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**INDIAN REFRACTORY MAKERS ASSOCIATION**
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## MESSAGE FROM THE CHAIRMAN

Dear Colleagues,

I wish you a prosperous New Year filled with accomplishments as part of your illustrious professional journey. Let us together raise a toast for a remarkable growth of our industry that we have been fortunate to witness for the past couple of years. India is growing fast and we all are happy to be a part of its amazing growth story.

Many an experts are pointing out to a subdued global appetite for steel especially in view of China' lesser internal consumption, impact of Russia-Ukraine conflict affecting large parts of Europe as possible causes. However, our domestic steel market has been robust this fiscal and the latest World Steel Association outlook suggests that the demand will maintain a good run rate and hit around 136 million tonne in 2024. driven by higher infrastructure spends, and impetus from the government in an election year. China too is ramping up its exports with gross exports reaching eight million tonnes each month. This is 40% higher than the monthly average of approximately 5.5 million tonnes seen in 2021 and 2022. This will likely improve the sentiments of the Chinese steel industry.

Another good thing happening in India is the cement sector. Research organisation Fitch Ratings has forecast continued 'steady' growth of 6 – 8% year-on-year in cement demand in India in 2024. This stands in stark contrast to weak demand forecast for China and other developed economy.

We have reasons to be bullish about the prospects of our industry for the year 2024 and our optimism is ensconced in the strong fundamentals of our economy.

Again, wishing you all the best,

*Ish Mohan Garg*
Chairman

# Noble Refractories

Excellence In Quality Refractories

[NOBLE] SINCE 1982

## PRODUCT RANGE

- Low Iron Special Refractories (Zircon, Zirmul, Mullite, Sillimanite etc.)
- All types of Super Duty & High Alumina Refractories
- Alumina Silicon Carbide Carbon Bricks
- Hi-Tech Insulation Bricks upto 95% Alumina
- Low Cement, Ultra-Low Cement & No-Cement Castables upto 95% Alumina
- High Alumina & High Purity Dense Castables (Conventional)
- Self Flow Dense Castables (Conventional)
- Medium Purity Dense Castables (Conventional)
- Medium & High Purity Insulating Castables.
- All Types of Fireclay, High Alumina & Special Mortars
- PCPF upto 95% Alumina.
- Hi-Tech Products (Monolithics) for Critical Applications area
- Basic Rammig Mass, Gunning Mass & Mortars
- Silica Ramming Mass & Mortars
- Plastic Refractories
- Cordierite Kiln Furniture's

**Recipient of National Awards for Best Entrepreneurship, R & D, Innovation, Quality Products & Lean Manufacturing Techniques.**

National Award

National Award

## INDUSTRIES WE SERVE

Cement

Ceramic

Chemical

Glass

Iron & Steel

Foundry

Non Ferrous

Power Generation

Sponge Iron

**Noble Refractories** (An ISO 9001 & ISO 14001 Company)

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27, National Highway, PO Box No.202, Hasanpar, Wankaner (Dist.: Morbi) 363621, Gujarat, India.

# ASSOCIATION ACTIVITIES

## IREFCON 2024

The 15th India International Refractories Congress (IREFCON 2024) will be held from 13th–15th November, 2024 at Taj Resort and Convention Centre, Goa. The theme of the Congress is "powering a greener future together" keeping in mind the important role played by refractories in reduction of emission and energy conservation in core sector industries.

### IREFCON24 Organizing Committee comprised:-

| | | |
|---|---|---|
| • | Sunanda Sengupta (Chairman) | (TRL Refractories ies Ltd.) |
| • | Gangadharan Manari (Co-Chairman) | (Totale Global Pvt Ltd.) |
| • | Aditya Agarwalla | (Maithan Ceramic Ltd.) |
| • | Chinmay Basu | (Calderys India Refractories Ltd.) |
| • | Jyotirmoy Bhattacherjee | (RHI Magnesita India Ltd) |
| • | Kushal Agarwal | (Sarvesh Refractories Pvt. Ltd) |
| • | Samit Sengupta | (IFGL Refractories Ltd) |
| • | Shashi Kumar | (Vesuvius India Ltd.) |

### IREFCON24 Technical Committee comprised:-

| | | |
|---|---|---|
| • | Indra Nath Chakraborty (Advisor) | (Calderys India Refractor ies Ltd ) |
| • | Arup Kumar Samanta (Chairman) | (TRL Refractories ies Ltd.) |
| • | Saumen Sinha (Co-Chairman) | (Calderys India Refractories Ltd ) |
| • | Brijender Singh | (Tata Steel Limited ) |
| • | Dipak Mazumdar | (IIT, Kanpur ) |
| • | Goutam Bhattacharya | (Imerys ) |
| • | Manas Paliwal | (IIT, Kharagpur ) |
| • | Thomas Mathew | (RHI Magnesita India Ltd ) |
| • | Premanshu Jana | (Vesuvius India Limited. ) |
| • | Sachi Dulal Majumdar | (IFGL Refractories Ltd) |
| • | Shankha Chatterjee | (Almatis Alumina Pvt Ltd) |
| • | Ujjwal Sengupta | (Refratechnik (India) Private Limited ) |

The meetings of IREFCON 24 Technical Committee was held on 20th October, 2023 and 12th December, 2023.The issues discussed were theme of the congress, identification of keynote speakers and theme lecturers, flow of events etc.

Further details about the event is available at **www.irefcon.com**.

# IN THE NEWS

## Rashtriya Ispat Nigam Ltd

RINL has restarted its Blast Furnace-3 (BF-3) to raise hot metal production by 2 million tonne per annum. The added capacity will also enable the steel plant to clock increased sales turnover of Rs 500 crore per month. The BF-3 had been down since January 2022 due to raw material shortage.

JSPL said has entered into a memorandum of understanding with RINL for the operationalisation of the said blast furnace-3 (BF-3). The tie-up with RINL will release additional liquid steel for slab casting and onward rolling into hot rolled coils from JSPL's upcoming state-of-the-art hot strip mill at Angul.

## Indian steel demand

As per CRISIL, Indian steel sector has enjoyed a multi-year demand surge which will continue in the current FY'24 but it is expected to moderate in the coming fiscal. The sector has witnessed double digit demand growth rate of 11 to 13 per cent during three consecutive years and is likely to moderate to 3 to 5 per cent in FY'25. A similar voice by Steelmint says India's steel demand is expected to grow at a CAGR of 7 per cent to touch 190 Million Tonne (MT) level by 2030.

## India's mineral output

India's mineral production went up 13.1 per cent in October 2023, over the same month a year ago. The index of mineral production of the mining and quarrying sector for October was 127.4, 13.1 per cent higher than October 2022, as per the provisional figures of Indian Bureau of Mines (IBM).

## Coal production

India's coal production increased 12.29 per cent to 664.37 Million Tonnes (MT) from April to December 25 this fiscal over the year-ago period, according to an official statement. The country's coal output was 591.64 MT in the same period last year. Incidentally, the country's production target of the fossil fuel for 2023-24 is 1,012.14 MT.

## Coal gasification project

Government of India has notified two policies with respect to coal gasification and plans to provide financial support as well as tax incentives for such projects. The ministry of coal has set a target to gasify 100 million tonnes of coal by FY 2030 in line with its energy transition plans. Coal gasification is expected to reduce imports by 2030 as well as reduce carbon emissions and foster sustainable practices.

## Copper demand

MP Birla Group flagship company Birla Corporation has drawn up a strategy to augment its cement production capacity to 25 million tonnes by the 2025-26 fiscal from the existing 20 million tonnes. The report stated that the allocation of Rs 10 lakh crore for capital spending in the last Union Budget, coupled with ambitious targets set under the National Infrastructure Pipeline (NIP), is likely to drive copper consumption in the medium term.

## SAIL

As per media reports, Steel Authority of India Limited (SAIL) is working on a plan to increase installed capacity by 15 million mt per year in a first phase, adding to its current installed capacity of 20 million mt per year.

## Indian cement market

Research organisation Fitch Ratings has forecasted continued 'steady' growth of 6 – 8% year-on-year in cement demand in India in 2024.

## Shree Cement

Shree Cement inaugurated its new 4.2Mt/yr Nawalgarh cement plant in Rajasthan in December 2023. The plant boasts an 11,500t/day kiln, which is among the largest in India, according to the company. Following the inauguration, Shree Cement's installed production capacity now stands at 53.4Mt/yr.

# OVERSEAS NEWS

## Imerys

Imerys and Seitiss have partnered to create in a Joint Venture: Seitiss Imerys Minéraux Circulaires (SIMC), to provide a circular economy offer that allows the utilization of waste minerals from various industrial activities. Imerys will provide SIMC with industrial and commercial know-how as well as its international presence to accelerate the development of the first identified opportunity relating to the valorization of recycled calcium carbonate from industry.

## Calderys

Calderys has made significant investment in USA to ramp up its infrastructure as well as expansion in capacity. They include:

- Completion of Overall Equipment Effectiveness Initiative (OEE) production software upgrades across HWI's highest volume plants: Alabama1; South Point, Ohio; Vandalia and Fulton, Missouri; White Cloud, Michigan; and Windham, Ohio.
- Monolithics expansion investments at HWI's White Cloud, Michigan plant to increase capacity by 12,500 MT and robotics upgrades for hydraulic presses.
- Expansion of HWI's Lowellville, Ohio facility to increase capacity from 300 MT to 2,000 MT.
- New press installations in Windham, Ohio, and Vandalia, Missouri, facilities to increase capacity.
- New grinding equipment installation at the Mexico, Missouri Machine Shop.
- Expansion of the Thomasville, Georgia plant to increase capacity to 7,500 MT.

## Almatis Alumina

Almatis has announced a substantial investment to increase the capacity of calcined alumina production in North America. The project is designed to boost primary calcined alumina production capacity at its Benton, Arkansas plant. The project consists of four distinct phases, all working towards the impressive goal of achieving a capacity increase of 15%.

## Shinagawa Refractories

JFE Steel and major refractory manufacturer Shinagawa Refractories have been working together to expand the recycling of refractories used for steelmaking. The used refractories collected from JFE Steel's steel plants are sent to Shinagawa Refractories, and after the used refractories undergo processing, they are reused as raw materials for refractories. The ratio of recycled raw materials utilized for manufacturing refractories used to be around 10%, but currently the companies have succeeded in raising the ratio to about 20%.

## Japan refractories output

According to the Japan Refractories Association, in 2022, the output of Japan's refractories was 828,100 tons, a decrease of 13.38% compared with 2021. Among them, the output of monolithic refractories was 578,200 tons, and the output of shaped refractories was 249,900 tons.

## MEMBERSCAN

### Refratechnik India

Refratechnik Group has recently inaugurated its state of the art greenfield plant at Vizag, Andhra Pradesh to produce Magnesia Carbon refractories to meet the demands of steel customers and high alumina monolithic plant to meet the requirement of steel, cement and non-ferrous industrial customers.

### RHI Magnesita India

RHI Magnesita India plans to invest Rs 200-300 crore in modernising the five Dalmia plants over the next three years to meet world-class standards. The company has set an ambitious goal of securing 40 per cent of the refractories market within the next four years.

### IFGL Refractories

IFGL Refractories Ltd has unveiled its Research Centre in Kalunga, Odisha, on 24th November, 2023. The state of the art facility provides IFGL a world class capability to complete fundamental research along with a metal melting facilities to enable confirmation of material, steel, slag interface reactions.

### OBITUARY

Shri Gopal Rajgarhia, former Managing Director of Orient Refractories Ltd and former IRMA Chairman (1992-1994) peacefully passed away on 11th November 2023. A graduate of IIT Kharagpur (1968), he successfully marked his creativity in the growth and development of Indian refractory industry through his own successful venture. He was an active patron of IRMA and took number of initiatives to strengthen its activities. May His Soul Rest in Eternal Peace.

## ECONOMY AT A GLANCE

- Indian economy witnessed a significant year, closing 2023 with a GDP of US$ 3.73 trillion, GDP per capita at US$ 2,610 and a projected GDP growth rate of 6.3 percent against the global average of 2.9 percent.
- Exports declined by 5.43 percent on a year-on-year basis for the period January-October, imports declined by 7.31 percent in the same period, improving the trade balance.
- The core inflation, which is the CPI inflation excluding food and fuel, has remained stable indicating that it is primarily food price shocks that are causing the headline inflation to deviate from the target rate of 4 percent. Double-digit inflation exhibited by cereals, pulses, and spices has kept the food inflation momentum high which is being combatted by the government through export prohibitions to stabilise domestic prices.
- Throughout 2023, India's manufacturing PMI remained above 50, signalling an expanding output, with the PMI hitting 56 in November. However, in October, growth eased to the slowest pace since February with the uptick in new orders hitting a one-year low, as the Global India Manufacturing PMI slipped to 55.5 from 57.6 in September.
- The rupee depreciated 0.29% from January 1 to mid-December this year from around 82.7 on January 1 to around 83.01 on December 15, lower than last year's over 11% depreciation.
- According to the Centre for Monitoring Indian Economy (CMIE), the unemployment rate peaked at 10.1% in October for this year.
- The repo rate has remained unchanged since February this year at 6.5%. This is expected to be maintained till August next year.
- According to Deloitte, India will need at least 6.5% growth to emerge as the world's third largest economy by 2027. Deloitte further expects India to grow between 6.5% and 6.8% between FY23 and FY24 in our baseline scenario, followed by an average of 6.65% and 7.95% over the next two years as the global economy turns buoyant.

**Outlook:**

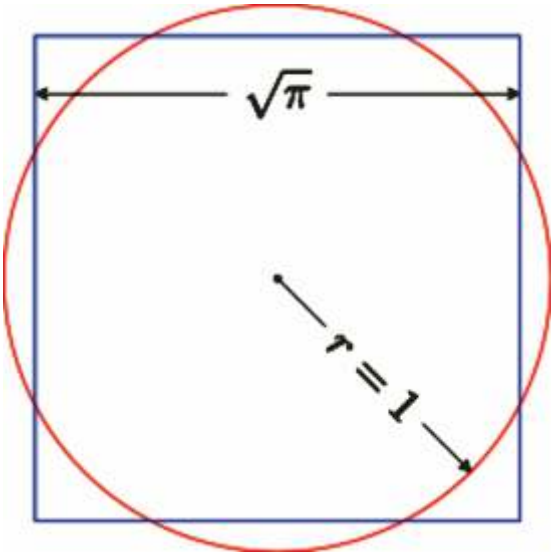
| Indicator *(percent y-o-y growth, unless otherwise specified)* | FY20/21 | FY21/22 | FY22/23 | FY23/24 | FY24/25 | FY25/26 |
|---|---|---|---|---|---|---|
| **Real GDP Growth, at constant market prices** | -5.8 | 9.1 | 7.2 | 6.3 | 6.4 | 6.5 |
| Private Consumption | -5.2 | 11.2 | 7.5 | 5.9 | 6.0 | 6.4 |
| Government Consumption | -0.9 | 6.6 | 0.1 | 4.1 | 5.1 | 5.8 |
| Gross Fixed Capital Formation | -7.3 | 14.6 | 11.4 | 8.9 | 7.8 | 7.3 |
| Exports, Goods and Services | -9.1 | 29.3 | 13.6 | 0.9 | 6.7 | 8.2 |
| Imports, Goods and Services | -13.7 | 21.8 | 17.1 | 3.0 | 7.2 | 8.7 |
| **Real GDP Growth, at constant factor prices** | -4.2 | 8.8 | 7.0 | 6.3 | 6.4 | 6.5 |
| Agriculture | 4.1 | 3.5 | 4.0 | 3.5 | 3.6 | 3.7 |
| Industry | -0.9 | 11.6 | 4.4 | 5.7 | 6.4 | 6.4 |
| Services | -8.2 | 8.8 | 9.5 | 7.4 | 7.2 | 7.3 |
| **Inflation (Consumer Price Index)** | 6.2 | 5.5 | 6.7 | 5.9 | 4.7 | 4.1 |
| **Current Account Balance** *(percent of GDP)* | 0.9 | -1.2 | -2.0 | -1.4 | -1.2 | -1.6 |
| **Net Foreign Direct Investment** *(percent of GDP)* | 1.6 | 1.2 | 0.8 | 1.1 | 1.4 | 1.5 |
| **Fiscal Balance** *(percent of GDP)* | -12.6 | -9.6 | -9.0 | -8.7 | -8.1 | -7.9 |
| **Debt** *(percent of GDP)* | 89.3 | 84.8 | 82.9 | 82.9 | 82.5 | 82.4 |
| **Primary Balance** *(percent of GDP)* | -7.2 | -4.4 | -3.9 | -3.3 | -2.7 | -2.5 |

Source: CEIC and World Bank Staff calculations
Note: (j) Shaded columns are WB forecasts

## *BUSINESS SECTION:*

### SQUARING THE CIRCLE: CHALLENGES & OPPORTUNITIES IN RECYCLING REFRACTORY MINERALS

*Mike O' Driscoll, Director, IMFORMED, Squaring the Circle: Challenges & Opportunities in Recycling Refractory Minerals*




"Squaring the circle" is a problem in geometry first proposed in Greek mathematics.

The expression "squaring the circle" is sometimes used as a metaphor for trying to do the impossible.

Also can mean, to bring together two things which are normally thought to be so different that they cannot exist together.

**1. DRIVERS:** *ENTERING A NEW ERA OF REFRACTORY MINERAL RECYCLING*

Entering a new era of refractory mineral recycling Primary drivers: "Rule of Six"

1. **Environment:** saving the environment; drive for the "Circular Economy" gathering momentum; $CO_2$ reduction; sustainable Development of raw materials Development of raw materials.
2. **Cost factors:** rising cost of primary minerals, energy, waste treatment, landfill; future penalties, legal costs
3. **Limited primary sources:** shortage of commercially developed mineral resources and processing plants:"critical"+ "strategic"; **Source over reliance:** risky over reliance on supply/trade from limited overseas sources; logistics stress; vulnerability spotlighted by Covid-19 pandemic, Russia-Ukraine war, China-Taiwan?
4. **China in change:** supply issues, wide range of factors ;end of an era for low cost import reliance? Time to de-risk?
   - ➢ Build a more resilient supply chain: to support projects, attract more private investment for recycling (and mining & processing).
   - ➢ European standardization to fast Track secondary raw material production
   - ➢ June2023:EU Council proposals to improve CRMA:
     - raises level of ambition for processing and recycling capacity: from 40 to 50% for processing and from 15 to 20% for recycling
     - adds Bauxite/Alumina (& Aluminium) as strategic raw and critical materials
5. **Emergence of hi-tech growth markets requiring "critical" raw materials:** to become more mainstream, particularly in the energy sector (eg. Li-ion batteries, EVs, solar, wind), and thus demand for respective critical minerals (eg. lithium, graphite, rare earths); minerals "gaining criticality"; = increasing government awareness/reaction/support/investment.
6. **Recycling technology more economic/ established** evolved from esoteric, expensive sideshow, to mainstream

processing line Advances in processing & sorting technology; opportunities sensed and sought after.

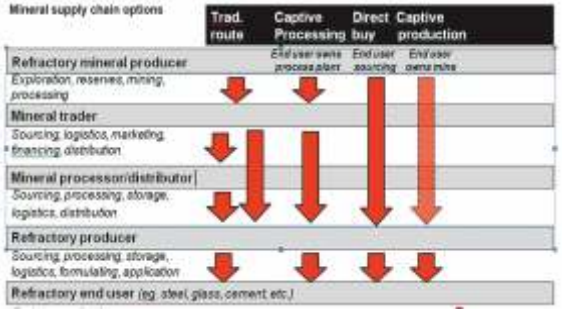
## Entering a new era of refractory mineral recycling

EU big push towards a Circular Economy–"Closing the loop"

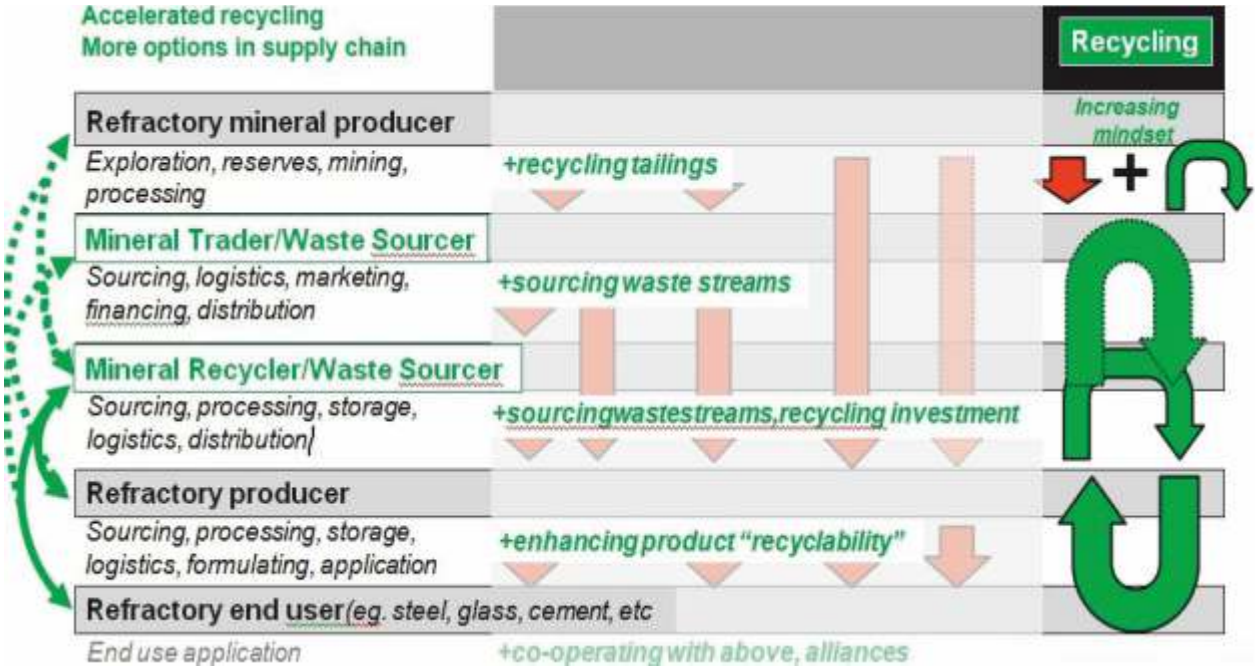
- **2008+**:EC Critical Raw Materials List
- **2014:**Horizon 2020 Project Funding(-2027HorizonEurope)
- **2019**:European Green Deal
- **2020:**Circular Economy Action Plan
- **2022**:Critical Raw Materials Act(CRMA) proposed
- **2023**:CRMA adopted; The Green Deal Industrial Plan
  - ➢ A robust and integrated single market for secondary raw materials and by-products, requiring deeper co-operation across value chains.
  - ➢ Legal requirements to boost the market of secondary raw materials with mandatory recycled content
  - ➢ Build a more resilient supply chain: to support projects, attract more private investment for recycling (and mining & processing).
  - ➢ European standardization to fast Track secondary raw material production
  - ➢ June 2023: EU Council proposals to improve CRMA:
    - raises level of ambition for processing and recycling capacity: from 40 to 50% for processing and from 15 to 20% for recycling
    - adds Bauxite/Alumina (& Alumi - nium) as strategic raw and critical materials

Government awareness/action | Evolving assessment of "Critical" or "Strategic" minerals worldwide

- 2008 by industry to promote European CRM policy
- 2020 platform for UK industry, academia, and govt.
- EC Raw Materials Initiative 2008 EC Critical Raw Materials List 2011; updated 2014, 2017,+Action Plan 2020,CRM Act 2022
- BGS Risk List 2015 UK Critical Minerals Intelligence Centre 2022
- US Federal Strategy to Ensure Secure & Reliable Supplies of Critical Minerals 2019
  DOC Calls to Action 2019
  USExecutiveOrders2020-22
  Defense Production Act 2022
  Inflation Reduction Act 2022
- USGS Critical Minerals List 2018 Updated 2021, 2022
- Australia's Critical Minerals Strategy 2020, 2022 Processing Road Map2021
- US-Australia partnership on developing critical mineral assets 2019 India-Australia Critical Minerals Investment Partnership 2022
- Canada-US Joint Action Plan on Critical Minerals Collaboration 2020-21
- Canada Govt. Critical Minerals Strategy 2022, List 2023
- Brazil Govt. Pro-Strategic Minerals Policy 2021
- 2022 "observatory of critical metals" led by BRGM, France.
- UK Govt. Critical Minerals Strategy 2022
- New Dept. for Energy Security & Net Zero (DESNZ) 2023
- India Min. of Mines Critical Minerals List 2023
- US DoE Critical Minerals List Update 2023 Added Natural Graphite, Silicon Carbide



## 1. DRIVERS: ENTERING A NEW ERA OF REFRACTORY MINERAL RECYCLING




## 2. Trends & Developments

**Refractory minerals overview** Categories |Chemistry |Source

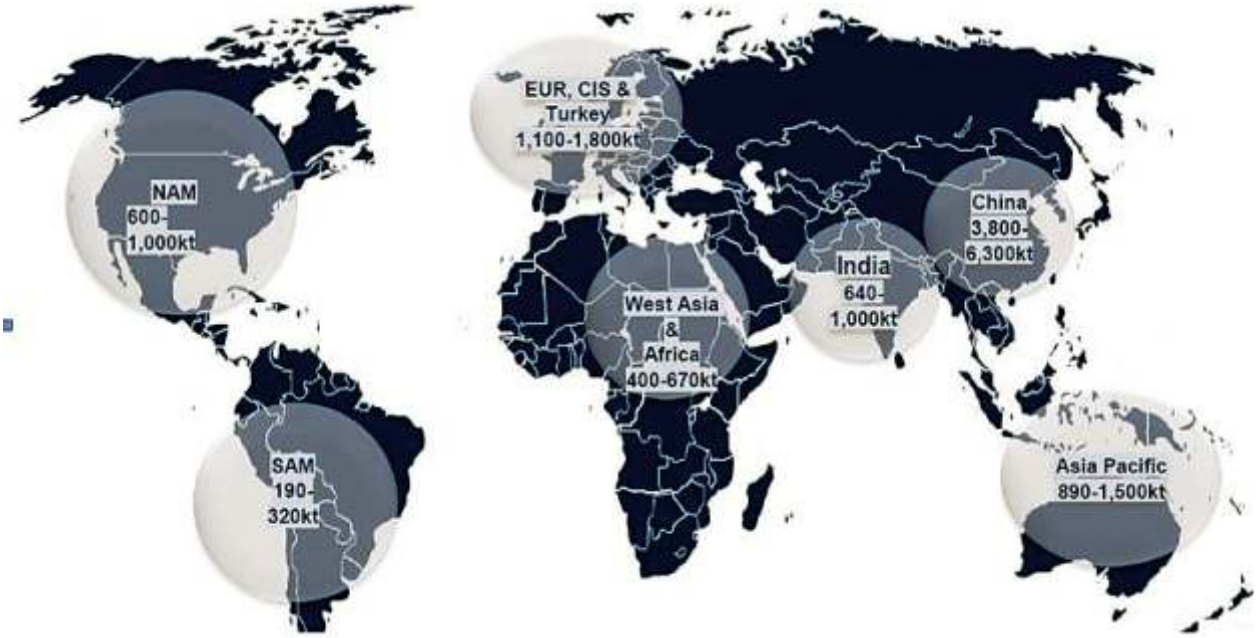
| Refractory classification | Industrial mineral (incl. synthetic) | Main chemical component | Primarysource country |
|---|---|---|---|
| BASIC | Dead burned magnesia | 85-99.8%MgO | China |
| | Fused magnesia | 97-99.8%MgO | China |
| | Dead burned dolomite | 56-62%MgO,36-40%CaO | USA |
| | Chromite | >46%$Cr_2O_3$ | SouthAfrica |
| | Sintered/fused spinel | 66-80%$Al_2O_3$,21-33%MgO | China |
| | Olivine | 40-50%MgO,35-45%$SiO_2$ | Norway |
| ACIDIC High alumina | Calcined alumina | >99.5%$Al_2O_3$ | China |
| | Fused alumina | 94-99.5%$Al_2O_3$ | China |
| | Calcined bauxite | 85-88%$Al_2O_3$ | China |
| | Sintered/fused mullite | 40-75%$Al_2O_3$ | USA |
| Lowalumina | Andalusite, sillimanite, kyanite | 60-65%$Al_2O_3$ | SouthAfrica |
| | Refractory clays | 20-45%$Al_2O_3$ | China |
| | Pyrophyllite | 20-30%$Al_2O_3$ | SouthKorea |
| Silica | Quartzite, silica sand | >97%$SiO_2$ | Regional |
| | Fused silica | >99.8%$SiO_2$ | USA |
| SPECIALISED | Zircon | 66%$ZrO_2$+$HfO_2$ | Australia |
| | Zirconia | >99%$ZrO_2$ | China |
| | Silicon carbide | >93%SiC | China |
| | Graphite | 75-99%C | China |
| INSULATING | Diatomite | >75%$SiO_2$ | USA |
| | Perlite | 65-80%$SiO_2$ | China |
| | Vermiculite | 45%$SiO_2$ | SouthAfrica |

**Limited primary sources**

- Limited commercially developed mineral resources
- Risky over reliance on supply/trade from limited overseas sources, eg China; logistics stress; vulnerability spotlighted by Covid-19 pandemic, Russia-Ukraine war, China-Taiwan?

## Refractory recycling

- Estimated 7.6-12.6m.tpa generation of refractory waste worldwide
- Approx.50% of this volume is reused in refractories production



- Estimated 7.6-12.6m.tpa generation of refractory waste worldwide
- Approx.50% of this volume is reused in refractories production


**Examples of closed loop refractory recycling products**

**MgO-Cr bricks :**recycled as gunning mixes for steel furnaces and permanent lining bricks

**MgO-C bricks:** widely recycled as they exhibit less contamination due to non wetting characteristics of C; recycled in low grade remanufactured MgO-C bricks and ramming masses

**Alumina bricks** from aluminium carbon bake furnaces: reused as castable for furnace headwalls and floors.

Source: Navin Singh, Head of Growth-Refractories &Special Projects, Veolia Australia and New Zealand(2023)

## 2A. TRENDS & DEVELOPMENTS: USA

- North America consumes about 6%of world refractories, Almost 50% consumed by steel.
- Total US refractory demand estimated at 2.9m tpa, with forecast growth from automobiles, construction and oil and gas industry.

- Limited recycling activity, mainly "open-loop", "opportunistic".
- Very few known independent refractory recyclers:
  - Glenn Hunter & Associates
  - BPI
  - CREMER ERZKONTOR
  - Lock 3 Mineral Processing & Recycling Co.
  - Harsco Environmental
  - Levy Group
  - Wisdom Environmental
  - Steel Valley Firebrick Recycling & Recovery(Maryland Ref.)
  - Metropolitan Ceramics

At present, refractory recycling not a top priority owing to:

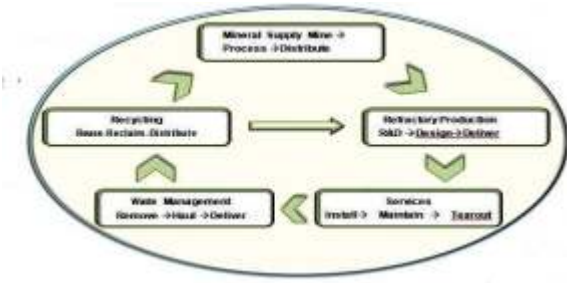
- Environmental drivers currently focused on regulations related to Energy efficiency, water, and emissions.
- Refractory users have not made the connection to refractory and impacts of minerals mining (Scope 3 emissions).
- Land filling of non-hazardous refractory is not considered a "good neighbour" issue, "it's just rock"; & low cost.
- There are not yet incentives or regulations that encourage refractory recycling.
- Refractory is ~1% of the overall cost stack.

Mineral recycling in general now emerging as a **"megatrend"** within North America, driven by Government funding and supply chain disruption. There is momentum building among North American refractory producers for closed-loop recycling.

| RefractoryManufacturer | Country Base | US Sites | Mexico Sites | Canadian Sites | Claim Closed-Loop Recycling Programs** |
|---|---|---|---|---|---|
| Harbison Walker International* | US | 15 | 1 | 2 | Yes |
| Resco* | US | 9 | 0 | 1 | Yes |
| Calderys | France | 6 | 0 | 0 | Yes |
| Minteq-MineralsTech | US | 5 | 0 | 0 | Yes |
| Vesuvius* | UK | 5 | 1 | 1 | Yes |
| AlliedMinerals | US | 3 | 0 | 0 | - |
| RHI-Magnesita* | Austria | 3 | 2 | 1 | Yes |
| Morgan Advanced* | UK | 3 | 2 | 1 | - |
| Shinagawa | Japan | 2 | 0 | 0 | Yes |
| PRCO | China | 1 | 0 | 0 | Yes |

* Five suppliers account for 80% of total NA refractory demand; HWI viewed as market leader.(custom research)

** Claim R&D efforts or active in closed-loop MgO and/or alumina refractory recycling-not necessarily in North America.(public website)

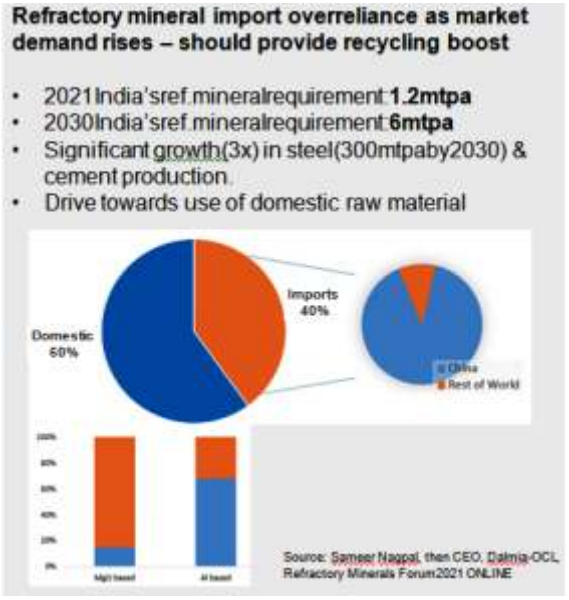


SOURCE: DAVID HARWICH & REBECCA MOHR, HWI, MINERAL RECYCLING FORUM 2023

- 1992+:RESERV programme; HWI glass customers may return upto 45%of material purchased.
- Partnered with GHA for material preprocessing; material is then electro-fused and returned to HWI.
- Approx.300 tpa of used furnace avoids land fill and is made into useful product.
- 2015: HWI-Mexico developed 45-80% alumina conventional monolithic castable from recycled 60% alumina brick; recycled material usage as high as 45%; accounts for ~5% of plant production
- Recycle fused AZ Sand zircon grog in monolithic, recycled material usage as high as 30%.
- 2019: lab study of advanced methods for closed loop Recycling of mag-carbon brick.
- 2021: appointed Director of Mineral Recycling
- 2022: trialling closed loop recycling brick compositions at customer sites.

## 2B. Trends & Developments: INDIA

- India has 6.55% market share by value of the global refractory market.
- Indian refractories production in FY22-23 estimated at 1.6m tonnes.
- About 250,000 tpa of spent refractory materials are recycled in market sectors like iron and steel, glass, cement, ceramics, non-ferrous, petrochemical, etc.




- = c.15% of recycle draw materials being used on average.
- Indian aims to increase this to 25% by 2025, thus creating an additional use of 150,000 tonnes over the next 2years.
- Overall, expected increase in refractory recycling within India, plus increased imports of secondary materials and refractory grogs.

However, key challenges to refractory recycling in India include:

- ➢ Only a limited quantity of recycled refractory is available
- ➢ over-dependence on the iron & steel industry; other end use segments like the power, cement, glass etc. contribute to around only 30% of the refractory consumption.
- ➢ Not enough high-grade refractories will always be available for recycling
- ➢ Too many contaminants, makes it difficult to recycle every

## 2C. TRENDS & DEVELOPMENTS: SOUTH KOREA

- Total refractories market about 700,000 tpa, domestic production estimated at 470-500,000 tpa, about 30% Imported refractories (mostly from China).
- About 80% consumed by steel market.
- Recycling rate has increased from 33% in 2013 to 65% in 2019 driven by rising costs of landfill and environmental fees.

- **2011**: Korea Material Co. Ltd founded

  **2016**: Comprehensive Waste Recycling Permit

  **2017**: Waste Graphite Recycling Process Patent

- **2017**: Plant 1(Pyeongtaek; recarburizer (99%), pitch, needle coke (99%), alumina, mullite, SiC, zirconia(33%, 90%), WFA)
- **2018**: Plant 2(Asan;):chamotte, pyrophyllite, magnesia)
- **2020**: Plant3(Pyeongtaek; recarburiser (85%), chamotte)
- **2023**: Active in recycling alumina part sandglass from semiconductors and screens ,& recycling fused aluminas from shot blasting.
- **2023**: with Technology Research Institute developing graphite anode recycling from Li-ion batteries, and valuable metal extraction from sagger boxes used in cathode production.

**Pros**

- Limited mineral resources
- Lower expansion and shrinkage
- Price competitiveness(10-20%lower)
- Reduce dependency on foreign materials

**Cons**

- Stigma of "tarnished" recycled materials
- Difficulties in controlling consistent chemical specs.
- Cost of recycling

**Challenges**

- Lack of talent and sales network(overseas)
- Capital intensive business(high capex & large land requirement)
- Difficulties with acquiring waste recycling permit
- Complaints from the local community(dust, noise, large trucks, etc.)
- Lack of support from the government(lack of financial support and tax incentive)
  Increasing incentive to recycle but not much incentive to use recycled refractory raw material
- Changing regulations that limit the recycling capacity based on warehouse capacity rather than actual processing capacity
- Advancement on refractory recycling technology and process.
  - ➢ Unshaped refractory recycling
  - ➢ Increasing performance of recycled materials
  - ➢ More optimized process that lowers the recycling cost, eg. automatization of recyclable material identification

## 2D. Trends & Developments: CHINA

- Recycled materials are used in the Chinese refractory market in a very big way!
- Most of the MgO-C brick manufacturers in China put significant volumes of recycled MgO-C brick into production.
- The source of the recycled MgO-C brick and the procedure on how to process the recycled MgO-C brick are critical to the final product.

For a successful recycling operation, a few key success factors are required:

1. Source of recycled material
2. Location of the plant
3. Compliance with local EPA regulations?
4. Operating license?
5. Process control
6. Quality control

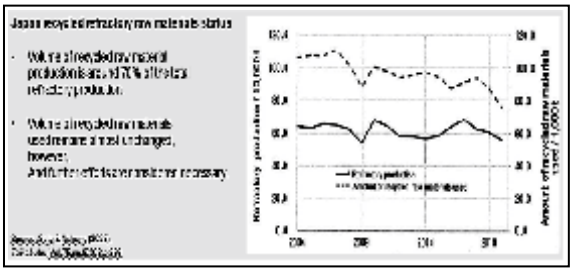
NCR is focussing on specific projects, so ou involvement in recycled material is limited.

Refractory brick waste sorting in China

- Recycling has been an established practice in the Chinese market for quite sometime.
- Most activities are spread out across several small-sized suppliers and traders.
- Quality standards are quite different from Europe, but most Chinese refractory players are flexible enough to adapt recipes and products quickly to make full advantage of the usage of recycled material.
- It is our strong belief, that in the not too distant future refractory manufacturers will be more and more forced to utilise recycled material as virgin raw material.
- Might not be available to the same degree as in the past ,or might not be available for a competitive price.

RHIM's Dalian plant just celebrated 20 years

## 2E. Trends & Developments JAPAN



Recycling used refractories is obviously one of the most important management issues in Japan for refractory manufacturers and their customers. Shinagawa is actively engaging in recycling used refractories.

I believe the challenges we are facing are:

- ➢ Labour shortage for logistics / transportation & sorting / crushing processes

- Lack of storage space of used refractories
- It is necessary to further reset our mind set about recycling.

  -remaining concerns that using recycled materials might lead to a decline in product quality, and some believe that using used refractories is just to cut production cost, while recycling used refractories actually is creating added values for products.

- Krosaki Harima has been using recycled products since the company was founded (1918).
- >20 years collaboration with customers to further expand the use of recycled products while maintaining quality.
- Recycling contract work at customers' steelworks.
- Promote reduction of industrial waste and the recycling of refractories through collection and sorting of used refractories to use in the manufacture of new products.

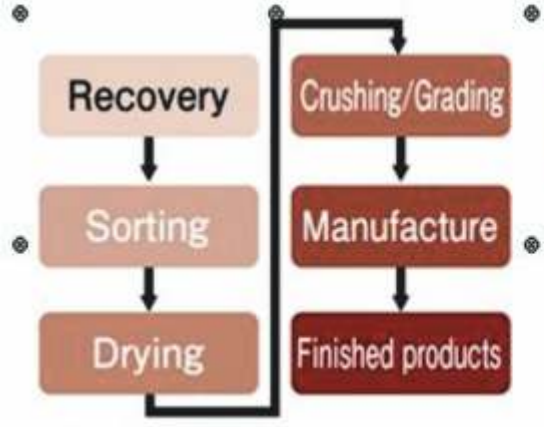



Figure 5-10 Refractory recycling process

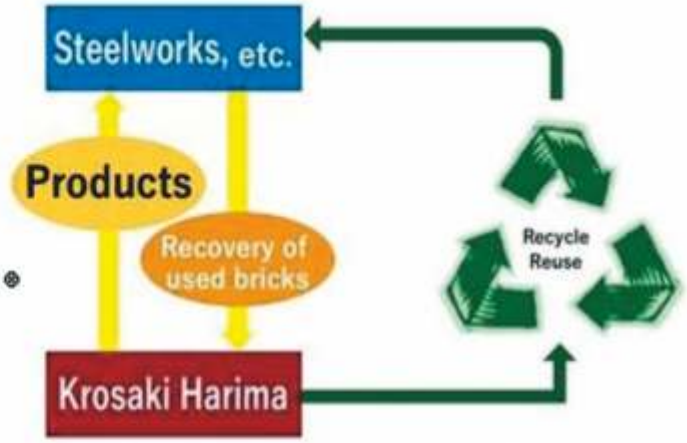



Figure 5-9 Refractory recycle flow

Photo 5-11 Used refractories after crushing and grading

Source: Krosaki Harima

## 2F. Trends & Developments EUROPE

Much more developed and progressing; mainly composed & driven by:

1. Independent/JV refractory recycling companies
2. EU-wide research consortiums of collaborating players from raw material, processing, refractory, & end use sectors

| Company | Op.Country |
|---|---|
| AFT(UK)Ltd | UK |
| Alfaref GmbH | Germany |
| Deref SpA | Italy/France |
| Extracthive(co-op.Saint-Gobain) | France |
| Fromtec Engineering(Fromberger / Tymo Engineering JV) | Germany |
| HARSCO Environmental | UK |
| Horn&Co. Group | Germany/Poland/ Kosovo |
| LKAB Minerals | UK |
| MIRECO(RHIM/Horn JV) | Austria/France/ Germany/Sweden |
| Mineralen Kollée | Netherlands |
| Mineralmahlwerk Hamm GmbH(CREMER Erzkontor) | Germany |
| REF Minerals | Latvia/Germany |
| Refra-System Ltd | Hungary |
| Refratechnik Horn Produktions GmbH(Refra/Horn JV) | Germany |
| Richmond Reclamation Ltd | UK |
| SEBOREF(REF Minerals) | Czech Republic |
| Valoref (Saint-Gobain) | France |

### 1. Independent/ JV refractory recycling companies

- 15-20+independent refractory recyclers
- Several very well-established over 10+ years
- Certain owned by larger industry players
- Certain with specific focus, eg. AZS glass ref.

  Historically a “low profile” approach
- Recent trend to JV with refractory producer
- Some consolidation already, eg .Horn,

  REF Minerals (acquired SEBOREF, CZ, Feb. 2023, new 2nd plant on-stream end-23)

  Refratechnik Horn Produtions GmbH
- **Sept.2021**:Refratechnik Horn Produktions GmbH

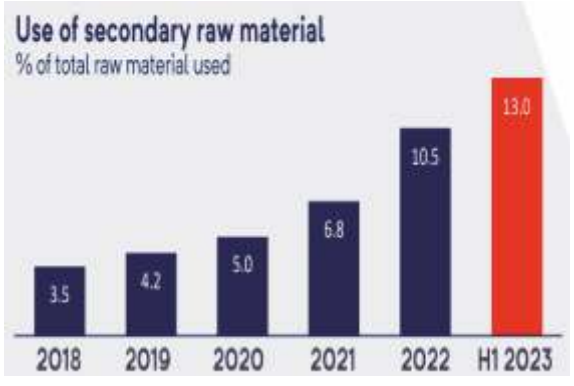
  (Refratechnik Steel/Horn & Co. Minerals JV)
- **2022:** revival of Horn's Hünsborn plant, ramp up to 20,000 tpa MgO-C brick in 2022, 40,000 tpa in 2026.

  - 2nd hydraulic 2000t press operational Q2 2022
- 25% raw material recycled refractories from Horn, remainder DBM/FM from QMAG, Australia.
- Key drivers were:
  - Reducing the dependence on China
  - Reducing the carbon footprint of Refra MgO-C production
  - Increasing availability of European refractories for European steel plants

Horn & Co .RHIM Minerals Recovery GmbH

- 28 Mar. 2022: Horn & Co. RHIM Minerals Recovery GmbH (RHIM (51%) / Horn & Co. Minerals JV) Combines plants of Horn, Siegen & Weitefeld, Germany, and RHIM, Mitter dorf, Styria, Austria; process> 150,000 tpa material

- 7 April 2022:New €7m RHIM Veitsch recycling centre opened
- 15 November 2022:JV branded as MIRECO
- 2023:Recycling volume targets:>160,000 tpa 2026: >270,000 tpa
  - ➢ Approx. 40-45% metallurgical additives
  - ➢ 55-60%critical raw materials for refractories.
- RHIM strategy boost: to globally increase recycling rate in its products to >15% in 2025
  - ➢ H1 2023:13%(H12022:9.3%)




Source: RHI Magnesita

| Customer | Sourcing volume Refractory outbreak | MIRECO deliveries Based on CRM | CRM-rate MIRECO delivered products | CERO - waste rate |
|---|---|---|---|---|
| I | ~1.600t | ~1.300t | 100% | 81% |
| II | ~15.000t | ~11.300t | 96% | 75% |
| III | ~2.800t | ~2.100t | 77% | 75% |
| IV | ~10.000t | ~7.350t | 96% | 73% |
| V | ~ 8.100t | ~ 4.000t | 100% | 55% |
| VI | ~15.500t | ~1.500t | 100% | 10% |


**Importance of refractory sorting knowledge**

- Manual cleaning by hand or magnetic separation at the crushing/treatment
- Slag-heads and infiltrated parts are used for metallurgical additives. Carbon containing bricks must be sorted into the different types

2. EU-wide research consortiums of collaborating players from raw material, mineral processing, refractory, & end use sectors

- EC Horizon 2020 & Horizon Europe funding
- REFRASORT (Innovative Separation Technologies for High Grade Recycling of Refractory Waste using non destructive technologies)
- To design and implement a strategy based on the 5R approach (Reduce - Reuse - Remanufacture - Recycle - Re-educate) for the management of refractory waste
- "Refractory Sorting Using Revolutionizing Classification Equipment" (ReSOURCE)
- Evolved refractory waste recycling management with LIFE 5RefrAct Project 2018-2020.
- Aim: develop high value added refractory materials
- Incorporating a significant amount of refractory waste.
- SIDENOR co-operation
  - Magna = 9 MgO products @ 70% recycled
  - Refralia = 12 $Al_2O_3$ products @ 65% recycled

## 3. Outlook Challenges:

- **Competitive:** to be cost, quality, & performance Competitive with primary raw materials
- **Image:** is using a "waste" product – still a stigma?
- **Quality control:** issues in making the grade
- **Adapting:** recycling compatibility in established product formulations; a new mind-set encouraging recipe modification to "ease" recyclability; combined with new low-$CO_2$ recipe
- **Investment:** in skilled labour; processing/sorting technology/ automation; eg. Hand sorting vs laser sorting?

MIRECO employs both hand sorting and laser sorting technology (LIBS)

- **Incentivisation:**
  - **Government / state support structure:** $CO_2$"credits" in recycling ?
  - **Tax/monetary drivers**
  - **Landfill bans/penalties:** "Landfill prices are so low in USA it is hard to justify doing anything." Tom Vert, Strategic Refractory Consultant (2022)

- **Permits/legislation:** eg. In handling/storing/treating refractory waste material
  - clarity, consistency, across country borders
  - harmonization of waste handling /permitting

- **Refractory waste source site:**
  - Simplified, structured schedule & process:
    - To tear-out, sort, remove refractorys from site of use
    - Develop/ collaborate on mutual benefits for waste provider and recycler.
    - Mobile crushing/sorting plant?

  - **Awareness &speed:**
    - careful & controlled demolition to ensure proper segregation of refractory material grades
    - Swift on-site sorting a priority, eg. MgO-C from AMC In a steel ladle.
    - swift transfer from waste source to recycling plant(& decent storage) to minimise further potential degradation and yield losses

Refractory waste stockyard at MIRECO 50,000 tpa plant

- **Supply chain:**
  - **Sourcing**, securing, accessing, and maintaining adequate supply of refractory waste material; waste source becomes the new "refractory mineral resource"
  - **Assurance:** of long term supply of consistent quality of refractory SRM
  - **Costs:**
    - **Waste material charge**
    - **Demolition & sorting on waste site**
    - **Logistics:** proximity to waste source ⇨ recycler ⇨ refractory producer
    - **(More sorting) Processing & quality control at recycling plant**
    - Sum of above vs. delivered primary raw material price

- **Management:** balance between continuous and discontinuous flows of waste material to meet consistent supply of recycled material flow to end users material flow to end users.

Consistent access to and securement of refractory waste source at steel, glass, cement, etc. plants is key

- **Recycled material on mineral purchaser's menu:**

  The future "new normal", or regular sourcing option

- **More government input = support & investment potential?**

  Critical Raw Material policies; recycling initiatives.

- **More companies getting involved:**

  Evolution of new supply chain of:

  - Waste sources: eg. steel, glass, cement, ceramics etc.
  - Primary mineral producers: diversifying into recycling projects to expand portfolio and combined "package" to consumers.
  - Processors(Recyclers)
  - Traders
  - Distributors
  - Logistics/Handling

Logistics, including port handling, is a key factor in the recycling supply chain; *above* KB Group in final stage commissioning its new deep draft Amerikahaven Terminal, Amsterdam, driven by demand for recycled/secondary raw materials for the steel and building industry.

- **More companies getting involved:** Evolution of new supply chain of:
  - Suppliers of demolition / processing / quality control technology & equipment eg. **improved demolition** equipment eg. **Improved screening systems** eg. Improved sorting /processing systems: development of laser (LIBS-Laser-Induced Breakdown Spectros copy),sensor based sorting (SBS) and mobile sorting systems, other processing technology eg. crushing, screening, pelletising.
- **Increasing refractory recyclability globally:**

  development of new product formulations to enhance/ease SRM use and ultimate recyclability to achieve Circular Economy

  - Replicate progress & activity levels of EU worldwide.
  - Mind set of new manufacturing R & D with recycling at EOL.
  - Blends of primary and SRM?

- Provides mineral suppliers & mineral consumers with “green” portfolio branding

- **Added value product development:** for more diverse market applications.
- **Strategic partnerships**: increasing long term strategic alliances and co-operation(technical+investment) between refractory waste sources, recyclers, and refractory producers
- **Education:** of end users to positively engage in and Recognize benefits of recycling for Circular Economy = employment opportunities, better for environment.

  eg. RHIM's ANKRAL LC series used in rotary cement kilns

- Contains upto 50% recycled materials (incl. DBM).
- CO2 footprint of final product reduced by up to 14%.

## TECHNICAL SECTION

# INDUSTRIAL APPLICATION EXPERIENCES WITH MICROPOROUS CALCIUM HEXALUMINATE INSULATING MATERIAL SLA-92

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## Abstract

The microporous Calcium Hexaluminate insulating material SLA-92 has been introduced as an alternative to refractory ceramic fiber and other insulating refractory materials. Key properties can be listed as: high chemical purity, long term high temperature stability up to 1500°C, low thermal conductivity up to 1500°C, and high thermal shock resistance. The properties of the new material and various applications in the steel and ceramic industries have been reported in previous papers. The current paper summarizes the industrial application experiences with the new innovative refractories based on SLA-92.

## Introduction

SLA-92 was introduced to the refractories industry in 1998 by van Garsel, etal. [1] as a new insulating raw material for high temperature applications, followed by investigations [2] for long term temperature stability of this new lightweight aggregate up to 1500°C.It has unique properties regarding chemical purity and mineral composition and is a microporous, silica-free Calcium Hexaluminate ($CA_6$ – mineral name: Hibonite) and was developed as an innovative alternative to commonly used refractory ceramic fibers.SLA-92 chemical and physical data and mineral composition are listed in **Table 1**, microstructure, open and relative porosity are depicted in **Figure 1**.

**Tab. 1:** SLA-92 Product Data

| Chemical Composition [wt.-%] | Typical | Min. | Max. |
|---|---|---|---|
| $Al_2O_3$ | 91 | 90 | |
| CaO | 8.5 | | 9.2 |
| $Na_2O$ | 0.40 | | 0.5 |
| $SiO_2$ | 0.07 | | 0.2 |
| $Fe_2O_3$ | 0.04 | | 0.1 |
| Physical Properties | | | |
| Loose Bulk Density [kg/l] | 0.5 - 0.6 | | |
| Bulk Specific Gravity [g/cm³] | 0.80 | | 0.95 |
| Mineral Phase Composition | $CA_6$ ($CaO \cdot 6\,Al_2O_3$) Major<br>$CA_2$ Minor<br>α - $Al_2O_3$ Minor | | |
| Available Sizes | 3 – 6 mm<br>1 – 3 mm<br>0 – 1 mm | | |

Measurements on experimental castables showed excellent resistance to thermal shock. The low density in combination with the microporosity which hampers heat transfer by radiation on temperatures exceeding 1000°C, resulted in low thermal conductivity of 0.4 W/mK at 1300°C, details were reported by [1].This makes SLA-92 as an innovative alternative to refractory ceramic fibers and is an unmatched insulating aggregate for preferred use in state-of-the-art monolithic concepts, offering interesting application opportunities in the wide field ofdemanding high temperature insulation.Since its introduction, numerous papers and publications report about the use of SLA-92 as key raw material for high temperature insulation materials in a variety of applications. On closer examination of the papers, topics are mainly focused on:

- Fiber replacement
- Innovative raw material for improved performance

Besides advantages resulting from chemical purity, physical properties, microporosity, long term high temperature stability and resistance to demanding thermal shock, obviously one main driver for use of SLA-92 is to have a feasible substitution of refractory ceramic fibers, which are classified as category 2 carcinogens by EU legislation. A German public sponsored research and development project [3] reports about substitution of fiber containing concepts by SLA-92 based insulating materials in high temperature processes for steelmaking, glass and ceramic industry. This paper summarizes the industrial application experiences with the new innovative refractories based on SLA-92.

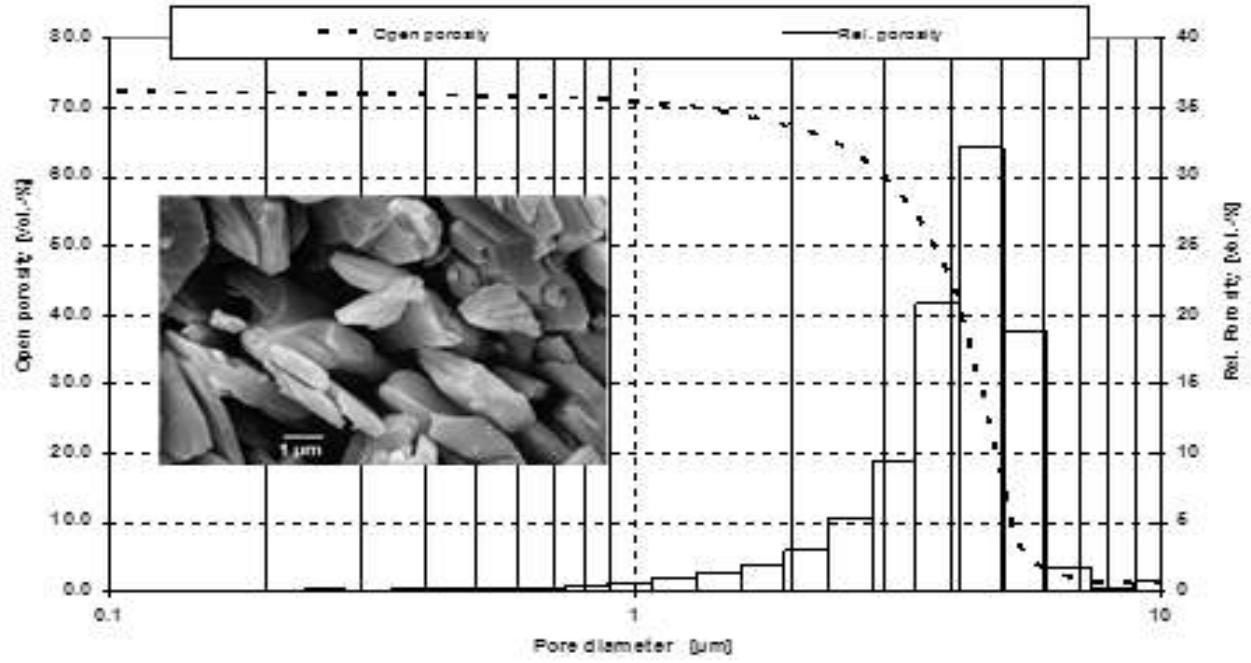


**Fig.1**: SLA-92 microstructure of calcium hexaluminate platelets (SEM) and micropore size distribution (Hg-intrusion method).

## Applications in Steel Industry

Often the steel industry is the driver for refractory innovations. One focus is on the replacement of refractory ceramic fiber (RCF's), so far mainly for preheaters applied in steelmaking processes and the variety of reheating furnaces at hot rolling mills.

## Ladle preheater cover lining:

Duhamel and Verelle [4] report about a new design of lids for ladle preheating in Dunkirk Steelworks. The objective was the elimination of drawbacks due to handling, installation and removal of refractory ceramic fibers, along with significantly increased service live and availability of the ladle lids. Emphasize is also on health aspects and additional cost involved by wrecking RCF linings and disposal of fiber wastes in compliance with the environmental legislation. Castable based on SLA-92 has been a key component of the solution to achieve the objective. Even at initial higher material cost of about 54% compared to the RCF lining, the reduced manpower requirement and increased service life by at least 100% result in substantial total saving for the SLA-92 based castable solution. The work of Duhamel and Verelle was rewarded with the “Young Engineer of the Year Award” of the Institute of Refractories Engineers (IRE) in the year 2000.

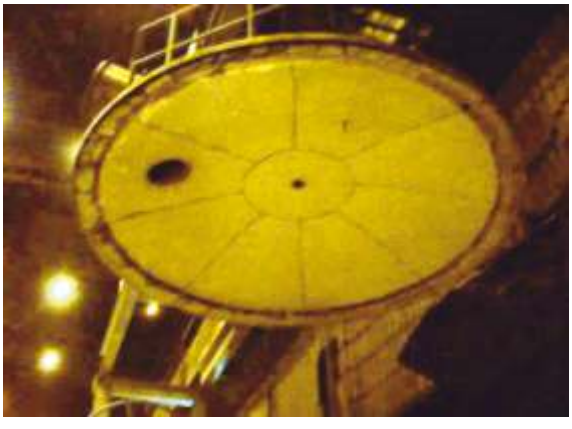

**Fig.2**: Ladle preheater refractory lining after 12 month usage without any repair

Fundamental properties of a new steel ladle preheater technology at CORUS Steelworks IJmuiden are described by de Wit, etal. [5]. The introduction of a new near netshape casting machine required methodical process changes and an adjustment of the steel ladle refractory lining. It became necessary to optionally empty steel ladles during the ladle cycles. Focus was on ceramic fiber-free refractory linings of the ladle preheater covers. SLA-92 based castable was selected to cope with the requirements of such linings which are in this case refractoriness of at least 1400°C which is up to 200°C above service temperature in order to tolerate temperature spots and contributing to long term stability. Additionally a low specific weight and a low thermal conductivity is important to achieve a low weight of the lining to keep the preheater steel construction and the hydraulic power within reasonable limits. Most important is the resistance to thermal shock to withstand numerous cycles between 1200°C and ambient temperature with rapid, almost immediate heating up and cooling down. **Figure 2** shows the SLA-92 based ladle preheater refractory lining after 12 months use without any repair. In the meantime the linings showed a tremendous service life of up to 3 years without intermediate repairs.

## Submerged Entry Nozzle Insulation:

The non-fibrous insulation of submerged entry nozzles (SEN) for continuous casting has been investigated by Gotthelf et al.[6]. Positive results have been achieved by coating the nozzles with SLA-92 based slurry as alternative to fibrous material wrapping. **Figure 3** shows that the spray coating procedure also enables to apply the insulation material in the port-holes of the sub entry nozzle in order to further reduce thermal stress and reduce prone to failures. The trials showed that SLA-92 based spray coating yields a better thermal insulation in comparison to fibrous material which required doubled thickness (6 mm versus 3 mm) to achieve comparable insulating results.

**Fig.3**: Submerged nozzle with sprayed on microporous insulation on the surface and in the port holes.

## Steel Reheating Furnaces:

Wuthnow et al.[7] report about the special insulating demands in steel reheating furnaces at Hoesch Hohenlimburg and Thyssen Krupp Stahl AG Bochum.The variety of steel grades produced in that mills require numerous and fast changes of the kiln temperature during use. These steelworks run walking beam furnace or pusher type furnace for reheating the steel slabs in temperature ranges from 1080°C to 1350°C. SLA-92 based material was tested in 3 main application areas: Precast shapes for stator and cross beam insulation in walking beam furnace versus refractory ceramic fibers, lightweight gunning mix for bricked furnace roof repairs and pre-cast shapes for furnace roof replacing high alumina insulating bricks. The furnace roofs are usually lined with such conventional lightweight refractories to accelerate the adjustment of kiln temperature between different steel grades to be reheated prior rolling. The thermal shock resistance of the refractory lining needs special attention to this frequent process temperature changes and especially during annual or bi-annual maintenance with harsh coolingfrom1300°C down to ambient temperature. SLA-92 based pre-cast shapes for furnace roofs (see **Figure 4**)were used in comparison to commonly used standard

lightweight bricks ASTM class 30,usually showing extensive spalling after 18 months use. The pre cast shapes (bulk density at 1.12 g/cm³) outperform the high alumina insulating bricks (bulk density at 1.08 g/cm³) with regard to thermal shock resistance and insulating behavior and SLA-92 based material is successfully tested over a period of more than 3 years.

**Fig.4**: Microporous pre-cast shapes for kiln roof, 400x350x160 mm with high alumina anchor brick and two 50 mm CA-silicate plates on top.

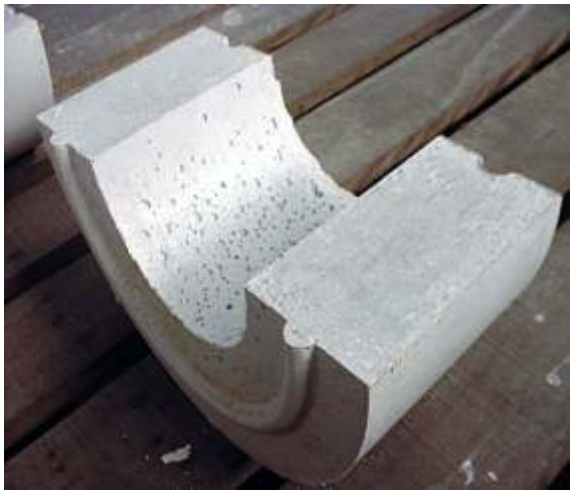

**Fig.5**: Pre-cast shape for walking beam reheat furnace stator insulation.

A parallel development for stator and cross beam insulation was reported by Kikuchi et al.[8]. Besides emphasizing on general concerns regarding commonly used fiber insulation in this application, test results clearly demonstrate excellent performance with SLA-92 based insulating castable over fiber insulation regarding resistance to slag and spalling. Lining options for stators are pre-cast shapes (see **Figure 5**) and were used in the introduction period. In the meantime the pre-cast shapes are replaced by more cost efficient on-site lining with the additional advantage of an installation without joints. Occasionally observed superficial cracks during use were eliminated by replacing calcium aluminate cement with hydratable alumina binder in the insulating castable. Service life of lining using SLA-92 of more than 2 years at publication of results is expected to exceed the conventional ceramic fiber insulation.The use of SLA-92 in insulating on-site installed castable for stators and cross beams in walking beam furnace is now an established application at a Japanese steelplant.

## Applications in Petrochemical Industry

Petrochemical applications with direct contact of the refractory lining to the process atmosphere are hydrogen reformers and gasifiers operating with reducing gases containing hydrogen and carbon monoxide gases. Process conditions are pressures around 25 bar and temperatures in the range of 950 – 1100 °C. Additionally, catalyst crackers (fluid catalytic cracking units = “cat crackers”), ethylene furnaces, pressurized fluid bed boilers, and transfer lines can be included as demanding refractory applications [9]. Important requirements of petrochemical applications are the stability of the refractory oxides against reduction, resistance against CO attack, and abrasion resistance due to high the high velocities of catalyst bearing gas streams in the vessels. Oxides with lower stability like SiO2 can be reduced by the process gases to gaseous SiO, which afterwards condenses in heat exchangers (“fouling”) and reduces the efficiency of this aggregate. Due to the SiO2 decomposition the strength of the refractory lining decreases and the porosity increases. The hydrogen attack is discussed in more detail by Tassot et al. [9].In a recent investigation by DIFK/Bonn, a SLA-92 based castable was classified for CO resistance

to class A after 540°C pre-firing and class B after 1095°C pre-firing according to the norm ASTM C 228.Reports about successful use of SLA-92 based material in petrochemical applications are not available in the literature so far.

## Applications in the Glass Industry

Windle and Bentley [10] discuss trends in the glass industry for oxy-fuel fired melters, primarily driven by regulation of both NOx and particulate emissions, which show significant reduction utilizing this technology. Besides associated benefits including decrease in fuel, increased melting rate and improved overall productivity, drawbacks are increased alkali concentrations from 1.5 to 6.0 times when compared with conventional melting. This would result in a severe wear of traditional silica crowns. Improvements for alkali resistance were achieved by use of magnesium aluminate spinel for the hot face in crown applications. Regarding the rear insulation for this spinel lining concept, calcium hexaluminate based insulating bricks were used since they show an improved resistance to alkali attack compared to the previous used Calcium-Silicate based insulation material. was recommended thanks to its tolerance to alkali attack. Due to increased temperatures at the outside face of the spinel crown, the high refractoriness of calcium hexaluminate has advantages over commonly used Calcium-Silicate based insulation material which would run very close to its classification limits.

## Applications in the Ceramic Industry

Modern ceramic fast firing uses very short cycles, e.g. 60 minutes for ceramic tiles from cold to cold with a maximum temperature of 1140°C, porcelain 300 minutes from cold to cold with a maximum temperature of 1400°C. The often used practice to turn off the kilns during weekends is an additional challenge to thermal shock resistance.In 1999, Stainer and Kremer [11] predict interesting potential in ceramic processing using this new microporous calcium hexaluminate. The key selection criteria is the excellent thermal shock resistance which is hardly found on other insulating materials at temperatures up to 1450°C.

Discontinuous kilns used in the ceramic industry benefit from a lowest possible bulk density of the refractory lining because it reduces energy loss through the store heat. Pörzgen et al. [12]describe an innovative kiln car lining for decoration firing of ceramic products. The lining is based on insulation castable using SLA-92 for pre-cast shape manufacturing. The key advantage for this concept is the combination of low thermal conductivity and high thermal shock resistance. This reduces significantly the thermal spalling of the lining compared to conventional used insulating bricks but also refractory ceramic fibers which devitrify during use and become brittle. Thereby less small particles are formed which are blown by the burners of the kiln and deposit on the decoration, downgrading the quality of the fired goods and reducing yield. A new system of kiln car lining concept for decoration firing with SLA-92 pre cast shapes and refractory plate on top is shown in **Figure 6**. Firing condition in the kiln is 90 minutes coldtocold with a maximum firing temperature of 1260°Cand each kiln car performs 40 cycles per week. The new lining design has been successfully tested over a period for 6 months, namely for about 1000 firing cycles. Excellent thermal properties could be achieved and no damage by thermal shock was observed. Later investigations showed that SLA-92 based material exceeds the lining life of conventional systems, which is between 12-24 months. Overhoff et al.[13] report in 2005 about successful tests with SLA-92 based insulating material in kiln cars for the porcelain industry and special wall bricks for a roller furnace. Particularly for high-alkali, reducing kiln atmospheres and temperatures between 1300 and 1500°C, the material was identified as a highly interesting alternative to corundum bricks with their much higher density and lower thermal insulation. The excellent thermal shock resistance enabled the production of very complex and large-sized components. **Figure 7** shows an application in a special roller kiln using pre-cast shapes as large sized bricks with 250x250x125 mm dimension. Even after 16 months in use, the wall is still in excellent condition.

**Fig.7**: Wall area of a roller kiln with special pre-cast insulating bricks.

**Fig. 6**:

a) Kiln car lining with microporous pre-casts shapes (white) and refractory plate on top. The bottom layer is made of moler bricks (left)

b) Kiln car with decoration firing kiln feed (right)

## Conclusion

The comprehensive application experiences with the microporous calcium hexaluminate SLA-92 clearly demonstrate that this insulating aggregate provides a both technical and economical alternative to conventional refractory ceramic fibersand other insulating materials. As a refractory aggregate it allows the formulation of monolithic concepts for pre-cast shape manufacturing and on-site installations as well as gunning mixes for repairs.

Unmatched properties and outstanding performance observed over the past years led to versatile use in various industries including steelmaking, glass, ceramics and other refractories and made it the material of choice for demanding high temperature insulation. Even under severe conditions, as for example exposure to harsh thermal shock conditions or alkali attack, service life has by far exceeded initial expectations. Obviously most established and growing application is insulation in steel reheat furnaces for hot rolling mills.

It can be expected that to-date applications will further broaden but also continue to deliver prospects to satisfy further needs for more new innovative high temperature insulation concepts for growing markets in worldwide regions.

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## STATISTICS

### ANNUAL STATISTICS 2022-23

**SUMMARY**

**('000 tonnes)**

| SL. NO. | ITEM | 2020 -21 | 2021 - 22 | 2022 -23 |
|---|---|---|---|---|
| I. | **CRUDE STEEL PRODUCTION** | | | |
| | **SAIL,TSL Group, RINL,AM/NS, JSW Group , JSPL** | | | |
| | Oxygen Route | 43947 | 52515 | 56665 |
| | EAF Units | 21106 | 22359 | 23389 |
| | **Other Producers** | | | |
| | Oxygen Route | 1138 | 2070 | 2127 |
| | EAF Units(incl. Corex & MBF/EOF) | 8301 | 8138 | 4815 |
| | Indcution Furnaces | 29052 | 35211 | 40201 |
| | **TOTAL (Crude Steel)** | **103545** | **120293** | **127197** |
| | % sh are of Other Producers | 37.2% | 37.8% | 37.1% |
| II. | **PIG IRON PRODUCTION** | | | |
| | SAIL,TSL Group, RINL,AM/NS, JSW Group, JSPL | 1413 | 1462 | 1184 |
| | Other producers | 3464 | 4801 | 4677 |
| | **TOTAL(Pig Iron)** | **4877** | **6262** | **5861** |
| | % share of Other Producers | 71.0% | 76.7% | 79.8% |
| III. | **SPONGE IRO N PRODUCTION** | | | |
| | Gas Based | 6175 | 8866 | 8007 |
| | Coal Based | 28201 | 30334 | 35614 |
| | **TOTAL(Sponge Iron)** | 34376 | 39200 | 43621 |
| | % share of Coal Based Route | 82.0% | 77.4% | 82.3% |

(Source: Joint Plant Committee)

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3. The print area shall be 16cm width X 24.5 cm height.

4. The title of the paper is to be in 14 point "Arial" Bold and Italics, al Capitals, brief but informative e.g.

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6. The sectional or sub-heading should be 10 point "Arial" Bold, e.g. **Effect of High Temperature**.

7. The body typing should be 10 point "Arial" Normal, e.g. The factor affecting the lining life

8. References are to be numbered in chronological order as cited in the text and should be given in 10 point "Arial" Normal, at the end of the article. The format should be:- surname and name of the author first, followed by the title of the book/article, the title of the paper/ publication, volume number, issue number, page and year of publication.

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