Refractory innovation at RHI MAGNESITA delivers furnace sustainability

RHI MAGNESITA demonstrates how refractory design directly drives greener glass production by efficiency increases in the range of various percentage points leading to significant energy savings. By its INNOREG regenerator concepts integrating high-efficiency checker shapes, advanced silica materials and honeycomb crown technologies, the company is showing clear pathways to increasing heat recovery, reducing fuel consumption and lowering CO_2 emissions throughout advanced refractory design.

With glass melting being an energy-intensive process that makes efficiency improvements essential for sustainability, in combination with furnace operation with greater stability and predictability, producers are increasingly turning their attention to a historically underestimated lever: refractories. Far beyond their traditional role as passive materials protecting the furnace structure, refractories today act as active enablers of heat recovery, combustion efficiency, melting performance and overall energy optimisation.

RHI Magnesita demonstrates, through its advanced designs and material innovations, that refractory engineering directly contributes to furnace sustainability. From the INNOREG regenerator concept with high-efficiency checker shapes, to emissivity-enhancing silica crowns, each development represents a precise intervention designed to reduce consumption, lower CO_2 emissions and improve furnace lifetime and operation.

REGENERATOR CONCEPTS

The regenerator is the thermal heart of an end-fired or cross-fired glass furnace. Its role -recovering heat from flue gases during each cycle- is fundamental to reducing the specific fuel consumption required for melting. A high regenerator performance depends on the proper calibration of several parameters :

- Optimised checker geometry, maximising specific heat transfer area (SHTA).
- Stable materials with high heat capacity, high thermal conductivity, low aging properties and corrosion-resistant grades, specifically-selected for each temperature zone.
- Clean operation, minimising condensation, sodium sulphate deposits and structural collapse.
- Homogeneous gas flow, driven by turbulence-enhancing shapes and well-sized flues.

A key element is INNOREG, RHI Magnesita's integrated regenerator concept that assigns material grades and shapes to different thermal zones:

This zoning strategy matches refractory performance to the severity of operating conditions (temperature, corrosion mechanisms, condensation behaviour). For instance:

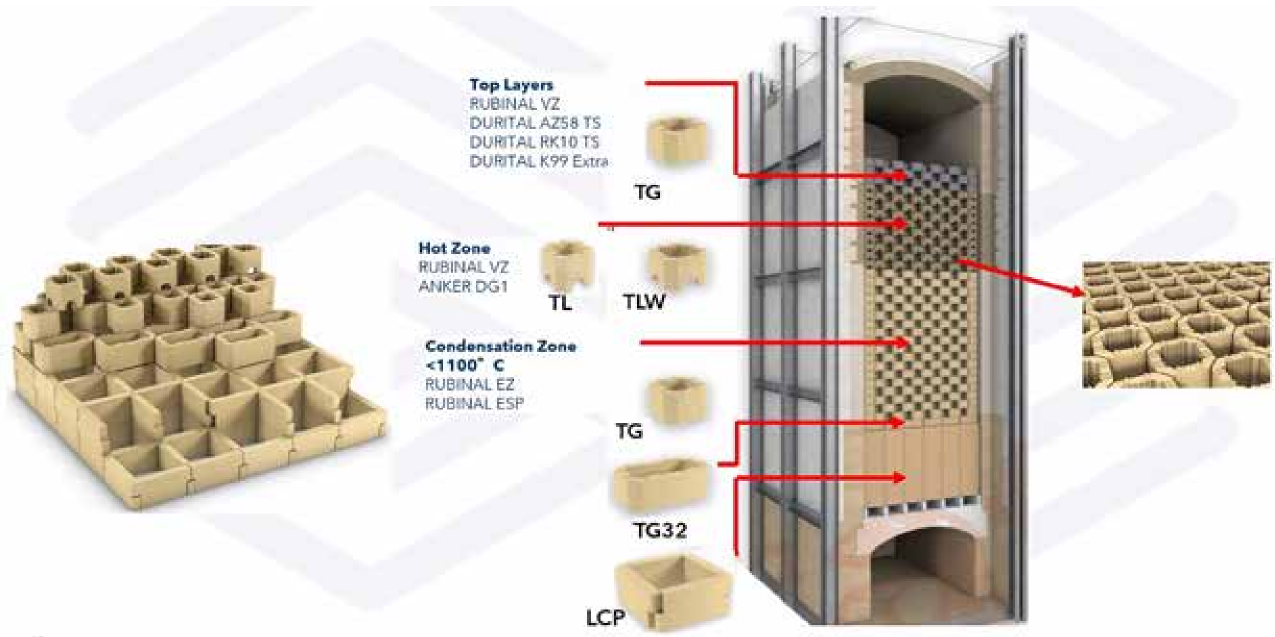
- Top-layer materials must show durability under batch carryover corrosion fluctuations and long-term structural stability.
- Hot-zone shapes need to maximise the heat exchange.
- Condensation-zone shapes must resist gaseous-to-liquid sulphate compound corrosion and accommodate sulphate-based deposits.

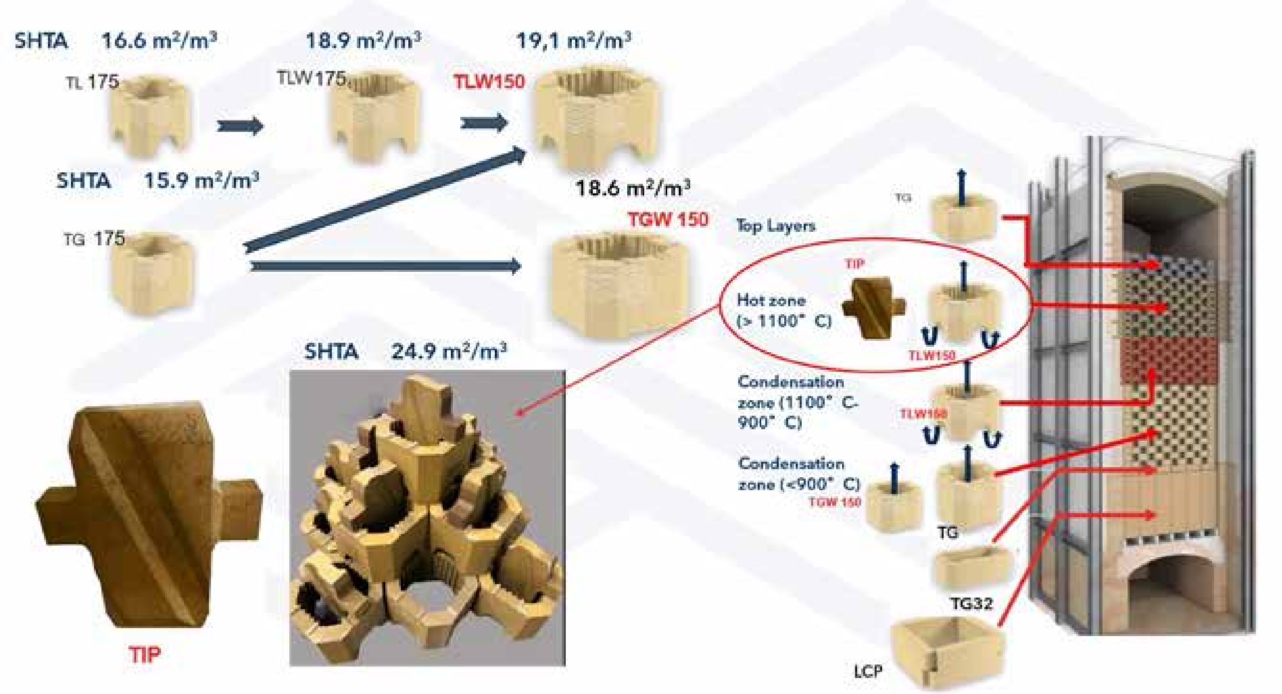
In particular, the LCP shape provides a larger flue cross-section to prevent clogging in areas prone to heavy sodium sulphate condensation - a persistent cause of regenerator underperformance.

INNOREG demonstrates that sustainability is not only about new materials: it relies on precise system engineering where design logic, shape innovation and material science coexist.

TLW, TGW AND TIP

Regenerator efficiency depends heavily upon checkerwork design, section and volume, turbulence, gas distribution, clogging potential and operational cleanliness. To address these requirements, RHI Magnesita, in addition to the traditional TG and TL shapes, has developed high-efficiency shapes such as TLW/15, TGW and the new TIP insert. TLW -already introduced in 2018- has become the company's standard hot-zone checker due to its high specific heat transfer area (SHTA); today the company has improved the design reducing the height to increase the number of openings to promote a better flow and temperature distribution while TGW, a recently developed shape, increases heat recovery in the lower condensation zone. The TIP piece is the latest development and consists of an insert (to be included inside the TLW or TL shape) that enables narrow channels in the hot zone, achieving a SHTA of 24.9 m^2/m^3. Comparative case studies show measurable efficiency gains (up to 5%) when TIP is added to TLW configurations.





The condensation zone typically experiences the highest risk of clogging, forcing the designer to adopt shapes that reduce the turbulence of the flows. TGW shapes address this aspect , and in parallel improve the heat recovery thanks to waves on its internal surface while still mitigating blockage risks. It complements TLW by ensuring that gains in the hot zone are not lost downstream.

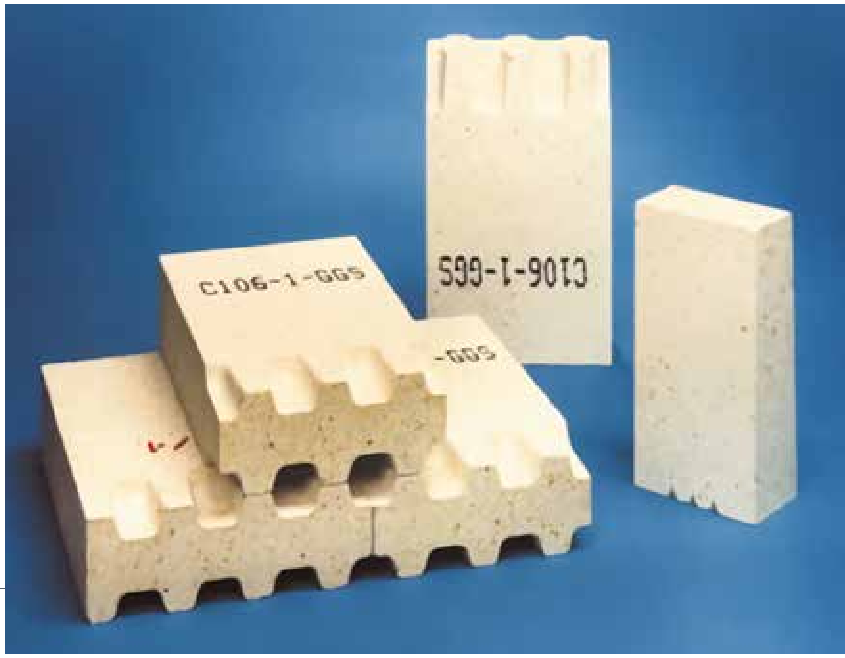
Smart checker designs are able to balance narrow channels in the hot zones and wider channels in condensation areas prone to clogging, by installing the LCP shapes. The result is a high efficiency checker package with high durability during the campaign (less maintenance and less risk of clogging).

HIGH EFFICIENCY CROWN BRICKS

The company also demonstrates how furnace-crown technology can significantly influence energy consumption. Honeycomb shapes increase emissivity simply through geometry. Their cavity structure enhances the chances to absorb and then re-emit radiant energy, increasing the radiation exchange according to the Stefan-Boltzmann law. Field observations show that honeycomb cavities absorb and re-emit more energy than flat sections, with customers reporting fuel savings of about 4 percent. εpsilon silica grade, consisting of high purity silica enriched with an emissivity agent, provides further improvements: modelling suggests that the introduction of the emissivity agent only, can lead up to 1.5 percent energy savings (or 3 percent fuel savings), depending upon combustion chamber geometry, stoichiometry, soot presence, glass emissivity and transmission effects. Combined, honeycomb design and εpsilon grade can deliver more than 5 percent fuel savings-equivalent in one field case to over 607,000 Nm³ of fuel saved and more than 1,190 tonnes of CO_2 avoided that year.

WHY REFRACTORY INNOVATION MATTERS FOR SUSTAINABLE PRODUCTION

Across all case studies and field results, a consistent message emerg-



Energy consumption	Before	After 1 year
Fuel [kcal/kg]	769	728
Electrical [kcal/kg]	74	75
Furnace total [kcal/kg]	*843*	*803*
Before: 339 tpd, 82 % cullet *1 year: 345 tpd, 83 % cullet*		≈ - 5 %

es: refractories are not a static cost - they are an active lever of furnace sustainability.

Direct Benefits for Glass Producers:

1. Lower fuel consumption - immediate cost savings and reduced carbon footprint.
2. Higher melting efficiency - potential for higher pull without furnace modification.
3. Improved thermal homogeneity - better refining, higher glass quality and reduced defect formation.
4. Lower crown temperatures - extended refractory lifetime and fewer maintenance shutdowns.
5. Reduced clogging risk in regenerators → more stable operation across the campaign.

This aligns with the industry's strategic priorities: controlling CO_2 emissions, increasing furnace longevity, and keeping operational costs predictable in volatile energy markets.

LOOKING FORWARD: THE ROLE OF REFRACTORIES IN DECARBONISED FURNACES

As the industry transitions toward hybrid melters, oxyfuel combustion, hydrogen-enriched firing and electric boosting, refractory materials must evolve in parallel. The innovations presented -INNOREG zoning applying high-efficiency checker geometry, and emissivity-enhanced crowns-represent scalable, ready-to-implement steps that work independently of future energy configurations.

While alternative fuels or electrification require heavy infrastructure changes, refractory optimisation provides immediate, low-risk, high-impact sustainability gains.

CONCLUSION

Refractory innovation sits at the intersection of sustainability, operational excellence and economic performance. By redesigning checker geometries, tailoring material grades to specific temperature zones and enhancing emissivity through shape and chemistry, RHI Magnesita demonstrates that smart refractories are indispensable to the next generation of efficient and low-carbon glass melting.

Whether through advanced INNOREG regenerator concepts, or advanced silica solutions, each development actively contributes to reducing energy consumption, improving heat transfer, enhancing pull and ultimately lowering CO_2 emissions.

In an industry where every percentage point of efficiency matters, refractories are no longer simply the materials that line the furnace - they are an essential part of the strategy for sustainability. ■

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