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Sustainable Tundish Lining—Reducing Energy Consumption and CO_2 Emissions While Achieving Cost Savings

As the most relined vessel in a steel plant, the tundish can be very time-consuming and work-intensive regarding lining frequence, drying, and preheating. Therefore, when it comes to the modern tundish lining, it is important to supply refractory products that are cost-efficient, time saving, as well as sustainable. In this regard, the combination of sol-bonded permanent linings and cold-setting wear linings are state-of-the-art for tundish applications because these refractories not only enable a reduction of the CO_2 footprint and energy consumption, but also the possibility of faster lining installation requiring less manpower. Additional environmental benefits are also possible by switching the primary raw materials to a more local source or even substituting a proportion with recycled materials. This paper provides a description of RHI Magnesita's sustainable tundish lining recommendations, including case studies that exemplify the achievable savings that support green steel production.

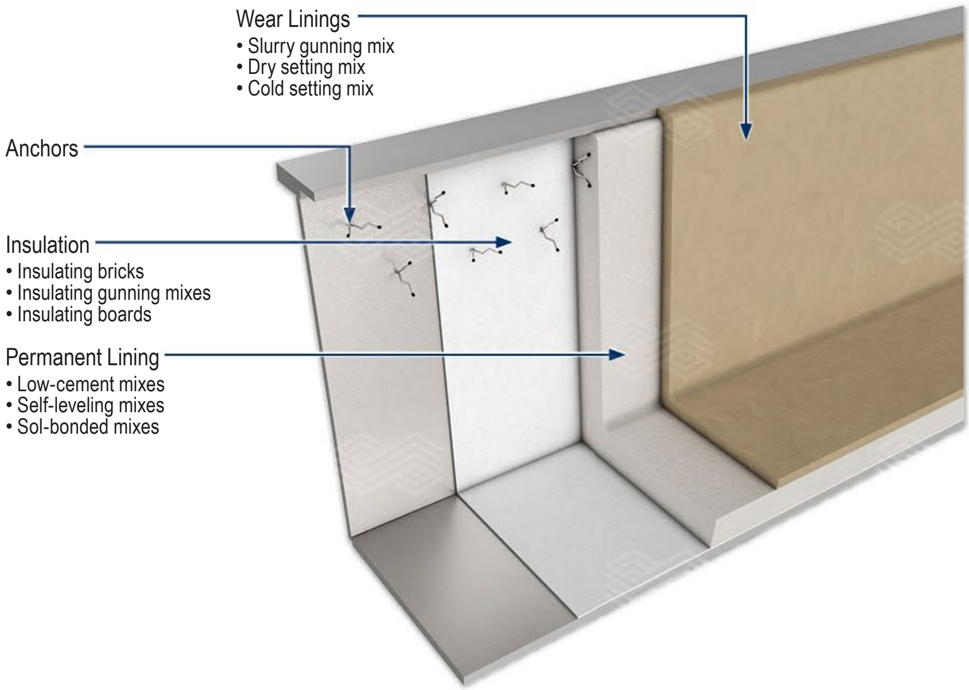
Introduction

With respect to sustainability and cost efficiency, CO_2 emission reduction, energy consumption as well as CO_2 emission allowance and energy costs are becoming increasingly more important, with both the steel and refractory industries challenged to achieve change. This article focuses on the tundish, as the most relined unit in the steel plant, to demonstrate how RHI Magnesita products decrease energy consumption and CO_2 emissions and how this translates into cost benefits for the customer.

In continuous casting, the tundish serves as a reservoir for distributing molten steel to the moulds while also fulfilling essential metallurgical functions. The vessel comprises a steel shell and anchors, with an insulation layer, permanent lining, and wear lining (Figure 1). In this article refractories for the permanent lining are described that highlight the multiple advantages of using sol-bonded castables for this application, including energy savings. Furthermore, the various wear lining approaches are reviewed with a focus on cold-setting (i.e., self-hardening) mixes, which also provide benefits including reduced CO_2 emissions through a decreased gas requirement and increased tundish availability.

To quantify the savings that can be achieved by adopting sol-bonded and cold-setting mixes, trials were conducted in various steel plants to determine the gas and CO_2 emission allowance costs per tonne of installed refractory mix. Prompted by the substantial natural gas price increases that started in 2021, the case studies presented in this article using 2024 gas and CO_2 emission allowance costs clearly demonstrate the advantages of using sol-bonded and cold-setting mixes.

Figure 1.
Schematic of the various layers in a tundish, detailing different options for the insulation, permanent lining, and wear lining.



Tundish Permanent Lining

Typically known as the permanent or safety lining, this refractory layer is the last defence to prevent a breakout of liquid steel through the tundish steel shell; therefore, the aim is to minimise any wear and keep it in operation for as long as possible. Ideally, and with appropriate maintenance practices, the lifetime can be extended to years. Currently, the most commonly used refractories for the permanent lining are hydraulically bonded low cement castables (LCC), which are mainly composed of mullite-rich raw materials or bauxite.

For a standard LCC, 7% water is added during mixing and the castable is applied using a template equipped with vibrators. During processing the water reacts with calcium aluminate phases to form hydrates, which result in the necessary bonding and the template can be removed after dimensional stability has been reached (~24 hours). For safe operation and to prevent a vapour burst the added water must then be removed. Since the undried cement-bonded castable is dense and has low gas permeability, the first heat up must be performed very carefully and slowly so initially the physically bonded water can evaporate, followed by release of the chemically bonded water with increasing temperature [1]. For a 150 mm thick permanent lining, this time- and energy-consuming drying can take ~55 hours, with a stepwise temperature increase to 600–700 °C (Figure 2a).

Renowned for their easy and fast heat-up procedure, sol-bonded mixes are a sustainable alternative for the permanent lining. Processed in a similar manner to LCCs, the binder is added during the mixing procedure in the form of a liquid sol (i.e., DIVASIL) that contains nano-sized silica particles [1]. As with LCCs, sol-bonded castables can be applied using a template equipped with vibrators, although free-flowing and gunnable versions are also available for additional flexibility. After setting, water in the sol-bonded mix is not chemically bonded and as a result the main water component in the gel structure is easily removed at very low temperatures. A comparison of the vaporisation rates for a sol-bonded mix and a LCC is shown in Figure 3. This thermogravimetric analysis clearly shows that the sol-bonded mix reaches zero vaporisation at 100–110 °C while the LCC does not release all the water until 450 °C. In addition, the pore size distribution of sol-bonded castables results in a high permeability even at low temperatures, which further facilitates dehydration. As a result, the drying time of a 150 mm thick sol-bonded lining can be reduced to ~20 hours (see Figure 2b), increasing tundish availability and decreasing gas demand. There is also an option to avoid any gas consumption by using alternative heat sources such as electric drying.

Figure 2.

Recommended drying procedure for a 150 mm thick (a) LCC and (b) sol-bonded mix. The temperatures refer to the tundish chamber (e.g., castable surface).

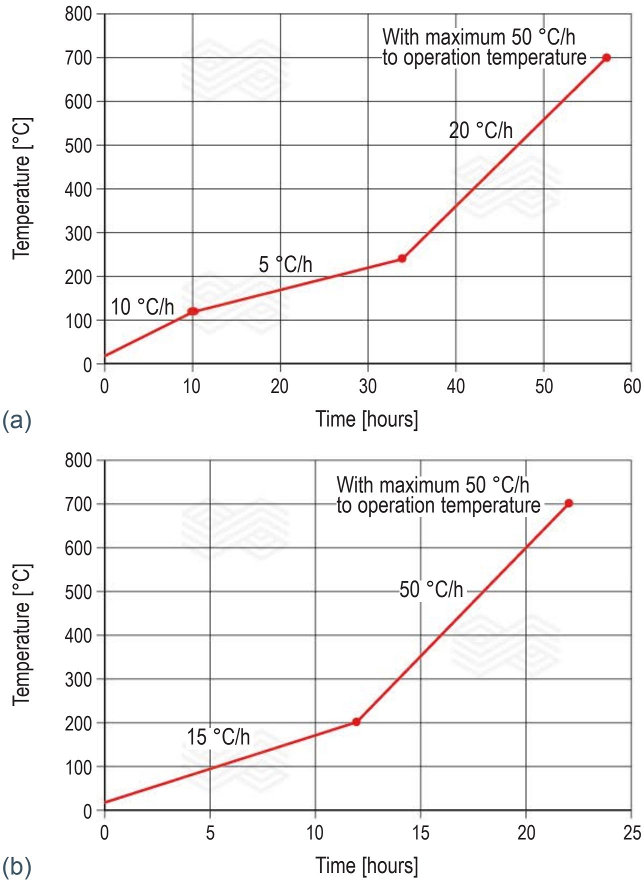
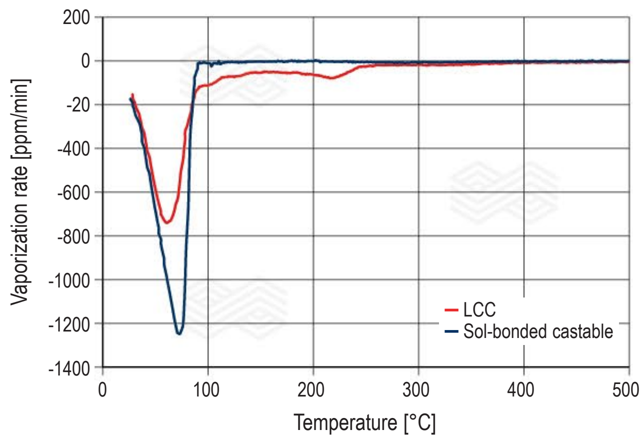


Figure 3.

Vaporisation rates of a sol-bonded mix and LCC determined using thermogravimetric analysis [1].



In summary, the main advantages of sol-bonded mixes include:

- Fast and easy heat-up procedure.
- Decreased gas demand for drying and the associated CO_2 emission reductions.
- Option for drying with green electricity.
- Increased tundish availability.
- Various application methods (i.e., vibrating, self-flowing, and gunning mixes).
- Longer shelf life than LCCs as the dry mix does not contain binder.
- Reduced sensitivity to incorrect dosing of the mixing liquid.
- Higher refractoriness compared to equivalent LCCs.
- Longer operational lifetime than LCCs.

There is a wide range of sol-bonded mixes available from RHI Magnesita and the positive experiences regarding performance, installation, and handling over the years have resulted in their increasing application in diverse areas by multiple industries (e.g., steel, cement, and nonferrous). Table I details the chemical composition and main raw materials of three sol-bonded castables recommended for the tundish permanent lining.

Tundish Wear Lining

To withstand casting sequences that can be over 100 hours, the alumina silica based permanent lining is protected by a sacrificial basic refractory wear lining. Unlike the permanent lining, the wear lining is directly exposed to various chemical and thermomechanical wear mechanisms during steel casting (e.g., from slags and cover powders). Consequently, it must be removed after use (via deskulling or tilting) and replaced. Over the last decades, three main technologies have become the industrial standard for wear lining applications, namely:

- Slurry gunning mixes.
- Dry-setting mixes.
- Cold-setting mixes.

As the most conventional type of wear lining, slurry gunning mixes require ~20–35% water content to reach a pumpable consistency. After continuous water addition, the wet mix is conveyed to a collecting hopper and then pumped through a hose to the nozzle. Compressed air, injected directly at the front end of the spraying nozzle, propels the mix towards the target area (e.g., tundish wall). Characterised by their broad flexibility in terms of the desired lining thickness, slurry gunning mixes are still the primary tundish wear lining mix type used in most steel plants. Due to the relatively high water addition, a drying process is crucial prior to steel casting, which can take place at a controlled drying station in ~3–5 hours. To decrease or even eliminate this drying step, RHI Magnesita developed the FAST TO CAST gunning mixes [2].

Dry-setting and cold-setting mixes are widely used alternatives to slurry gunning mixes. For dry-setting mixes, the dry mix is filled into a gap between the template and the permanent lining. During curing at 200–300 °C, the organic or inorganic binders are thermally activated and result in a stable wear lining after ~1–2 hours of total preparation. In contrast, cold-setting mixes are applied via a continuous mixing machine, for example the ANKERTUN CS machine shown in Figure 4, whereby the addition of 1–3% water initiates a chemical cold-setting reaction. Simultaneously, the

Table I.
Examples of sol-bonded castables for the tundish permanent lining.

Grade	Al_2O_3 [wt.%]	SiO_2 [wt.%]	Fe_2O_3 [wt.%]	TiO_2 [wt.%]	MgO [wt.%]	CaO [wt.%]	Na_2O [wt.%]	Main raw material	Installation method
DIDOFLO SB B89-6	89.0	7.5	1.0	1.5	0.1	0.8	-	Bauxite	Self-flowing
COMPAC SOL M64-6	66.0	29.0	0.9	2.6	-	-	0.1	Mullite	Vibrating
COMPAC SOL B88-6	87.0	8.5	1.2	2.1	0.1	0.8	-	Bauxite	Vibrating

Figure 4.
ANKERTUN CS machine.

mix is filled into a gap between a vibratable template and the permanent lining. After approximately 30–60 minutes the mix hardens without further actions, such as temperature treatment. After template removal, a cold-setting lining can be used directly for steel casting as the added water is already at a reasonably low level. Since no drying or preheating cycles must be applied to cold-setting tundish linings, the total gas consumption and associated CO_2 emissions can be reduced to a bare minimum.

Cold-setting mixes can be defined as mixes that set or harden at room temperature without any external heat, as a result of starting a chemical reaction during the mixing process. Typically, this is achieved by using either a two-component binder system based on the well-known reaction of liquid sodium silicate with a hardener or the patent protected self-hardening (SH) system where only minimal water is required to activate binding. For the wear lining case study examples in this article, the focus is on ANKERTUN SH mixes as they represent an environmentally friendly, state-of-the-art tundish lining solution where the liquid additive is free of chemicals.

The SH binder consists of a solid acid component, in combination with a solid inorganic basic material. This SH binder is mixed with the desired refractory raw materials (e.g., sintered magnesia and olivine) in a dry state before delivery to the customer. During application at the customer and due to the slight water addition, the SH binder forms a metal-organic complex leading to the formation of binder bridges with the refractory material. At this stage the water is in a nonchemically bonded form and can easily evaporate from the lining at ambient temperature [3]. The chemical composition and main raw materials in commonly used ANKERTUN SH wear lining grades are detailed in Table II.

Principally, the benefits that can be achieved by using ANKERTUN SH mixes and the ANKERTUN CS machine are:

- Minimised total lining time compared to other technologies.
- Setting without an external heat supply.
- Reduced energy consumption and the associated CO_2 emissions.
- Increased tundish availability.
- Easy application and working conditions.
- Minimal material waste.
- Minimal cleaning effort due to the machine's automatic cleaning mode.
- Nontoxic, phenol and silica free binding agents.
- Only water required—no storage and handling of other liquids.
- Cold start practice possible.

Table II.

Examples of ANKERTUN SH mixes recommended for the tundish wear lining.

Grade	MgO [wt.%]	CaO [wt.%]	SiO_2 [wt.%]	Fe_2O_3 [wt.%]	Al_2O_3 [wt.%]	Main raw material
ANKERTUN SH10	93.2	3.0	2.9	0.6	0.1	Low-iron sintered magnesia
ANKERTUN SH40	90.0	4.2	2.1	2.8	0.4	Sintered magnesia
ANKERTUN SH60	88.6	4.2	1.2	5.2	0.6	Sintered magnesia

Tundish Lining Case Studies—Combining Cost Efficiency and Sustainability

Gas costs and CO_2 emission allowance prices

In 2021, natural gas prices increased dramatically due to various reasons such as the Ukraine war [4]. As this energy source is primarily used to dry tundish linings and preheat the vessel, the case studies described in this section were initiated to accurately determine the financial benefits that can be achieved using sol-bonded and cold-setting ANKERTUN SH mixes. Despite the recent decline in gas prices, for example in Europe (Figure 5), the studies clearly show the cost savings that can be achieved per tonne of installed refractory with these lining technologies as well as the reduced susceptibility to future fuel price volatilities. Additionally, as approximately 2 kg of CO_2 are emitted for every cubic metre of gas consumed [5], the reduced gas consumption also has a positive environmental impact as well as an economic advantage in regions with carbon pricing schemes. As the European Union Emission Trading System (EU ETS) is the world's first and largest carbon market [6], the EU CO_2 emission allowance price was used to calculate the monetary implications. Although this allowance price has fluctuated during the last years (Figure 6), since the EU ETS is based on a "cap and trade" principle, CO_2 allowance costs are predicted to increase over time and become even more relevant regarding these types of cost calculations. For the studies, April 2024 natural gas and CO_2 allowance prices of €26.2/MWh and €61.1/tonne CO_2, respectively, were used.

Permanent lining comparison

For the permanent lining case study, three customers were selected to compare the costs associated with drying either LCC or sol-bonded linings. The maximum drying temperature and time, tundish capacity, as well as the amount of mix per lining at each customer are provided in Table III. In the case of customer C, a direct comparison could be made as the lining technology was recently changed from LCC to sol-bonded mixes. Regarding gas consumption, it is important to state that the equipment for tundish lining is often on the same gas loop as the ladle preheating stands or other gas consuming equipment. Therefore, the gas consumption for the lining drying was measured indirectly and it was necessary to make certain assumptions for any missing customer data, including whether the equipment was new or old as well as the tundish dimensions and lining thickness. Using this approach, figures for the specific gas consumption ($m^3/tonne_{refractory}$) to dry the permanent lining were

Figure 5.

Natural gas price (€/MWh) development in Europe (Netherlands) [7].

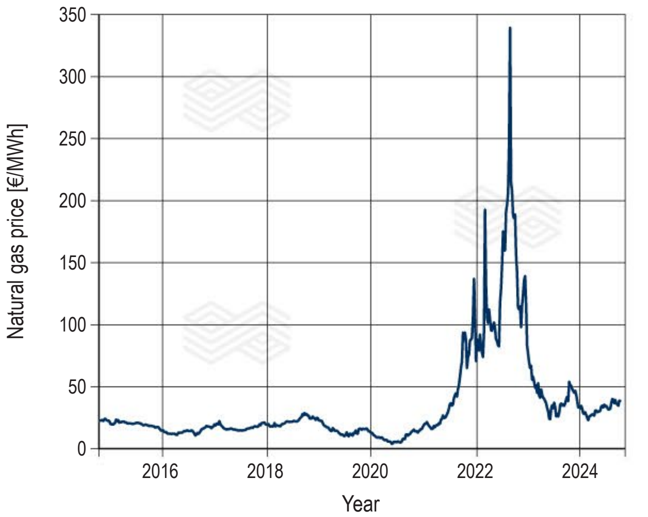


Figure 6.

CO_2 emission allowance price (€/tonne CO_2) development in Europe [8].

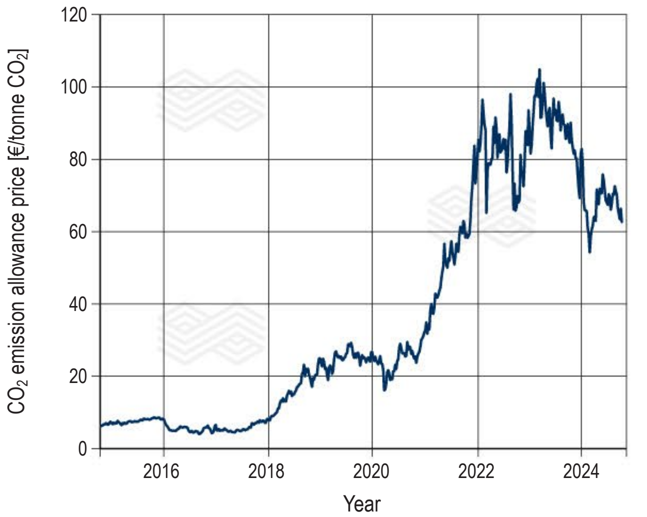


Table III.

Details of the permanent lining type, maximum drying temperature and time, tundish capacity, and amount of installed refractory for the three customers.

Customer	Tundish mix	Maximum drying temperature [°C]	Maximum drying time [hour]	Tundish capacity [tonne]	Mix amount per lining [tonne]
A	LCC	500	70	25	7.5
B	Sol-bonded	750	30	20	8.5
C	LCC	500	75	30	15.0
C	Sol-bonded	700	15	30	15.0

determined that show sol-bonded mixes required significantly lower amounts of gas (Figure 7). For example, a gas saving of 70% was achieved at customer C by changing from LCCs to sol-bonded mixes and there is the possibility to further decrease this by optimising the drying curve, as illustrated by customer B. In this case, after improving the drying schedule at customer B, an 86% lower specific gas consumption was achieved compared to customer A using LCCs, although the amount of mix installed per lining was similar.

To determine the financial implications, the emitted CO_2, as well as the gas and CO_2 emission allowance costs per tonne of installed refractory were calculated from the specific gas consumption (Table IV). A value of 0.0105 MWh/m^3 was used to convert the gas consumption (m^3) to MWh. These results indicate that ~€45/tonne$_{refractory}$ can be saved by changing the permanent lining from a LCC to a sol-bonded mix (Figure 8), as well as a time saving of 60 hours in the case of customer C.

Wear lining comparison

In the wear lining case study, the focus was on comparing traditional slurry gunning with the cold-setting ANKERTUN SH mixes. Two of the customers selected were also part of the permanent lining evaluation, while the third customer D provided a direct comparison of the lining technologies as both mix types are used in this steel plant. Details of the wear lining type, maximum drying temperature, maximum preheat temperature, tundish capacity, and amount of installed refractory for the three customers are given in Table V. The gas consumption for drying the slurry gunning wear linings and preheating the tundishes was

Figure 7.

Specific gas consumption (m^3/tonne$_{refractory}$) required to dry LCCs and sol-bonded (SOL) permanent linings at the different customers.

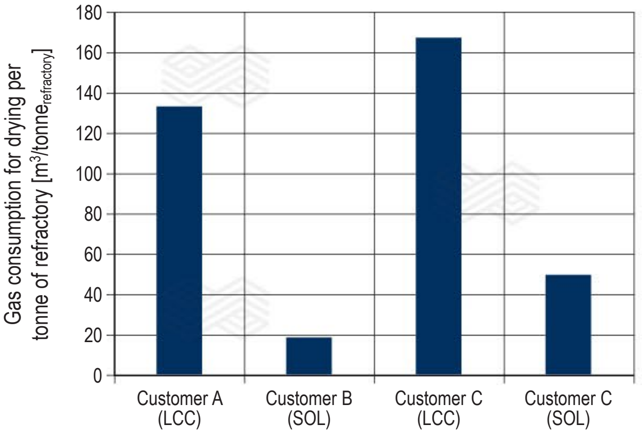


Figure 8.

Comparison of the specific gas and CO_2 emission allowance costs (€/tonne$_{refractory}$) resulting from drying LCCs and sol-bonded (SOL) permanent linings at the different customers.

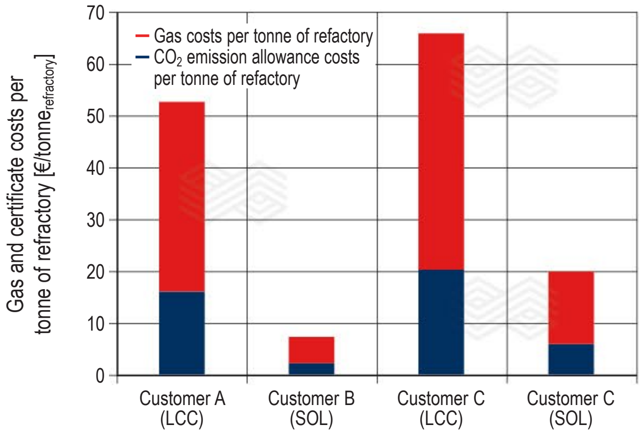


Table IV.

Specific gas consumption, emitted CO_2, as well as the specific gas and CO_2 emission allowance costs (€/tonne$_{refractory}$) at the different customers.

Customer	Tundish mix	Gas consumption [m^3/t$_{refractory}$]	Emitted CO_2 [t$_{CO_2}$/t$_{refractory}$]	Gas costs [€/t$_{refractory}$]	CO_2 emission allowance costs [€/t$_{refractory}$]
A	LCC	133.33	0.27	36.68	16.29
B	Sol-bonded	18.82	0.04	5.18	2.30
C	LCC	166.67	0.33	45.85	20.37
C	Sol-bonded	50.00	0.10	13.76	6.11

Table V.

Details of the wear lining type, maximum drying temperature, maximum preheat temperature, tundish capacity, and amount of installed refractory at the different customers.

Customer	Tundish mix	Maximum drying temperature [°C]	Maximum preheat temperature [°C]	Tundish capacity [tonne]	Mix amount per lining [tonne]
A	Slurry gunning	600	1200	25	1.7
B	Self-hardening	-	1100	20	2.5
D	Slurry gunning	400	1000	35	3.0
D	Self-hardening	-	1000	35	3.5

directly measured as it was possible to ensure that no other equipment on the same gas line was concurrently in operation. Figure 9 shows that a >40% specific gas consumption saving was achieved with the ANKERTUN SH mixes, as no lining drying step was required and the preheating time was slightly shorter than for slurry gunning mixes. Following calculation of the emitted CO_2, and gas and CO_2 emission allowance costs per tonne of refractory (Table VI), potential savings ranging from €40/tonne$_{refractory}$ up to €90/tonne$_{refractory}$ were determined for ANKERTUN SH mixes, depending on the specific preheat practice (Figure 10). Furthermore, since it is possible to use the ANKERTUN SH mixes with a cold start practice at the caster, the specific gas consumption and financial savings can be considerably more.

In conclusion, the case studies show that sol-bonded and ANKERTUN SH mixes can significantly reduce the specific gas consumption required in the tundish area for drying and preheating, thereby providing both financial and environmental benefits. Furthermore, since certain steps during the tundish turnaround cycle are shorter or can be eliminated, tundish availability is also increased by using these refractory technologies. For example, comparison of typical time schedules for slurry gunning and ANKERTUN SH mixes, from wear lining installation to transfer to the casting platform, show that 210 minutes can be saved using ANKERTUN SH mixes (Table VII), with additional time savings possible from implementing a cold start practice.

Figure 9.

Specific gas consumption (m^3/tonne$_{refractory}$) required to dry and preheat tundishes lined with slurry gunning (SG) mixes and ANKERTUN SH mixes at the different customers.

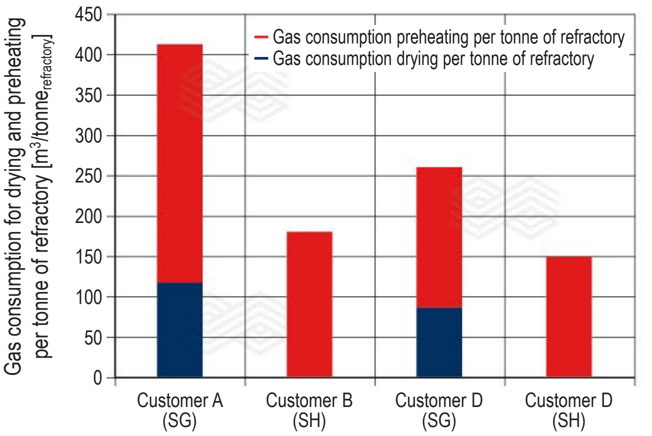


Figure 10.

Comparison of the specific gas and CO_2 emission allowance costs (€/tonne$_{refractory}$) resulting from drying and preheating tundishes lined with slurry gunning (SG) and ANKERTUN SH mixes at the different customers.

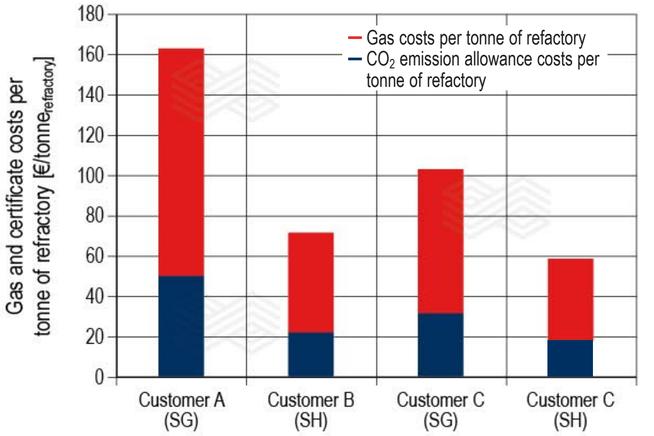


Table VI.

Specific gas consumption, emitted CO_2, as well as the specific gas and CO_2 emission allowance costs (€/tonne$_{refractory}$) at the different customers.

Customer	Tundish mix	Gas consumption [m^3/t$_{refractory}$]	Emitted CO_2 [t$_{CO_2}$/t$_{refractory}$]	Gas costs [€/t$_{refractory}$]	CO_2 certificate costs [€/t$_{refractory}$]
A	Slurry gunning	411.76	0.82	113.28	50.32
B	Self-hardening	180.00	0.36	49.52	22.00
D	Slurry gunning	259.99	0.52	71.53	31.77
D	Self-hardening	148.57	0.29	40.87	18.16

Table VII.

Time schedule comparison of slurry gunning and ANKERTUN SH mixes from wear lining installation to crane transfer to the caster [9].

Step	Operation	Slurry gunning mix Time [minutes]	ANKERTUN SH mix Time [minutes]
1	Wear lining installation	30	30
2	Drying at ambient temperature	60	-
3	Drying at ~500 °C	180	-
4	Hardening	-	30
5	Further installation of equipment (e.g., stopper)	30	30
6	Crane transfer to casting platform	10	10
	Total	**310**	**100**

Tundish Mixes—Additional Decarbonisation Initiatives

Greenhouse gas (GHG) emissions, such as CO_2, are subdivided into three categories [10]:

- Scope 1: Direct emissions of an organisation (e.g., fuel combustion).
- Scope 2: Indirect emissions of an organisation directly associated with the provision of energy (e.g., emissions from a coal electricity power plant).
- Scope 3: Indirect emissions upstream or downstream of an organisation (e.g., purchased raw materials and third-party transport).

In the case of sol-bonded and ANKERTUN SH mixes, the decreased natural gas consumption directly impacts scope 1 emissions at the steel plant. However, there are additional decarbonisation initiatives that enable scope 3 emissions to be tracked and decreased.

Product carbon footprint and recycling

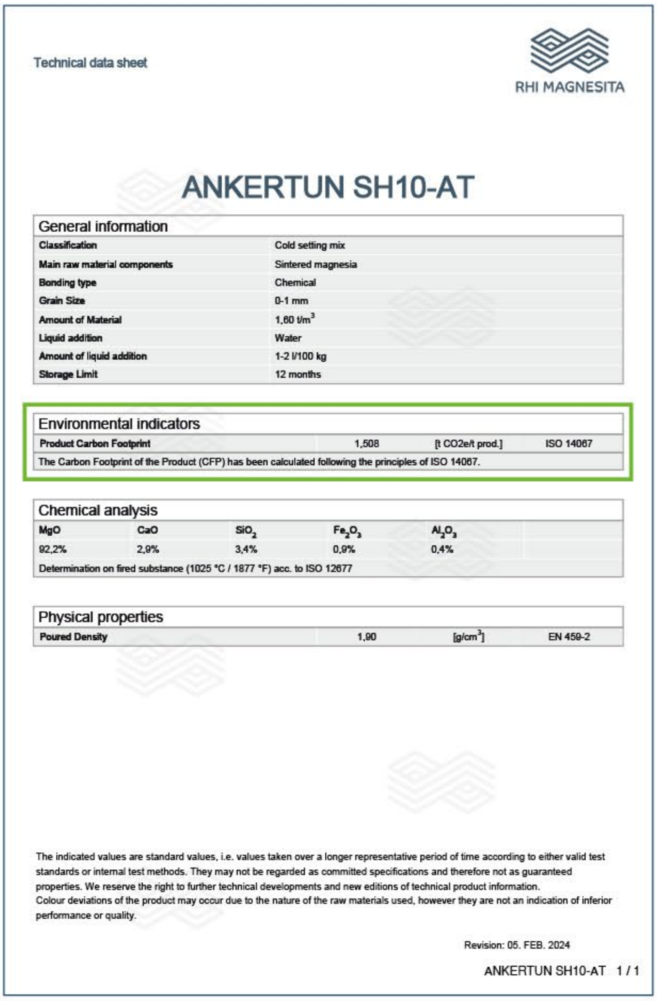
In line with RHI Magnesita's corporate climate strategy, it was decided to create 100% transparency regarding the GHGs emitted during refractory production. Therefore, the product carbon footprint (PCF) of our products is calculated in accordance with the principles of ISO 14067 and disclosed on the technical data sheets (Figure 11). The PCF covers all GHG emissions from upstream sources and the direct manufacturing of a product (i.e., cradle-to-gate) [10], enabling customers to make purchasing decisions based on this sustainability criterion. Furthermore, RHI Magnesita is committed to reducing the GHG intensity of its products by becoming more circular and using recycled raw materials. This has resulted in the tundish mix portfolio including grades that contain appropriate amounts of circular raw materials, which have a decreased PCF while maintaining the required performance.

Local-for-local

With a global network of 47 main production sites, RHI Magnesita follows a local-for-local strategy by using production facilities located as close as possible to the customer. This translates into scope 3 benefits, as third-party transport to the customer can be minimised. In addition, by operating our own raw material production sites across several continents, the uncertainties and volatility of raw material supply and price fluctuations can be mitigated. However, when considering raw materials for tundish wear mixes, local raw material sources can differ from standard raw materials available on the world market (Table VIII). To establish the most cost efficient and sustainable usage at the customer, the local raw material compositions must be considered and the grades optimised for individual customer applications. This might lead to rethinking well-known standard concepts based on Chinese raw material sources, opening up the possibility to use high-quality local raw materials with slightly different chemical compositions and colours.

Figure 11.

Technical data sheet detailing the product carbon footprint.


Technical data sheet

RHI MAGNESITA

ANKERTUN SH10-AT

General information	
Classification	Cold setting mix
Main raw material components	Sintered magnesia
Bonding type	Chemical
Grain Size	0-1 mm
Amount of Material	1,60 t/m³
Liquid addition	Water
Amount of liquid addition	1-2 l/100 kg
Storage Limit	12 months

Environmental indicators			
Product Carbon Footprint	1,508	[t CO2e/t prod.]	ISO 14067
The Carbon Footprint of the Product (CFP) has been calculated following the principles of ISO 14067.			

Chemical analysis				
MgO	CaO	SiO_2	Fe_2O_3	Al_2O_3
92,2%	2,9%	3,4%	0,9%	0,4%
Determination on fired substance (1025 °C / 1877 °F) acc. to ISO 12677				

Physical properties			
Poured Density	1,90	[g/cm³]	EN 459-2

The indicated values are standard values, i.e. values taken over a longer representative period of time according to either valid test standards or internal test methods. They may not be regarded as committed specifications and therefore not as guaranteed properties. We reserve the right to further technical developments and new editions of technical product information.
Colour deviations of the product may occur due to the nature of the raw materials used, however they are not an indication of inferior performance or quality.

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Table VIII.

Comparison of the chemical composition of different locally produced RHI Magnesita magnesia raw materials with Chinese dead burned magnesia (DBM) available on the world market.

Raw material source	Austria (Europe)	Brazil (South America)	Türkiye (Europe)	Chinese DBM 9010 (world market)
MgO [wt.%]	70–91	~94.5	>93	90–93
CaO [wt.%]	2–25	~0.5	~3.0	~2.5
SiO_2 [wt.%]	<1.5	~1.5	~3.5	~4
Fe_2O_3 [wt.%]	4–6	~2.3	~0.5	~1.2
Description	High iron (and lime)	Medium iron	Low iron	

Conclusion

RHI Magnesita is committed to sustainability, which includes developing decarbonisation initiatives for our customers [11]. This article presents case studies that demonstrate CO_2 emission reductions and cost savings can be achieved in the tundish area by adopting permanent and wear lining technologies that require less drying and preheating. For example, by changing the permanent lining refractory at a customer from a LCC to a sol-bonded mix, the drying time was reduced by 60 hours and the natural gas consumption was decreased by 70%. At current gas prices this translates to a financial saving of ~€30/tonne$_{\text{refractory}}$. However, in 2022, when the average gas price in the Netherlands was €133.5/MWh (see Figure 5), this would have equated to a saving of ~€160/tonne$_{\text{refractory}}$. Furthermore, in regions with carbon pricing schemes, additional costs savings can be achieved due to the corresponding decrease in CO_2 emissions, which at a current allowance price of €61.1/tonne CO_2 equates to a further ~€14/tonne$_{\text{refractory}}$ for the customers using sol-bonded mixes.

The wear lining case studies show that by changing the lining method from slurry gunning to cold-setting ANKERTUN SH mixes it is possible to achieve gas costs savings of ~40–55% per tonne of installed refractory, with additional financial benefits in the same range due to reduced CO_2 emission allowance costs. Furthermore, even higher savings are possible by optimising the preheating schedule or using a cold start practice. Using the figures determined for customer D, who is currently using both wear lining technologies in parallel, it was calculated that annual gas and CO_2 emission allowance savings of €53655 and €23817, respectively, can be achieved using the ANKERTUN SH mix, considering 3.5 tonnes of mix per lining and 500 lining per year, with additional process efficiency improvements due to the decreased time between wear lining installation and transfer to the casting platform. In addition, there are supplementary approaches customers can take to reduce their CO_2 footprint related to the tundish, which include taking advantage of lining mixes that contain recycled materials and have a reduced carbon footprint as well as the local-for-local strategy using our high-quality raw materials.

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Cover picture: The image depicts the lower section of a RH degasser, a secondary metallurgical unit used in steel plants. In the RH degassing process, snorkels are submerged into liquid steel contained in the casting ladle. Argon gas is purged through the inlet snorkel, creating a suction effect that draws liquid steel into the lower vessel of the RH degasser, where a vacuum is applied. The steel treated in the lower vessel flows back to the ladle through the outlet snorkel, creating a continuous steel circulation between the ladle and the RH degasser. The strong negative pressure (vacuum) within the RH degasser facilitates various metallurgical processes that enhance steel quality, with the key process steps including degassing, decarburisation, deoxidation, and alloying under vacuum. Rail steel, flat steel for the automotive industry, and steel plates for shipbuilding are just a few examples of products that benefit from the RH degasser. Prefabricated snorkels, which RHI MAGNESITA manufactures ready for use and delivers to our globally operating customers, are essential components of the RH degasser.