Mould design services

Dominique Vassaux explains in a series of articles the importance of mould cooling, its influence on the performance of the IS process and on container quality.

To ensure best cooling performance of the mould equipment and consequently, to ensure the required heat removal from glass, cooling fans need to provide the correct air requirements to the forming machine in regards to air pressure versus volume. At the blow side, the design of blow heads will have a direct impact on how soft the glass of a newly formed container is when leaving the blow mould.

The latest computerised simulation software will help designers to predict the various cooling and forming processes on a forming machine, to decrease time from concept to final produced containers.

Cooling fan specification

To achieve optimal mould cooling performance on the forming machine, cooling air must be correctly supplied from the cooling fan(s) to the forming machine. In that sense, the cooling fan specification must always suit the cooling requirements of the moulds, not the other way around. Very often, people think that more air volume (bigger fan size) will give better mould cooling results. This is not always the case.

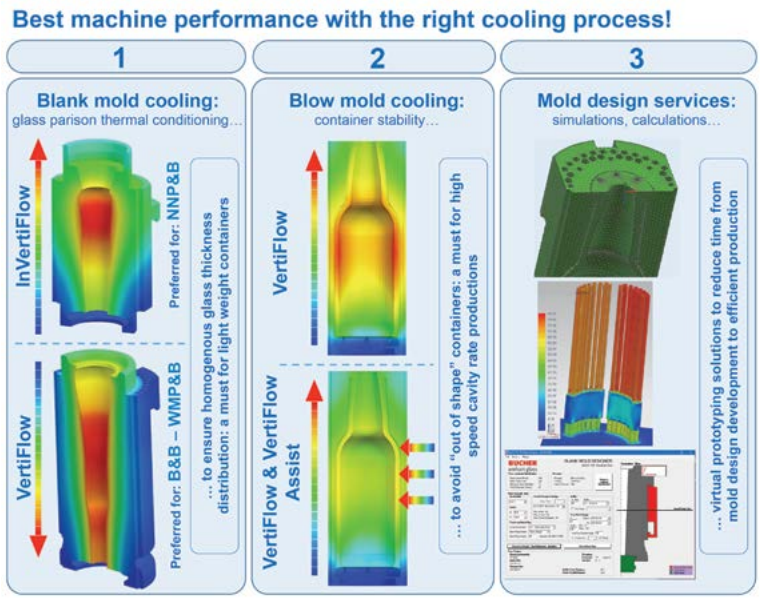
It is important to size the fan correctly in both pressure and volume, according to the latest BEG cooling air requirements specification. Volume undersized cooling fans will lead to mould cooling problems on the forming machine. However, oversized fans will also create severe issues to mould cooling. Not only will an over specified cooling fan heat up the cooling air (surges of pressure, which can even damage the fan installation), so that hot air with temperatures up to 70°C is supplied to the machine to cool down the moulds but the total air pressure also drops at the forming machine inlet. This leads to reduced air velocities inside the vertical cooling holes of the moulds, resulting in reduced heat transfer coefficients and consequently, poor cooling efficiencies of the moulds.

Oversized cooling fans generate much higher operating energy costs. Considering a 10-section triple gob machine, a cooling fan for a radial stack cooling machine (IS type) will consume approximately 250kW, whereas a cooling fan for a 'full VertiFlow' machine (AIS/NIS type) will consume approximately 90-120kW. Using VertiFlow cooling enables an energy cost reduction of at least 100-130kW, which corresponds to an annual saving of around €100,000 per cooling fan (based on an average cost of €0.1/kWh). In that sense, a cooling fan designed for a stack cooling machine must not be used on a 'full VertiFlow' forming machine (AIS/NIS) for energy reasons, as well as for poor cooling efficiency reasons that can strongly affect production performances on the machine.

For best mould cooling performance and energy cost reduction, BEG recommends that glass plants invest in cooling fans of variable speed drive type and rotary vane control, following the company's latest cooling air requirements specification.

Importance of blow head design

Blow head design is very often misunderstood, leading to certain glass cooling restrictions when inappropriate designs are used. The blow head arm supplies compressed



Optimum machine performance with the correct forming process.

air to the blow head's tube, having a specific inner bore diameter. This air usually exhausts via two holes having another specific inner diameter. The relationship between the inlet and outlet areas on the blow head design is very important, because it will directly influence the resulting internal pressure inside the container during the final blow process, as well as the mass flow volume of final blow air. These two aspects play an important role in removing heat from the recently formed container at the blow side and therefore need to be taken carefully into account to ensure high quality containers.

For a typical 28mm diameter finish design, for example, good results are achieved when using an inner tube diameter of 8mm, with two exhaust holes of 5mm diameter. Considering an inlet pressure of 1.6 bar at the blow head arm infeed, the resulting internal pressure inside the newly formed container will be approximately 1.2 bar (see accompanying images). This pressure is required to push the glass wall thickness against the blow mould cavity, in order to extract heat from glass to the blow mould.

By increasing the two exhaust holes from 5mm to 6mm, the total exhaust area will accordingly be increased (keeping an internal tube diameter of 8mm). However, this will result in a reduced internal pressure of 0.9 bar during the final blow process, instead of 1.2 bar as previously. Consequently, the glass wall is pushed less against the mould cavity, exchanging less heat to the mould, so that glass remains softer when leaving the blow mould. This can lead to dimensional defects (leaners, out-of-round), as the newly formed container can deform.

The ratio between blow head infeed and exhaust is an important parameter to control, in order to ensure correct heat removal from glass at the blow side.

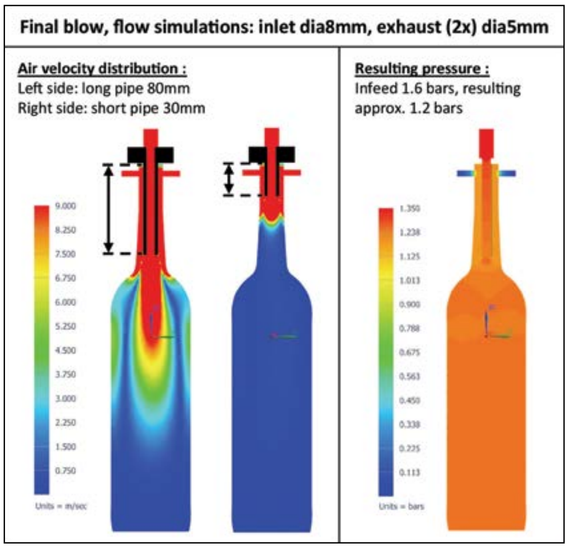
It is important to note that the length of the blow head's tube will also influence glass cooling at the blow side, as it can influence the air velocity distribution inside the newly formed container during the final blow process. The ideal length of the tube depends primarily on the container shape (long neck or high shoulder container), as well as on the maximum straight stroke given by the blow head mechanism on a machine. Forming machines with longer straight stroke (NIS/AIS) will allow the use of 80mm long tubes, which is a real asset to position the tube at the shoulder 'entrance radius' on long neck containers. In comparison with the use of a short tube, this will generate additional convection cooling in the shoulder and top body part of the container and consequently, extract additional heat from the glass during the final blow process (see images).

The use of blow side vacuum will also help maximise cooling efficiencies at the blow side. Not only does the vacuum process enable faster contact between glass and blow mould cavity, leading in an increased heat removal from glass to mould (because longer contact time equals longer heat removal from glass) but it actually helps to ensure that no air is entrapped in the blow mould cavity, in particular in the gap between the mould cavity and the glass wall. Having the correct resulting internal pressure inside the container during the final blow process, a perfect contact between the glass wall and the blow mould cavity is key to remove heat efficiently from the glass.

Future of mould design: Modelling and simulation

In the future, mould designers should evolve to become true process engineers, not only designing curves on CAD software but also fully understanding the IS process and being capable to better interact with production staff on the forming machines. This evolution in mentalities is key in order to increase production efficiencies, especially to reduce the development time from concept to final produced glass containers.

To facilitate that evolution, new software solutions and packages will need to be developed and correctly introduced to glass plants. Computerised designs provide for precise and predictable applications of mould cooling, blow head designs, cooling tube designs, as well as the glass forming process to predict theoretical glass thickness distribution. This virtual prototyping process is certainly a long-term development process. Each glass plant will experience a learning curve that depends mainly on the willingness of mould designers and IS operators to accept a new technology, which does not work against them but instead, helps those reaching faster, higher efficiencies on forming machines. ●



Final blow flow simulations; inlet diameter 8mm, exhaust (2x) diameter 5mm.

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