Intelligent annealing lehr integrated with a glass forming machine

Independent Glass Container Consultant, Peter J Firth*, examines the features and benefits of a T&T lehr that intelligently integrates with the Glass Forming Machine, while T&T's Managing Director, Rolf Themann**, provides technical and basic costing information for the lehr.

▲ Gas burners and access stairs to top of the lehr with safety rails for when working on top of the lehr.

The annealing lehr has often been viewed as a separate downstream stand-alone piece of equipment.

However, from an academic point of view, all glass scientists see the function of the lehr as an integral part of the glass bottle forming process.

This part of the forming process is visualised on a temperature-viscosity curve and then uses just the temperature of the lehr zones to set the key temperatures needing to be held and the rates of change in cooling, often termed the annealing curve.

These are then translated into lehr zone setpoints in accordance with the lehr belt speed to give the right heating and cooling 'curve' for the annealing of each different product.

All that is required from the IS Machine is to have bottles (or jars) that can stand upright and not deform under their own weight, as key shape characteristics are essential for producing high-quality ware for the customer.

To achieve this, the IS Machine has container cooling air fed from the bottom upwards on what is termed the dead-plate, which is where the containers are delivered to the machine conveyor.

Once on the machine conveyor, cooling air is blown up through the conveyor belt to prevent the newly produced ware from reheating which means the glass inside the sidewalls of the bottle cause the 'skin' of the glass to soften and weaken, allowing distortion of the bottle as a "leaner" or bulge and/or sink defect.

In the case of the base of the bottle it would lead to a sunken punt which can also put the container out of the required quality specification.

In some cases, where there is post-processing, such as labelling, then any deformation of the sidewall, either sinking in slightly or bulging out slightly, can give poor label application later and most commonly cause label 'creasing', for which such ware would then need to be rejected if not controlled within the tight limits.

If the reheating can be prevented during transportation, the stacker can push the containers into the lehr, and the lehr takes care of the rest of the forming process (glass annealing).

This is mainly to do with the reduction of any residual of permanent stresses in

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the bottle to an acceptable commercial level to avoid problems with breakage later when the ware is run down a customer's filling line.

Once the glass containers have been passed through the lehr, and they have been cooled at an acceptable rate to remove any permanent stresses that could weaken the glass containers, they are then sprayed with cold end spray to give protection for further handling without damaging the glass containers' surface and hence weakening the bottles.

The glass containers then go through automatic inspection for key defects and are also examined manually under a quality plan for the production being produced.

Any glass defects found are then reported back to the IS Machine operator for correction to ensure only good ware is entering the lehr.

T&T's new annealing lehr concept described herein actively communicates with the IS forming machine.

It adapts to any change in production conditions to maintain the physical form of the glass containers and also minimises the loss of production in the case of a major disruption, such as a production breakdown.

Capacity / Configuration	Estimated Cost (EUR)
Small lehr up to 150 tpd with integrated system	From €250,000
Medium sized lehr (150–250 tpd) with integrated system	€350,000 - €450,000
Large sized lehr (250–400 tpd) with integrated system	€500,000 - €750,000
High-capacity lehr (400 tpd+) with integrated system	€750,000 - €850,000+

Table 1. The approximate capital cost ranges (EUR) for lehrs.

The lehr control panel using a PLC to keep the number of parts low and prevent common system failures.

Integration concept

Unlike conventional lehrs that operate on fixed or semi-fixed temperature profiles, this new lehr control system is designed to integrate directly with the IS machine control architecture. This is achieved by:

- Continuous data exchange with the IS machine.
- Live monitoring of glass temperature, wall thickness distribution, and section production speed.
- Dynamic adjustment of heating zones, cooling intensity and heat extraction rates.
- Production rhythm monitoring, such as section downtime of production jam-ups necessitating the automatic closing of the lehr door, for example.

Intelligent control

Job changes on the IS machine are high-risk periods for temperature instability and glass container stress variation in the glass containers being annealed. The intelligent lehr is designed specifically to manage those transitions. During product changeovers, the system:

- Maintains the lowest safe thermal level to reduce energy waste.
- Automatically closes and opens tunnel doors as required.
- Adjusts belt speed in relation to the new product geometry and weight.
- Recalculates and reshapes cooling curves automatically.
- Stabilises internal temperature gradients before full production resumes.

The result is quicker stabilisation after job changes and reduced scrap during start-up.

Cooling curve technology

Distributed thermocouples and thermal modelling continuously monitor container surface and core temperature behaviour. Instead of using preset cooling curves, the system:

- Actively reshapes the annealing profile during production.
- Adjusts zoned air velocities and heat input or cooling dynamically.
- Responds immediately to wall thickness variation or speed fluctuation.

This makes it effective for lightweight containers, where stress margins are smaller and thermal control must be precise.

Upstream disturbances

One of the most important advancements is the lehr's ability to respond to disruptions elsewhere in the production line.

If errors occur in upstream manufacturing equipment – including feeder disturbances, short stops, or production speed changes – the lehr immediately adjusts its operation to minimise the overall production impact. To achieve this, it may:

- Modify conveyor speed.
- Adjust heating and cooling intensity.
- Temporarily reshape the annealing curve.
- Optimise airflow distribution.
- Manage the lehr entry and exit door positions automatically.

Therefore, rather than amplifying the effects of upstream problems, the lehr becomes a stabilising component of the entire hot-end forming process.

T&T lehr purchase price costing

As with other conventional lehrs, the actual investment capital depends on:

- Pull rate (tons per day).
- Lehr dimensions.

- Heating method (gas, electric or hybrid).
- Level of forming-machine integration requirement (certain features are optional).
- Degree of automation and adaptive modelling.
- Energy recovery systems options that are required to be installed for maximum efficiency performance.

The system is modular and scalable, which affects the cost of the lehr. However, approximate costings are given based on the glass tonnage sizing of the lehr. The typical approximate capital cost ranges (EUR) are given in ***Table 1, see previous page,*** as a rough estimate for a gas lehr. While initial investment in some cases may exceed that of cheaper but less well-made conventional fixed-profile lehrs, lifecycle economics are improved through:

- Lower energy consumption.
- Reduced scrap rates.
- Higher stable forming speeds.
- Elimination of skid frame replacement; giving reduced downtime during job changes.

Typical payback periods are expected to range from 18 to 36 months, depending on plant energy cost and production volume.

Common purchasing objections

When evaluating advanced lehr systems, the purchasing decision-makers may raise several concerns. These include:

- Capital cost may be perceived as higher than the cheaper, less-well-built lehrs.

Answer: Lifecycle savings and productivity improvements can easily offset the difference.

- System complexity concerns regarding advanced automation.

Answer: Automated adaptation reduces operator burden rather than increasing it.

- Preference for traditional suppliers (of which there are now fewer to select from).

Answer: The mechanical design is more robust, and the in-built intelligence is currently beyond what other lehr suppliers are offering.

- Current lehr works fine, which is a common risk-avoidance mindset by sticking with what the glass plant knows.

Answer: Without trying other suppliers, the current suppliers will not be motivated to change and improve, and so innovation and the benefits of that never get a chance to prove themselves.

Conclusion

For glass container producers seeking higher efficiency rates, reduced scrap, and long-term durability, the T&T lehrs with intelligent integration systems represent not just an upgrade – but a fundamental evolution in glass container manufacturing.

With the current installed lehrs at each particular glass plant, the intelligent integration element of the T&T lehr can be customised to operate with any combination of different lehr suppliers and forming machine manufacturers.

For this, custom quotations will be required based on the amount of integration work required and any hardware parts requiring replacement.

Seeing is believing

A T&T lehr with an intelligent forming integration system has been installed at Glass Futures in St Helens, UK. Glass engineers can arrange to see it and experience first-hand what has been written here. ■

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Looking down onto the top of the lehr and showing roof insulation and fans installation.