REFINERY CO_2 REDUCTION: PROVEN PERFORMANCE

Mateus Camparotto, Alkegen, South America, presents the results of a study undertaken to evaluate insulation alternatives for the convection section of petrochemical furnaces.

In the dynamic realm of industrial processes, the quest to reduce carbon emissions and cut down energy costs has never been more crucial. Recognising the pivotal role of heat as a critical resource, each step towards improved furnace performance translates into not just cost savings, but a substantial decrease in carbon footprint.

When it comes to furnace efficiency, strategic solutions are available that can help to enable a world where industrial furnaces become champions of energy conservation, significantly lowering operational costs while embracing a sustainable ethos.

Petrochemical sites, with their inherent challenges, provide fertile ground for the application of such solutions. During maintenance shutdowns – where every move is strategic – products that confidently navigate the labyrinth of confined spaces and ease of installation offer advantages. Beyond addressing critical safety risks,

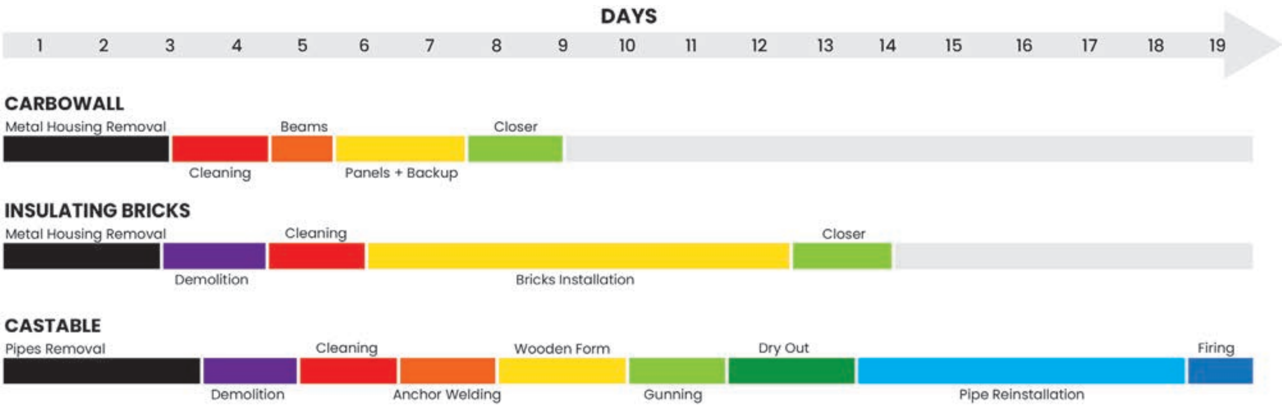


Figure 1. Downtime reduction would amount to 11 days for the Carbowall system and five days for insulating brick, both in comparison to castable.

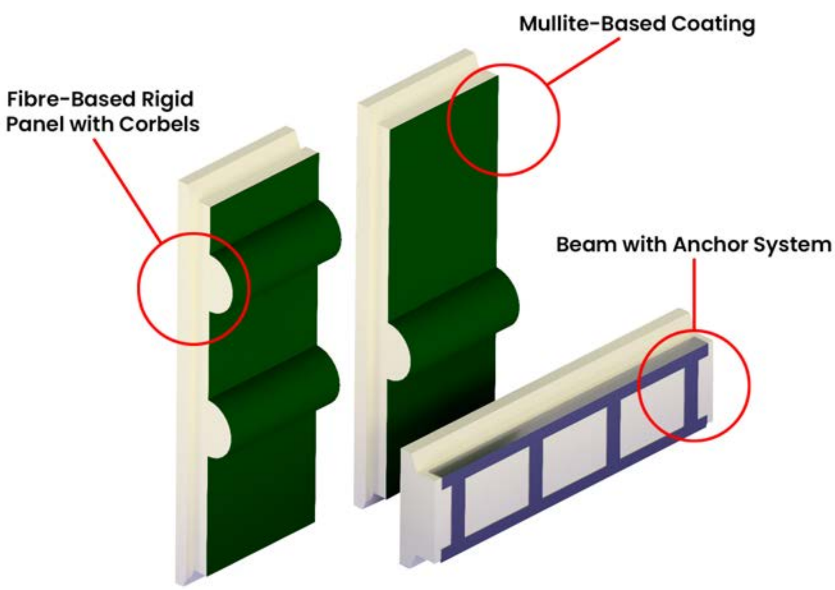


Figure 2. Carbowall is a pre-molded, high-density ceramic fibre system comprised of rigid, mullite-based coated panels and beams that incorporate the anchoring mechanism.

they guarantee a secure pathway to operational excellence, minimising downtime and advancing the pursuit of carbon neutrality.

The critical role that the convection section plays in heat capture

In a typical reformer furnace, natural gas is turned into hydrogen gas through a multi-step process. First, the gas is passed through tubes filled with a catalyst and water vapour. This mixture is then transformed into hydrogen gas and sent to other processes in the unit.

When the product is being processed, the catalyst tubes are heated by radiation to around 700°C (1300°F). The heat generated also passes through a section called the convection section. In this part, the heated gases are used to generate steam and warm up the product load and air for the radiant section. The convection section has a metal casing with insulating material, and within it, tubes are arranged to let the combustion gases preheat the fluid through heat exchangers.

Traditional approaches

Traditional refractory uses castable, insulating firebricks (IFB), or refractory ceramic fibre insulation that are anchored to the walls of the convection section. The maintenance of these walls is extremely challenging. It is often necessary to remove the piping to allow free access to the lining, causing damage to the surrounding lining. The removal process and potential damage becomes a critical path in the downtime of the unit and can result in long delays and increased cost expenditures.

Important considerations in insulation project design

Designing thermal insulation in the convection section requires detailed analysis and consideration of many factors. Maximising the thermal effectiveness of the system requires the selection of materials with low thermal conductivity properties while maintaining mechanical stability.

The insulating material must exhibit resistance to the maximum temperature required by the process along with erosion and thermal variations. The overall installed system, including anchoring, must maintain mechanical stability during service, resisting all chemical components present in the process, without disassociation, degradation, or disintegration.

Emerging solutions

Alkegen's ceramic fibre Carbowall™ addresses the challenges presented in traditional refractory through its rigid monolithic design. Its sections are engineered through vacuum forming of ceramic fibre and binders.

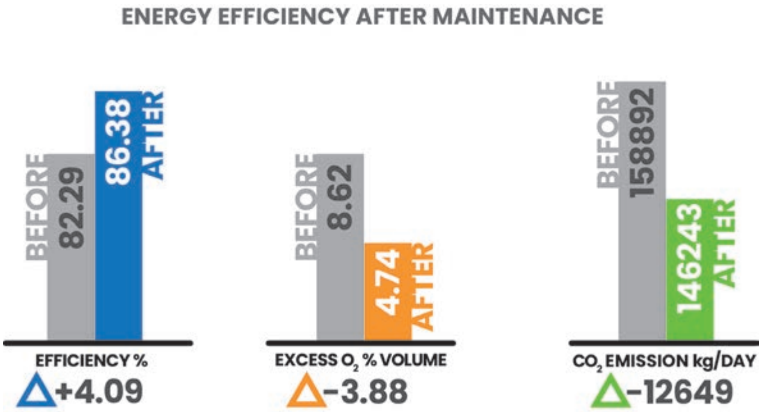


Figure 3. The actual measurements taken from the refinery show the increased energy efficiency of the equipment, including the reduction in CO_2 emissions.

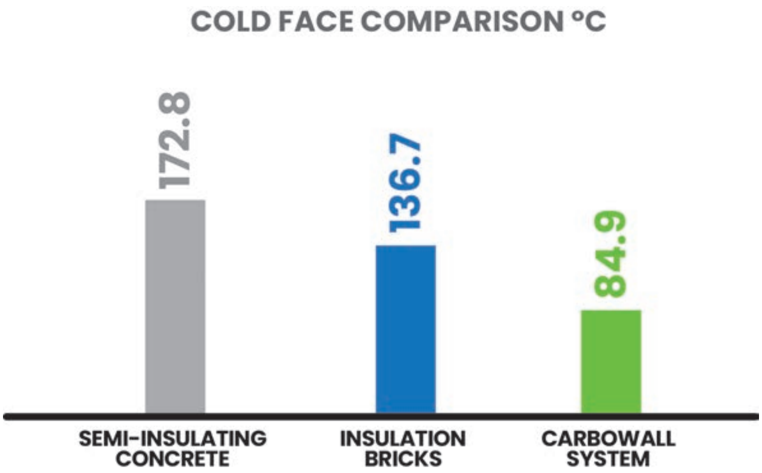


Figure 4. Cold face temperatures are lower for Carbowall, meaning they are excellent at minimising heat transfer. This property helps to maintain lower external temperatures and reduce energy loss in high-temperature environments.

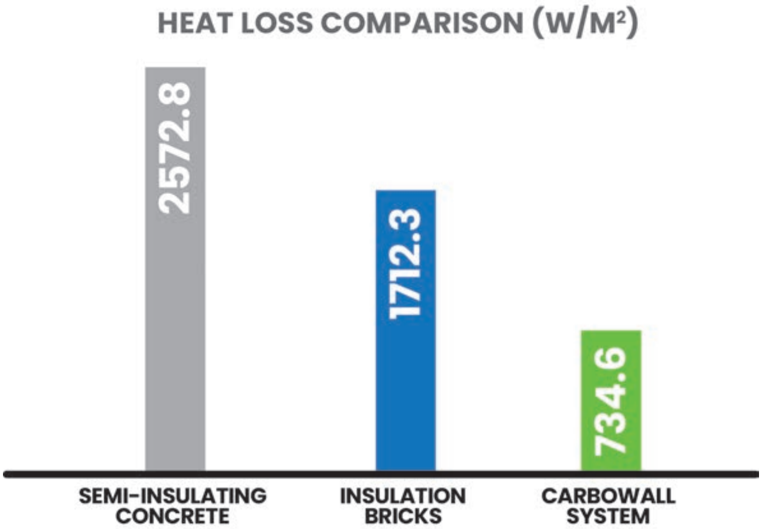


Figure 5. Carbowall is designed to provide maximum thermal insulation and reduce heat loss, helping to improve the efficiency of the furnace and reduce energy consumption.

The parts are shaped into an engineered design based on the furnace lining needs and engineered to minimise installation time (the area of just one rigid shape is approximately equivalent to the area of 18 insulating bricks). The manufacturing process allows the density of the material to be adjusted depending on the operating conditions of the equipment, meeting the three main requirements of refractory products: mechanical resistance, refractoriness, and thermal insulation.

To minimise downtime, these individual components are designed for ease of installation and worker ergonomics for safe and efficient application. Carbowall can be installed from the outside of the furnace, eliminating the need to remove the piping or the process fluids, resulting in a reduction of downtime and improved energy savings during service.

It can also be installed at the end user location or at external sites. It is applicable to oil heater reformers and pyrolysis furnaces, in both new unit installation and during any planned maintenance.

Typical application of preformed shapes in the convection section

To remove the old lining and install the new Carbowall system, only the metal plates that form the side casing of the convection section are removed, exposing the old lining from the outside. Structural supports and beams are not affected during this process and the process tubes remain intact. Once lining removal and clean-up is completed, the pre-molded high-density ceramic fibre beams are installed. The beams are used to support the rigid insulating panels.

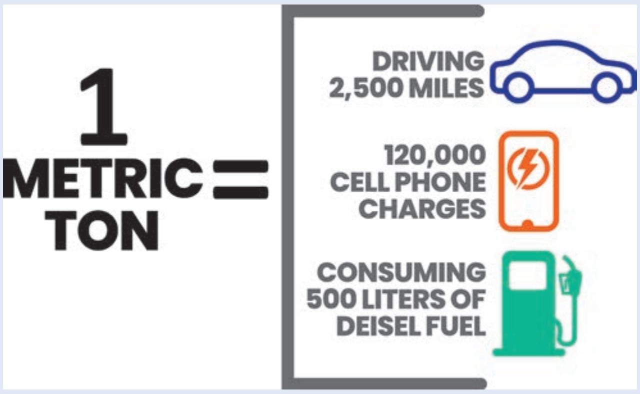
Carbowall panels are supplied with corbels designed into the shapes, following the design of the furnace. The arrangement of ceramic fibre panels can be installed in a horizontal or vertical manner, depending on access for the project. The design geometry of the panels is engineered to ensure that they are fully supported by each other and locked together to prevent any potential for hot gas bypass.

Installing the ceramic fibre backup blankets

To ensure the integrity of the insulation in this system and provide lighter insulation, a ceramic fibre blanket is applied to the cold face of the panels. The blanket is positioned between the face of the panel and the external metal sheeting, so that, when

Carbon reduction: what does 1 t of CO_2 look like?

In the application outlined in this article, carbon emissions were estimated at 158 892 kg/d. After installing Carbowall, CO_2 levels fell by 12 649 tpd. If carbon was reduced by 12 tpd for 365 days, that would equal 4380 t of CO_2 reduction in a single year.



compressed, it presses and seals the panels against the support beams, creating a thermal barrier and ensuring the integrity of the system.

After placing the blankets, the external metal sheeting is replaced on the structural beams by welding, or, if desired, bolted-on to allow easy access for pipe maintenance.

Easy installation

Carbowall is suitable for external installation. Assembling furnace insulation from the outside not only accelerates project timelines (Figure 1) but can result in positive changes including a significant reduction in the duration the furnaces are offline and improved working conditions through the elimination of work in confined spaces.

Installation time

Based on the estimated installation comparison of the characteristics of each system (Table 1), the Carbowall system exhibited lower installation time, weight, and overall cost in comparison to conventional systems.

Table 1. Carbowall utilises rigid monolithic parts formed through vacuum forming of ceramic fibre and binders. The parts are shaped into an engineered design based on the furnace lining needs and engineered to minimise installation time

	Carbowall system	Insulating bricks	Castable
Pipes removal	-	-	✓
Anchor cost per m²	- *	US$80	US$180
Application time (m²/h/team)	1	0.3	0.2
Required heating (h)	-	-	24
Specialised labour	-	✓	✓
Weight (kg/m²)	30	75	120
Cold face (°F)	185	278	343
Lifespan	>20 years	20 years	20 years

* Carbowall is supplied with built-in anchoring

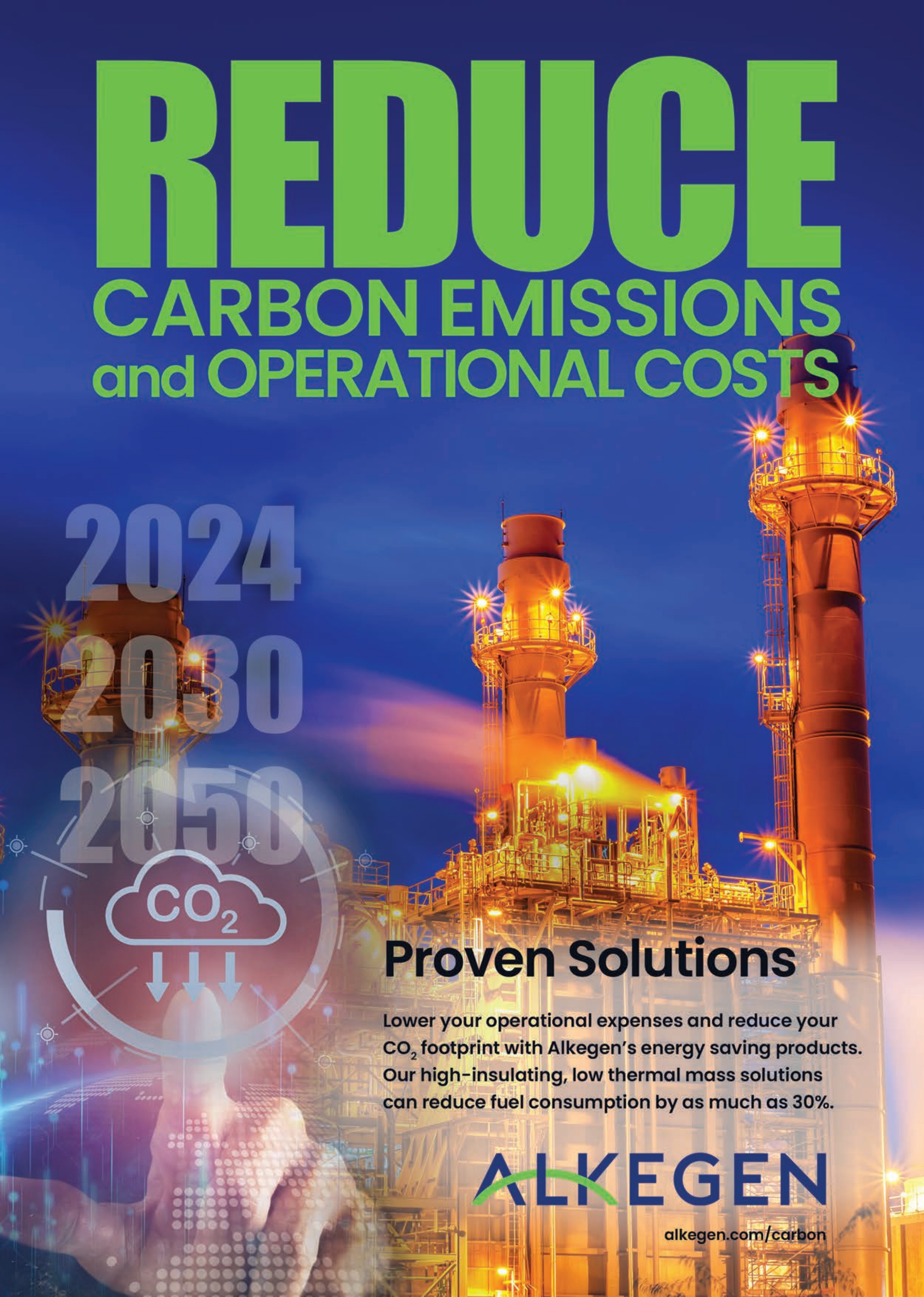
Figure 6. To withstand the severity of the furnace environment, Carbowall panels receive a mullite-based coating. This coating enables the panels to resist the high gas velocity inherent in this area, and withstand abrasion caused by soot or the velocity of steam injected to clean the pipes.

Reductions in heat loss and CO_2

Minimising heat loss contributes to improved furnace efficiency and a substantial reduction in carbon dioxide (CO_2) emissions. Carbowall measured cold face temperatures that were 51% lower than insulating castables and 38% lower than insulating brick. This resulted in a 4.09% overall increase in efficiency. Carbowall presented a heat loss reduction of 71% compared to insulating castables and 57% compared to insulating brick. Overall, CO_2 emissions fell by 12 649 tpd.

Conclusion

This article has presented an innovative and efficient solution for thermally insulating the convection section of industrial furnaces. The results from the study outlined represent a significant advance in the search for more efficient, sustainable, and safer processes.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