caused by the contact of the glass with the walls of the moulds. This contact during the various phases of the process can cause the internal surfaces of the moulds to be subject to oxidation and, in turn, reduce thermal conductivity.

The phenomenon of glass sticking to the inside walls of the moulds may take place if the thickness of the materials is too reduced: contact temperature must be optimal and the viscosity of the glass must be sufficiently low. The sticking temperature with sodium-calcium type glass can range from about 700°C to 800°C, as per the type of material used for the mould, such as: bronze-aluminium alloy and cast iron. To efficiently contrast this phenomenon, swabbing is carried on the internal walls of the moulds with graphite-oil, which lowers the temperature in some areas. The glass gob can therefore flow freely over the surface of the moulds, thus decreasing the heat to the materials. In order to re-establish the efficiency of the materials, the surfaces of the moulds can be polished to remove oxidation and obtain smooth surfaces. A layer of hardened glass forms on the external surfaces of the parison caused by the thermal exchange of the glass in contact with the walls of the blank mould (see Figure 2), thus maintaining its shape during processing.

**Reheating phase**

The reheating phase is extremely important because suitable homogeneity must be obtained with regards to viscosity regarding final blowing. If the parison remains inside the mould for a short time it becomes soft and unstable, which must obviously be avoided. When the parison is not in contact with the walls of the blow mould, but is inside the same, thermal exchange starts to take place by means of radiation, and the internal heat of the glass, together with the temperature of the mould, enable to reheat the previously hardened superficial film. This will require about 34 per cent of the entire cycle time for the blow-blow process, and 58 per cent of the press-blow process and NNPB time, before the parison is blown. The surface viscosity of the parison can vary during the final blowing phase, and, therefore, the highest temperature possible should be reached to avoid temperature variations that could cause differences in viscosity and glass thickness due to the lengthening and expanding of the parison.

**Final blowing**

During final blowing, the parison adheres to the blow mould and the bottle takes its shape. The permanence of the parison in the blow mould determines the
forming of the container with the features required on leaving the mould. In this phase, the external surface of the bottle has a colder surface layer, which is then continuously heated by the internal part of the glass, and, therefore, its thickness could have an effect. Viscosity can normally be about 109 Poise, but viscosity of less than 107.65 Poise is not advised.

During the processing of containers with IS machines, four highly important phases must be adjusted, more precisely:
1) glass contact time inside the blank mould;
2) reheat time of the parison inside the blow mould;
3) final blow time with blow head on blow mould;
4) cooling time of the container on the dead plate.

**Compresssion time**

Baffle compression time above the funnel – known as settle blow – is also important, as it enables the compressed air to press the glass gob in order to obtain a completely shaped mouth. Short compression time will enable to obtain a thin film of surface viscosity on the upper part of the parison, as well as improved distribution of the glass in the final stage, resulting in uniform thicknesses.

On the contrary, if a longer settle blow compression is used, it could cause a thicker surface viscosity film and, in turn, irregular thickness variations on the glass bottle. And this excessive cooling is the cause of changes in thickness and the effect known as wave of counter-blow, which can be seen three-quarters down the height of the bottle.

In order to have correct and uniform distribution of the glass, the following indications should be respected:
- glass gob temperature, which must be homogeneous with regards to composition and thermal temperature;
- shape of the glass gob, which must be the most suitable to enter the blank mould perfectly and centrally;
- uniform temperature of the blank mould by means of the correct design, with the most uniform mould thicknesses as possible;
- after the glass gob enters the blank mould, the compressed air must be consistent and for a short time, so as to completely form the mouth;
- the shortest reheating phase possible used on the external film to create the counter-blow, with enough compressed air required to form the parison;
- the correct shape inside the blank mould is also important if we want to have containers with uniform distribution of glass;

- reheating time: to enable to have uniform reheating of the film on the external surface of the parison during the reheating phase inside the blow-mould, prior to the final blow.

Bearing all this in mind, we must remind glassworks that the same criteria cannot be used in designing the parison line, since each and every glassworks uses different types of glass composition with, consequently, different behaviour.