May 2021

Institute of Refractories Engineers

# The Refractories Engineer

PRODUCTS
APPLICATIONS
TECHNOLOGY
NEWS ROUND-UP

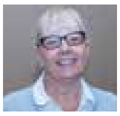
www.irengineers.co.uk | The Official Journal of the Institute of Refractories Engineers

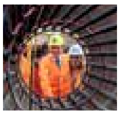
News Round-Up 6-15

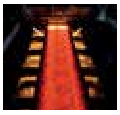
*Image: Shaft furnace technology with EAF Quantum*

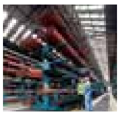
Institute of Refractories Engineers

# The Refractories Engineer







## Contents



Inspire and motivate

## General Secretary's Report

Dear Members,

Reflecting on my commitments to the Institute for more than two decades, I firstly helped Alan Whitehead, the Stoke Branch Secretary, then became Stoke Branch Secretary myself, and from 2011 have been your General Secretary and Treasurer. My first job was to organise our Golden Jubilee Ball at The Cutlers' Hall, Sheffield, an event that many will look back on with fond memories.

We also started using Sage, an electronic accounts package, and also Sage Pay, so that Members could pay direct without me having to take card details, making this system much safer. We have had many other firsts. We combined a technical paper with Sheffield and Stoke Branches. We also had our Conference connected to our President while in Japan. We have filmed our Conference and had it on social media, and also had our first online Training Day. When I look back, it seems we have introduced many new things in my time as General Secretary.

I have recently prepared a large number of Membership certificates, delayed because Council have not had face-to-face meetings owing to Covid-19 restrictions.

I would like to thank you all for your support over the last ten years, with special thanks to Marc Pittaway for his work on the Journal, Sam Franklin for his work on the Training Days and Paul Bottomley as Chairman of the Executive Committee. I would also like to thank two Presidents who were extra special – Chris Windle and Jan Theron. Unfortunately both have resigned from Council recently, along with Steve Parker and Chris Whelpton.

I am keeping busy walking my dog Yogi. In March we completed a 200K walk on which we raised £400 for Dementia UK.

The best of success to you all as we emerge from the Covid-19 pandemic. Please remember that it is your Institute after all: you need to be active, and you need to vote.

**Jayne Woodhead**

General Secretary & Treasurer
Institute of Refractories Engineers

The Institute of Refractories Engineers is dedicated to fostering the science, technology and skills of refractories engineering and to serving the needs of refractories engineers worldwide.

Aims: To raise the standard of ability and training in this field of science and technology. To promote and maintain the character, status and interest of Members of the Institute. To disseminate information, facts, ideas, news or suggestions that may be of interest to Members. To encourage the exchange of ideas and information among Members to their benefit and to the benefit of the industries they serve.

The Institute is a non-profit making body and its entire income is applied solely to the promotion of these aims.

# President's Column

Dear Members,

So from last year, when many of us couldn't meet and were dealing with the fallout of the pandemic, we are now planning ways of navigating our way through it. We find ourselves having a very active Council, you could say making up for lost time. Council have been meeting at least once, if not twice a month, so that we can progress matters and start effecting the changes needed in order to breathe new life into the Institute.

We have a new webmaster taking care of our online offering and have plans to develop this further. We have set a training strategy meeting to discuss how we should improve the offering of access to training for you all: we would welcome any ideas on this, so, if you have anything you would like to share, then please get in touch.

Since the AGM back in March, we have seen some Council members resign. We would like to thank Chris Windle, Chris Whelpton, Steve Parker and Jan Theron for their services to the Institute. We would also like to welcome anyone who may be interested in joining Council to get in touch. If you are committed to ensuring that the next generation of Refractory Engineers know all they need to know, then this is your calling and we need you!

Hopefully many of you will be starting to enjoy some freedoms again as Summer approaches: I am already visiting restaurants once more and seeing friends. I hope to see you all at some point too.

Regards

**Katy Moss**

President
Institute of Refractories Engineers

## Institute News

## Draft Minutes of the 59th AGM via Microsoft Teams Thursday 25 April 2021

1) Apologies
   D Hughes, V Thealez, A Whitehead, L Turner, M Turner, D Shaw, G Trimble, S Parker, P Walker, G Corbett, T Palin, S Smith, K Andrews, P Bell.
   KM asked everyone to mute and to raise their hand to speak.
   JW advised the meeting would be recorded for note taking purposes.

2) Approve the minutes of the 58th AGM held on 13 November 2019 Having been circulated to all members in the Refractories Engineer Journal were taken as read and confirmed as a correct record of the proceedings a unanimous show of hands gave approval. (Approved)

3) To Appoint an SVP for the year 2021, Council have not had time to appoint an SVP so KM proposed that it be deferred, she advised that the Council is planning on trying to get in an EGM to discuss Rule Changes over the coming months KM proposed this to be discussed at Council to put someone forward or it could be deferred to the AGM in November.
   M Lamkin said we are delayed because of exceptional circumstances due to Covid-19 instead of getting bogged down at an EGM why don't we do it at the AGM in November.
   J Theron said there is no alternative but to delay.
   DW advised that Katy is President until November anyway so we would not be extending her period and J Theron's period as SVP.
   P Walls advised we had time to discuss at Council we have 6 months to do this. Before the next AGM.
   No further questions were raised on this point.

4) (a) To Re-elect Members of Council to the 2024 AGM

| | | | | |
|---|---|---|---|---|
| S Smith | Proposed | P Rooney | Seconded | J Theron |
| P Rooney | Proposed | M Lamkin | Seconded | D Oates |
| D Woodhead | Proposed | J Coleman | Seconded | J Theron |
| P Bottomley | Proposed | D Woodhead | Seconded | P Rooney |
| P Bell | Proposed | D Woodhead | Seconded | C Whelpton |

   (b) To elect any other members to Council (None to elect)

*Continued overleaf . . .*

5) K Moss gave a Management and Operations Report of the Institute.

At the start of my presidency, I made a commitment to our members that I would endeavour to ensure the IRE would be… **Sustainable, Relevant and Engaging.**

## Sustainable

### Finances

In order to ensure we are first and foremost a sustainable entity it is incredibly important to me that we fully understand the financial picture of the institute. Given the high levels of debt write offs over the last few years we are looking into a more efficient way of managing our membership. Member numbers have been in decline and the council is putting in place measures to arrest this and grow membership in future. I have asked the accountants to do some work on the previous years accounts to give us a better picture.

Our review has also highlighted some areas where better more segregated financial duties need to be implemented to ensure transparency and good practice.

We are now taking legal advice as council on Roles and Responsibilities to ensure that Council members know their obligations to the IRE when they join and uphold the values.

### Impact of Covid

Since the new year the council has been having regular Zoom meetings to address the structure, organisation and operation of the institute.

### Journal Production

We are reviewing the Journal publication method, news, technical items and advertising and will have more news later on.

## Relevant

### Rule Changes

We will shortly be circulating a revised set of rules for the IRE and will call an EGM for members to vote on the changes.

### Website and Branding

This exercise went well with a proactive and positive approach from members and council, we now have a good basis to build from to take things forward. We are looking now at how we manage our online presence to keep it relevant and engage with members.

## Engaging

### Teams Training Day

This was very well received, give that this was a first for the IRE I think we learned a few things from the experience but it enabled a far further reach and lots attended, it also resulted in a few new memberships.

### Future Training Plan

A sub-committee formed to discuss the training strategy for the IRE.

### Virtual Conference

To be planned for later this year.

### 2021 Thoughts

When the World starts turning again, the “new” World will need industry and industry will need refractories. Industry will respond to the Pandemic with creativity and ingenuity which will be made real by the application of Engineering and will be enabled by Refractory Engineering in particular.

Engineering is at the core of everything we do. Look around. The limits of Engineering, making our ideas into reality, define the Modern World. Its progress shapes society.

With a heritage of nearly 60 years, The Institute of Refractories Engineers is a hub of knowledge and experience. It is a place where anyone in the industry can go to learn, progress and find out about new regulations and technologies - to train and to connect with others within the refractories community.

The aim is to capture the hearts and minds of existing members, but also that of a new generation who are looking to become part of it. IRE aspire to be the heart and voice of the refractory community.

6) Accounts

To approve Council recommendation that the audited accounts for 2019 be accepted KM said that she would like to defer this because they have not been recommended for approval by Council yet and also it's come to Council's attention that our accounts are not audited by shorts accountants they are unaudited. Because of delay due to Covid-19 Council need to have a meeting to approve them so they will presented at a later meeting with the 2020 accounts that are in the process of being prepared.

KM asked if anyone had any questions. No questions raised.

7) Membership Subscriptions because the AGM was cancelled in November 2020 due to Covid-19 the membership for 2021 will remain at £75.00 for Members and £37.50 for members under 25 undergoing training.

8) Because of Covid-19 the AGM did not take place in November 2020 and Shorts are already processing the 2020 accounts can we please ask if there is any objection to this. (No Objection)

AOB. There was no AOB.

KM thanked everyone for attending.

Meeting closed at 29 Minutes.

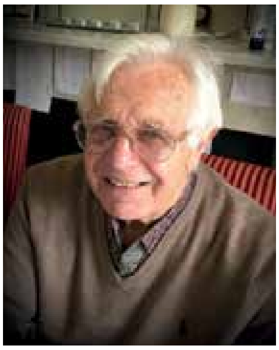
Inspire your future and be part of the IRE

# EGM

Pres

## Obituary

# Dr John Evans, 1933-2021



John was born in 1933 at Blaengarw, a village in the county borough of Bridgend, South Wales, where he was a lively child.

Sadly his mother died when he was 10. Aged 11, he became a boarder at Cowbridge Grammar School, where he excelled in athletics, was given the nickname Polly and mastered the art of eating very quickly, a skill he retained throughout his life.

Following a degree and PhD in Metallurgy at Sheffield University, he married Betsi in 1958. They met at the tennis club in Blaengarw. Betsi trained as a teacher, and they were happily married for 62 years. John was devoted to Betsi, caring for her as her health deteriorated.

One of John's strongest traits was his loyalty to his family and friends. He also cared for his sister Gaynor as her health declined.

His younger brother David spoke of John being a strong role model for him. John's career took them to Birmingham, Whitley Bay where Delyth was born, and Tutshill where Rod joined the family before settling in Porthcawl in 1973. Delyth and Rod enjoyed growing up at Rest Bay Close.

John was a strict father, particularly with Delyth, who would be sent upstairs to take that muck off her face! However, they both came to realise that this was because he loved them so much and wanted to protect them.

They were constantly reminded to switch the lights off and shut the door, whilst the grandchildren found it very amusing when Taid (Grandad) told them to "save the planet".

John was a pillar of Porthcawl Rugby Football Club and of the community in general. He was not only a devoted family man, but a massively respected employee of the British Steel Corporation and, even beyond his retirement, the company used to call upon his expertise. Another mantra of his was that, if you are going to do a job, do it properly!

John was thrilled when Delyth and Rod married James and Annette. He particularly enjoyed ribbing James if Wales were victorious over England, and Annette became a second daughter to him.

John's four grandchildren became his pride and joy. Taid enjoyed many happy times playing office supplies with Millie, rugby and cricket with Tom, adventures with Harri and football with Lachie. They all knew that Taid could fix anything, unlike their parents!

His family have fond memories of John sitting in his chair reading the Daily Telegraph, pottering in the garden, always wearing his hat, and telling them that, if they ended up like him, they wouldn't go far wrong!

Wise words from a strong role model who always took an interest in others and never said a bad word about anyone.

Sadly John's health deteriorated in the past year, but he enjoyed a wonderful Christmas Day making more precious memories with his family.

Sleep quietly with peace – cysga'n dawel gyda heddwch.

## News Round-Up

# Nucor Executive Vice President Ray Napolitan to retire

Nucor Corporation and its affiliates are manufacturers of steel and steel products, with operating facilities in the United States, Canada and Mexico. Nucor have announced that Raymond S Napolitan, Jr, Executive Vice President of Engineered Bar Products and Digital, plans to retire on 5th June 2021 after 25 years' service with Nucor. A succession plan will be announced at a later date.

*Raymond S Napolitan, Jr*

Ray Napolitan began his Nucor career in 1996 as Engineering Manager of Nucor Building Systems – Indiana. He became Operations Manager of Nucor Building Systems – Texas in 1999 and was promoted to General Manager later that year. He became President of American Buildings Company and Vice President of Nucor in 2007. He then served as President of Nucor's Vulcraft/Verco Group from 2010 until his promotion to Executive Vice President in 2013.

"For 25 years, Ray's dedication and exceptional leadership have contributed greatly to the growth and profitability of Nucor," said Leon Topalian, President and CEO of Nucor. "From his leadership at divisions, to his service as Executive Vice President of Fabricated Construction Products and Engineered Bar Products, to his leadership of our digital initiatives, Ray has been an invaluable member of the Nucor team. I am especially grateful to Ray for his unwavering commitment to safety.

"On behalf of all Nucor teammates, I want to extend our deep appreciation to Ray for his leadership and the countless contributions he has made to Nucor over the years. We wish Ray and his family every happiness as they begin this next chapter."

# Primetals to supply second Quantum furnace & expand slab caster in Turkey

Turkish steel producer Tosyali Demir Celik Sanayi A.S. has placed an additional order with Primetals Technologies to supply an additional, second EAF Quantum electric arc furnace with a capacity of two million metric tons of liquid steel per year, and to expand the production capacity of a recently ordered two-strand slab caster to 3.4 million metric tons per year.

The new order follows an order placed in 2020, which encompassed a first EAF quantum electric arc furnace, a twin vacuum-degassing plant with oxygen blowing, and the original version of a two-strand slab caster. All plants will be erected at a flat steel greenfield project in of Tosyali in Iskenderun, Turkey. Commissioning is expected for late 2022.

Tosyali Demir Celik A.S. is part of the Tosyali Group, which already operates another steel plant named TOSCELIK in Osmaniye, Turkey as well as a DRI direct hot-charge melting plant in Algeria, Tosyalı Iron Steel Industry Algerie.

The company also runs a number of rolling mills and is well established in the markets for flat products and welded pipes. In order to increase their capacity of semi-finished products like slabs for the existing downstream facilities, Tosyali Holding decided to set up a new greenfield facility in Iskenderun, Hatay Province.

The new EAF Quantum – as well as the one ordered in 2020 – are designed to handle metallic scrap and virgin materials such as HBI, pig iron in different composition and quality. The electrical energy requirement of the electric arc furnace is extremely low, mainly thanks to the scrap preheating system, but also due to many other features of EAF Quantum technology, such as FAST Tapping system, continuous foaming slag and continuous submerged electric arc (Flat bath operation). This reduces both the operating costs and the $CO_2$ emissions.

The EAF Quantum is a highly productive furnace that will reach lowest of possible power off times. The twin vacuum-degassing plant provides further treatment and steel quality to the production portfolio of Tosyali Demir Celik. With oxygen blowing possibility Tosyali Demir Celik steel plant will be ready to produce steel grades starting from ULC grades up to high carbon grades, peritectic grades, API grades, dual phase grades and also high strength low alloyed steel grades. The two-strand continuous slab caster will provide a capacity of 3.4 million tons of slabs per year and is able to process a wide range of steel grades.

The slab caster has a machine radius of 10 metres. The caster produces slabs with a thickness of 225mm in widths ranging from 900 to 1800mm. The production capacity increase from 2 to 3.4 million metric tons per year will be achieved by adding additional segments. The maximum casting speed is 2.6 metres per minute. The plant casts ultra-low carbon to high carbon steels, peritectic, and HSLA steels, as well as API grades.

The straight cassette-type Smart Mold is equipped with the Mold Expert breakout detection system, DynaWidth for automatic width adjustment, and the DynaFlex mold oscillator. LevCon automatic mold-level-control system with "autostart" casting functions and auto-adaptive dynamic bulging compensation and the Mold Expert on-line automatic breakout pre-detection will also be implemented. Bender and Smart Segments as well as I-Star rollers are used in the strand-guiding system.

The Dynacs 3D secondary cooling system dynamically calculates and controls the temperature profile along the entire strand. DynaGap Soft Reduction 3D is used to improve the interior quality of the slabs. The roll gap is dynamically adjusted during the final solidification in accordance with the operating points calculated by Dynacs. This minimises segregation in the centre of the strand.

***Shaft furnace technology with EAF Quantum by Primetals Technologies***

**September 29th and 30th, 2021 · Aachen, Germany**

ICR® International Colloquium on Refractories

# CALL FOR PAPERS

## REFRACTORIES in the global value chain

### Topics

**Raw materials**
- Primary raw materials
- Secondary raw materials

**Refractory materials**
- Innovative refractories
- Testing
- Manufacturing

**Applications**
- Iron and steelmaking
- Process industries
- Energy and bio-energy

**Scientific conference:**
Abstracts can be submitted for a 20-minutes scientific presentation and publication of a scientific paper. Please register your interest by submitting an abstract. The **deadline** for the submission of abstracts is ~~April 10th~~ **May 16th, 2021** and for the submission of scientific papers will be **July 31st, 2021.**

**Industrial exhibition:**
Interested companies and institutes are invited to contact the organizer for further information on how to be part of the industrial exhibition. Exhibitors are also offered the opportunity to present their organisation and/or new products, processes and services during a dedicated session of the conference. The registration **deadline** for the industrial exhibition is **June 18th, 2021.**

**Poster show and poster award:** - in co-organization with Göller-Verlag -
For participation in the poster show, please register you interest until ~~April 10th~~ **May 16th, 2021.**

**Gustav Eirich Award:** - in co-organization with Maschinenfabrik Gustav Eirich GmbH -
The award is presented annually for dissertations (Ph.D. theses) in the field of refractories that have been completed no longer than two years ago. Your application can be submitted until **May 31st, 2021.** Please visit **www.eirich-award.eu** for more information.

**For further information call +49 2624 9433-131 or contact info@ic-refractories.eu**

organized by:
**ECREF European Centre for Refractories gGmbH – ICR –**
contact: info@ic-refractories.eu

EUROPEAN CENTRE ECREF gGmbH FOR REFRACTORIES

hosted by:
**VDFFI Verband der Deutschen Feuerfest-Industrie e. V.**
contact: info@vdffi.de

DFFI Verband der Deutschen Feuerfest-Industrie e.V.

**www.ic-refractories.eu**

# Greensteel from recycled scrap for Forrestfield facility near Perth

The awarding of a Western Australian contract continues an ongoing relationship between Metronet and InfraBuild, which has previously supplied high-quality, Australian-manufactured steel to the Forrestfield Airport Link and Ranford Road Bridge projects.

The announcement comes as Western Australian Premier Mark McGowan and Transport Minister Rita Saffioti attended the Forrestfield facility on Wednesday 20th January 2021 to inspect the pile cages which will be used in the project.

InfraBuild WA State Manager Michael Hurley said the contract was a win for local jobs and local manufacturing.

"InfraBuild is a member of the GFG Alliance, which has a purpose to create a sustainable future for industry and society; projects like Metronet underpin our ability to deliver on that purpose in the communities we operate in," stated Hurley.

"This contract secures a pipeline of work for 75 employees at the Forrestfield site, while the broader contract has created the opportunity for an additional 13 jobs.

"We want to be part of a sustainable and successful future for manufacturing in Western Australia and Australia more broadly, and we were proud to have the Premier and Minister for Transport on site to inspect the facility."

The steel used in the project will be Greensteel, which is manufactured from recycled scrap metals in electric arc furnaces at InfraBuild's mills in Sydney and Laverton.

***Western Australian Premier Mark McGowan & Transport Minister Rita Saffioti inspect pile cages at Forrestfield site***

"Greensteel is a fundamental part of our strategy to be carbon neutral by 2030, and this is a great example of how recycled scrap metals can be used in the construction of large-scale infrastructure projects," emphasised Michael Hurley.

"Through our recycling business, we remelt and re-use around 1.4 million tonnes of scrap each year, turning it into prime steel production for infrastructure, construction and building at those two mills."

# Seven Refractories Russia completes robotic repair for MMK Magnitogorsk

MMK Magnitogorsk, a long-term customer of Seven Refractories Russia, has recently entrusted the company with another demanding repair project at their production site in Magnitogorsk. With a volume of more than 2000 $m^3$, Blast Furnace no.9 was due for a substantial repair.

The project started with a comprehensive plan including the selection of suitable material, equipment, and installation methods. The repair period was planned to be completed within five days. With an actual project duration of only three days, production could be restarted even sooner than planned, leading to considerable time and cost savings for the client.

"The repair was conducted with a mix of shotcreting and so-called grouting (pumping) from outside the furnace," explains Aleksey Patrakov, Technical Manager, Seven Refractories Russia. "Overall we used approximately 300 tons of monolithic refractory materials. In our selection of products and application technology, we considered both economic and technical factors to ensure an optimal outcome."

During the course of the repair most of the procedure was conducted with robot technology. "We regularly use our own robots for monolithic repairs," adds Dmitriy Tabolin, Process Engineer, Seven Refractories Russia.

"Normally the robot is inserted from above into the space to be repaired. Due to the specific situation on site, we decided on a different approach, bringing in the robot from below."

The project was finished in late December 2020 to the full satisfaction of MMK, and post-repair controls – as well as the production output of Blast Furnace no.9 after the refractory job – have proven the success of the intervention.

Maryana Rogacheva, Managing Director of Seven Refractories Russia, thanks her team: "This was another job well performed: modern monolithics and innovative methods combined ensure that our client is happy."

# Changes to senior leadership at DSF Refractories & Minerals Ltd

DSF have announced two new appointments to the Board. Janette Flower and Matt Handley have been promoted to the roles of Manufacturing Operations Director and Strategic Operations Director respectively.

DSF, located near Buxton in Derbyshire, are in the infancy stage of a site-wide process improvement and investment program, which is seen as an integral part of its future growth ambitions. These two new appointments underpin this strategy and bring more focus on operations to the Board.

Matt and Janette were already part of the senior management team at DSF and had started to make significant improvements to the site and its performance. They have also been instrumental in seeing DSF through the Covid-19 pandemic, keeping its workforce safe, whilst maintaining productivity and quality.

*Janette Flower & Matt Handley*

Janette Flower is a Human Resource Management postgraduate with over 30 years' experience within the manufacturing sector. A wealth of experience has come from numerous management roles in Human Resources, Health & Safety and Production. For the past two years she has held the position of Manufacturing Operations Manager and stated she was delighted to be invited to join DSF's board in January 2021:

"It is such a privilege to be the first female Director to join the board at DSF. I am very much looking forward to my new role and will strive to execute further my proven track record of developing and delivering business plans, policies and procedures associated with the operational aspects of the business."

Janette's key objective is to direct and co-ordinate the day-to-day operations to allow the business to grow and be profitable: "We will only achieve this by satisfying our customers by producing high-quality refractories and delivering on time."

Matt Handley has a background in Electrical Engineering and brings over 20 years' experience in the heavy industries, from quarrying and building materials to latterly refractory and mineral processing. Matt joined DSF in 2014 as Engineering Manager and has quickly risen through the ranks to take up his position on the Board:

"During my short time at DSF the company has really invested in my development; culminating in two promotions up to Board level. DSF also supported me through to the completion of my Diploma in Leadership and Management in 2018. My ambition is to continue with the development of the site and its processes, with the aim of making DSF more profitable, more sustainable and the first choice of employment for the local community and surrounding areas."

# Therser UK supports National Apprenticeship Week

Therser UK, a major UK kiln and furnace manufacturer, is heavily investing in the future generation by providing a wide range of apprenticeships from mechanical and electrical installation to refractories, fabrication and accountancy.

Courtney Ward is aspiring to become an accountant and is currently studying her AAT Level 3 Accountancy qualification. Working closely with the accounts team, Courtney is making excellent progress. We asked Courtney a few questions to get her thoughts on her apprenticeship and how it is helping her to build a successful career.

*Courtney Ward*

*Why did you choose to do an apprenticeship?*

I believe that an apprenticeship is the best option for developing a career, since you are gaining experience from your job role, whilst completing a qualification. This increases your overall knowledge and understanding, because you are always implementing aspects of the qualification into your day-to-day responsibilities within your organisation. Furthermore, choosing an apprenticeship enables employment to start earlier, meaning there's potential for the individual to progress quickly in their chosen career path.

*How has the apprenticeship helped you to develop already as an individual?*

When Therser UK gave me the opportunity, it helped me to develop as an individual, as it has given me a high level of skill and knowledge, which has increased my confidence greatly when performing tasks within my role at work. The knowledge that I have gained from progressing through the qualification has enabled me to offer more to the company as I am now able to take on more responsibilities.

My work is also more reliable, which helps to maintain a trusting relationship with work colleagues. I have a study day every week, where I revise certain units of the qualification. Ensuring that I am making a timeslot for revision allows me to keep on top of my academic work, so that my knowledge continues to increase. This is then implemented in my role at work: for example, learning about reconciliations allows me to complete these with great confidence.

*Would you recommend an apprenticeship?*

I would strongly recommend an apprenticeship to anyone who is looking to develop a career quickly. It gives you the opportunity to implement what you are studying into your job role, so that you can progress through your career more quickly with a higher level of knowledge and skill. This helps to create more opportunities for the individual, by gaining a qualification which they could use to progress up the employment ladder.

Furthermore, if you choose this career option, it enables the individual to be earning at the same time as gaining a qualification: this increases independence and benefits him or her financially. I am very thankful for this opportunity at Therser UK and excited to see what the future holds.

sales@therseruk.com

# April 2021 crude steel production

World crude steel production for the 64 countries reporting to the World Steel Association was 169.5 million tonnes (Mt) in April 2021, a 23.3% increase compared to April 2020.

## Crude steel production by region

Africa produced 1.3 Mt in April 2021, up 93.9% on April 2020. Asia and Oceania produced 125.0 Mt, up 19.2%. The CIS produced 9.0 Mt, up 20.7%. The EU (27) produced 12.9 Mt, up 42.8%. Europe, Other produced 4.2 Mt, up 33.9% The Middle East produced 3.5 Mt, up 15.3%. North America produced 9.7 Mt, up 38.2%. South America produced 3.8 Mt, up 70.9%..

The 64 countries included in this table accounted for approximately 98% of total world crude steel production in 2020. Regions and countries covered by the table:

- **Africa:** Egypt, Libya, South Africa
- **Asia and Oceania:** Australia, China, India, Japan, New Zealand, Pakistan, South Korea, Taiwan (China), Vietnam
- **CIS:** Belarus, Kazakhstan, Moldova, Russia, Ukraine, Uzbekistan
- **European Union (27)**
- **Europe, Other:** Bosnia-Herzegovina, Macedonia, Norway, Serbia, Turkey, United Kingdom
- **Middle East:** Iran, Qatar, Saudi Arabia, United Arab Emirates
- **North America:** Canada, Cuba, El Salvador, Guatemala, Mexico, United States
- **South America:** Argentina, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela

## Top 10 steel-producing countries

China produced 97.9 Mt in April 2021, up 13.4% on April 2020. India produced 8.3 Mt, up 152.1%. Japan produced 7.8 Mt, up 18.9%. The United States produced 6.9 Mt, up 43.0%. Russia is estimated to have produced 6.5 Mt, up 15.1%. South Korea is estimated to have produced 5.9 Mt, up 15.4%. Germany produced 3.4 Mt, up 31.5%. Turkey produced 3.3 Mt, up 46.6%. Brazil produced 3.1 Mt, up 59.3%. Iran is estimated to have produced 2.5 Mt, up 6.4%.

worldsteel ASSOCIATION

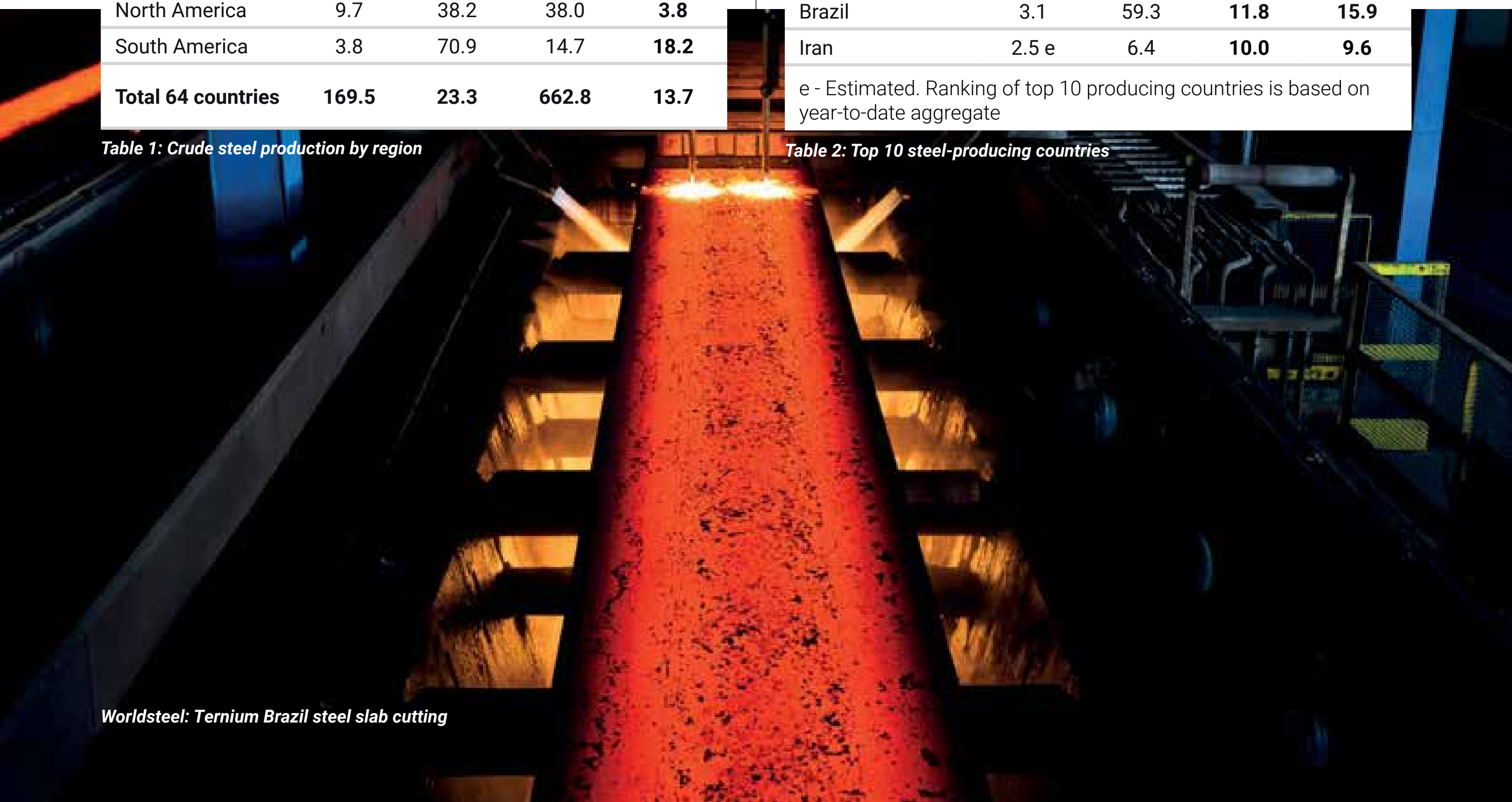
| | Apr 2021 (Mt) | % change Apr 21/20 | Jan-Apr 2021 (Mt) | % change Jan-Apr 21/20 |
|---|---|---|---|---|
| Africa | 1.3 | 93.9 | 5.2 | **17.0** |
| Asia and Oceania | 125.0 | 19.2 | 487.8 | **15.3** |
| CIS | 9.0 | 20.7 | 35.3 | **7.4** |
| EU (27) | 12.9 | 42.8 | 51.0 | **11.6** |
| Europe, Other | 4.2 | 33.9 | 16.7 | **13.1** |
| Middle East | 3.5 | 15.3 | 14.1 | **6.0** |
| North America | 9.7 | 38.2 | 38.0 | **3.8** |
| South America | 3.8 | 70.9 | 14.7 | **18.2** |
| **Total 64 countries** | **169.5** | **23.3** | **662.8** | **13.7** |

*Table 1: Crude steel production by region*

| | Apr 2021 (Mt) | % change Apr 21/20 | Jan-Apr 2021 (Mt) | % change Jan-Apr 21/20 |
|---|---|---|---|---|
| China | 97.9 | 13.4 | **374.6** | **15.8** |
| India | 8.3 | 152.1 | **38.2** | **26.9** |
| Japan | 7.8 | 18.9 | **31.5** | **2.7** |
| United States | 6.9 | 43.0 | **27.3** | **2.8** |
| Russia | 6.5 e | 15.1 | **25.5** | **7.1** |
| South Korea | 5.9 e | 15.4 | **23.4** | **6.5** |
| Germany | 3.4 | 31.5 | **13.5** | **9.0** |
| Turkey | 3.3 | 46.6 | **13.1** | **16.9** |
| Brazil | 3.1 | 59.3 | **11.8** | **15.9** |
| Iran | 2.5 e | 6.4 | **10.0** | **9.6** |

e - Estimated. Ranking of top 10 producing countries is based on year-to-date aggregate

*Table 2: Top 10 steel-producing countries*



*Worldsteel: Ternium Brazil steel slab cutting*


# Carbon border vote proves majority support for stronger carbon leakage protection

The European Parliament has voted on its Carbon Border Adjustment Mechanism (CBAM) resolution, prior to a legislative proposal expected to be published by the European Commission in June. The resolution passed with a firm majority: Parliamentarians agreed on the principle that the EU's higher climate ambition requires improved carbon leakage protection.

*Axel Eggert*

"The European Parliament has sent a clear signal that a workable carbon border measure is of critical importance for the transition of industry towards climate neutrality," said Axel Eggert, Director General of the European Steel Association (Eurofer). "The measure must fill the gap of the carbon cost differential with global competitors and imports instead of replacing or reducing current levels of carbon leakage protection."

"The straight replacement of free $CO_2$ certificates with a border measure and full exposure to the costs of the EU Emissions Trading Scheme would be bad policy. Primary steelmaking makes up three-fifths of European production, and such producers would face carbon costs at least twenty times higher than global competitors exporting to the EU," added Axel Eggert. "This vote shows that the Parliament intends to defend manufacturing and jobs in Europe."

European steel companies have been launching many projects to develop and implement breakthrough low carbon technologies. This transition will be successful only under the right market conditions facilitated by a supportive framework that includes effective carbon leakage measures.

European industry in general, and steel specifically, need a level international playing field – one that favours fair competition, supports investment in innovation and the roll-out of breakthrough technologies. Markets for green materials must be created and appropriate low carbon energy sources also need to be available.

"Higher climate ambition for 2030 and 2050 requires strengthened, not weakened, carbon leakage protection. This can only be achieved if the carbon border measure is implemented as a complementary tool to buttress existing carbon leakage measures. We welcome that elected MEPs recognised this," emphasised Eggert. "A border measure reinforcing existing carbon leakage measures is not double protection, as such mechanisms are already only partial and digressive."

Even with free allocation and compensation, EU producers bear carbon costs that are not applied to extra-EU competitors. This divergence will further increase in the future as the EU Emission Trading System (EU ETS) is adjusted to attain higher levels of climate ambition. A carbon border measure without free allocation would see steelmakers in Europe, in effect, paying carbon costs multiple times higher than those faced by exporters to the EU.

"A carbon border measure complementary to existing carbon leakage measures would decrease the product price impact on downstream sectors within the EU," concluded Eggert:

"This would better preserve the entire value chain. It would also reduce the direct impact on trade flows and mitigate trade tensions, providing a longer transition for negotiations over how other regions can follow Europe's decarbonisation lead."

## British Steel investing £100m this year to improve manufacturing & environmental performance

British Steel has announced it is investing £100m this year to support the next stage of its transformation.

The company, which has returned to profit after being brought out of liquidation by Jingye Group 12 months ago, will focus the investment on improving its manufacturing operations and supporting clean growth.

Projects the money will help finance include a new billet caster, a scrap pre-heating facility, cranes and a new environmental emission control system.

Jingye Group CEO Li Huiming said: "We're committed to building a long-term future for British Steel and thanks to the hard work and diligence of our new colleagues, the business is now on a more sustainable footing.

"Their skill and dedication has enabled British Steel to maintain safe iron and steel production throughout the pandemic, ensuring customers' requirements were – and continue to be – fulfilled. I'm extremely grateful for their efforts, and for the way they've embraced and driven change during a challenging period for everyone, both personally and professionally.

***Jingye Group CEO Li Huiming pictured at British Steel in Scunthorpe***

"British Steel's people and products are the reason Jingye is investing with such confidence."

During its first year as a new business, British Steel achieved significant operational improvements, launched new products, introduced 24-7 operations at its Teesside and Skinningrove mills and resumed operational control of Immingham Bulk Terminal.

CEO Li Huiming continued: "Moving into profitability was a significant milestone for the new business, but we're only at the start of our journey and still have many challenges to overcome, such as the exceptionally high raw material prices.

"However, British Steel is increasing production, reducing costs and growing into new markets, all of which is giving us a stronger platform upon which to build. We're optimistic for the future and I'd like to thank customers, suppliers and stakeholders for their continued support."

British Steel has also confirmed that its CEO Ron Deelen stepped down from his role at the end of March although he continues to work closely with the business and Jingye.

Li Huiming commented: "Ron has been an important and valued member of our team during the last year, and we're extremely grateful for his leadership throughout the sales process and beyond. I look forward to us continuing to work together on the ambitious plans for British Steel."

Ron Deelen responded: "With British Steel back in profit and starting to build a sustainable future, now is the time to pursue a new challenge. Jingye have proven themselves to be caring and responsible owners and I look forward to supporting them, and British Steel, on the next step of their journey together."

British Steel President Xijun Cao, who assumed the CEO role at the beginning of April, declared: "I'm honoured to be leading the next stage of British Steel's transformation and look forward to helping my colleagues build on their achievements during the last 12 months."

## Refurbishment at Tata Steel's Shapfell site

Work has started at Tata Steel's Shapfell site in Cumbria to refurbish Kiln 4, one of the four kilns there that make 'burnt lime' for making sinter and for treating liquid steel.

The refurbishment includes replacing the refractory lining, as well as the refurbishment and renewal of various mechanical and electrical items on the kiln and associated plant.

Works Manager Chris Queen explained: "Burnt lime is made from heating limestone in a kiln and is a key ingredient in iron and steel production.

"The lime helps to create good quality sinter and is key to forming slag which is essential in removing unwanted elements in the steelmaking process. Steel can't be made without it.

"The fact we are able to produce it locally makes Shapfell a valuable part of Tata Steel UK, saving costs and reducing the environmental impact of transporting raw materials from overseas."

The project, which will take several months, is being supported by a number of specialist contractor partners working alongside the local engineering and operational teams.

## New materials community is launched by Lucideon

Lucideon, the materials technology company has launched a new online community for anyone interested in materials.

The MaterialsMatrix has been built with input from leading materials experts in industry and academia. It will be the go-to place to discuss research, developments, collaborative projects, industry challenges and solutions across a wide range of materials and applications.

*Tony Kinsella*

Tony Kinsella, CEO of Lucideon, commented:

"While there are many great associations that focus on a single material discipline, our vision for the MaterialsMatrix is to build a community that spans a diverse and comprehensive range of materials and sectors. This will enable easy engagement and collaboration across many different disciplines in industry.

"Just as different materials have to work together for different applications, so materials scientists and engineers in different disciplines have to come together to solve challenges and to push the boundaries of what is possible.

"This cross-collaboration is what the MaterialsMatrix will enable and what leading organisations in industry and academia have told us they would like to see."

Caroline Mullington, Technology Partnership Manager, said:

"We've had lots of enthusiasm for the MaterialsMatrix from organisations in industries ranging from defence, nuclear and aerospace to construction and ceramics.

*Caroline Mullington*

"Collaboration is one of the areas that people are keen to see grow in the community. As anyone who works with materials knows, forming project partnerships to develop materials and technologies is key to progress. As such, a part of the community is focused on collaboration and on funding opportunities."

The MaterialsMatrix community will ultimately be run and governed by a select group of relevant companies, academic institutions and relevant organisations that lead their respective fields in materials science.

The MaterialsMatrix is free to access and can be found at materialsmatrix.org

MATERIALS MATRIX

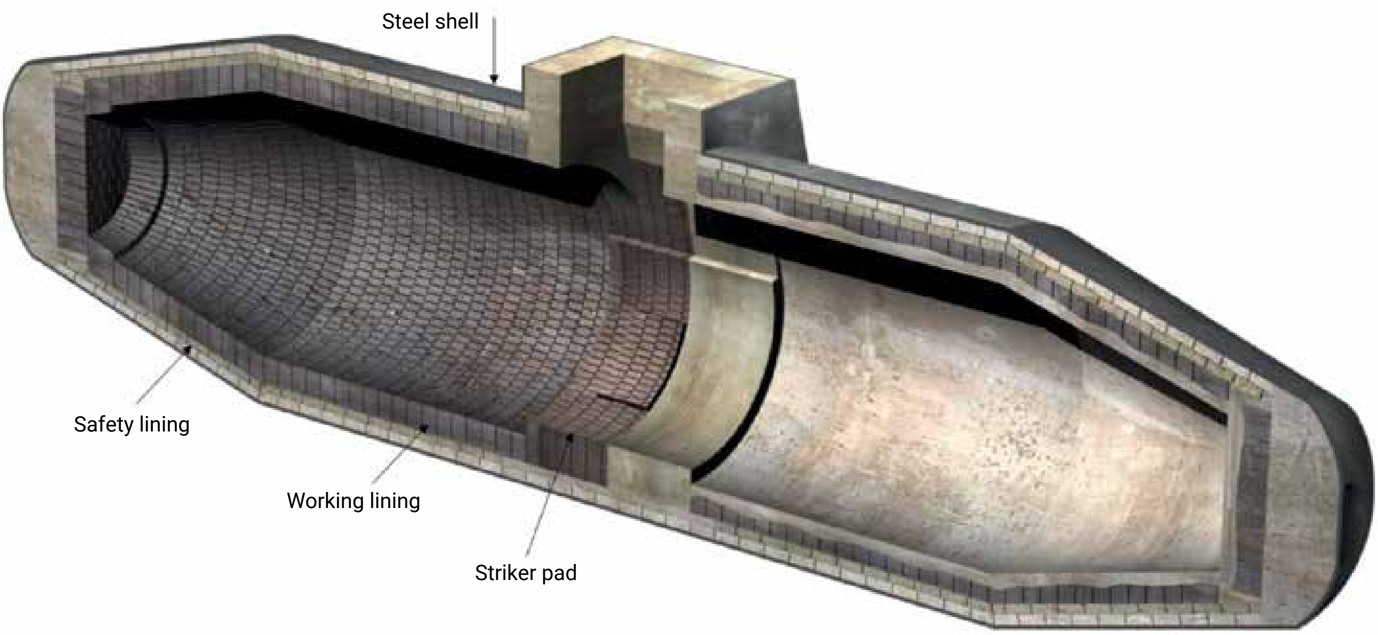
## New lining for steel torpedoes

A new type of brick lining for the steel torpedoes that transport liquid iron across the Tata Steel Port Talbot site is proving its value in terms of cost, plant stability and environmental benefits.

The safety lining of Torpedo 43 developed by partners at Vesuvius and installed by Monolithics is still in great condition after carrying a million tonnes of liquid iron at 1500°C.

Did you know:

- The Port Talbot site has 26 active torpedoes.
- Different series of torpedoes have different capacities – the 40 Series can carry up to 350 tonnes of liquid iron.
- It takes about 17,000 shaped refractory bricks to line a torpedo.
- Future developments include an idea to use a laser to 3D scan refractories while the torpedo is still red hot.



# RHI Magnesita to invest €23m in modernising plant at Urmitz

RHI Magnesita, a market leader for refractory products, plans to invest €23 million in modernisation of its Urmitz site, near Koblenz in the Rhineland, over the next two years.

This investment, the Group's largest in Germany, will be used to expand and upgrade the traditional plant as a hub for non-basic refractory products. The comprehensive modernisation measures will increase the plant's production volume while at the same time boosting energy efficiency by 10%.

In addition, investments to be made in recycling, allowing RHI Magnesita to increase the share of secondary raw materials. The refractories produced in Urmitz are used all over the world as heat-resistant linings for aggregates, predominantly in the steel industry, but also in the glass, cement, lime, energy and chemical industries, in all high-temperature processes above 1200°C.

"Our strong focus on our customers and their needs has always been the key to our success," says Constantin Beelitz, Regional President Europe, CIS & Turkey at RHI Magnesita. "This is a significant and groundbreaking investment in the German and European site which, in addition to increasing productivity, will in particular strengthen product quality and delivery reliability for all our markets. As sustainability is an equally important issue for our customers as it is for us, I am delighted to report that our modernisation work will also enable us to increase the energy efficiency of our plant as well as save resources through recycling."

As part of the investment in Urmitz, RHI Magnesita's pressing capacities will be increased, and a new tunnel kiln with an automatic circulation system and several climate drying chambers will be installed. The plant will thus become a central European hub for non-basic refractory products such as bricks, mixes, and prefabricated components. The workforce at the site will be increased by around 70 employees, most of whom will move to Urmitz from the neighbouring site in Kruft.

"We are creating a high-performance centre for non-basic refractories. Our customers will benefit from state-of-the-art manufacturing processes and more digitalisation, which will allow for greater transparency," explains Markus Pung, Plant Group Manager of RHI Magnesita.


"This will enable us to strengthen our position as a supplier in ingot casting, refractory wear products and refractory functional products, increase our output, and broaden our range of non-basic products at the site – while also improving our future environmental footprint."

The investment represents part of the drive to optimise RHI Magnesita's global production network. The company's growth strategy will involve focusing on specialisation and an individual alignment of its European sites. At the same time, RHI Magnesita will expand in regions with high growth.

# Multi-million pound transformation of Corby steelworks

Tata Steel is transforming its Corby steel tube making site in the East Midlands, which will give the business the best chance of a strong future.

Work has started at the 150-acre site which produces vital products for everything from sports stadium and iconic skyscrapers – such as the Shard in London – to hospital beds and renewable green energy schemes around the world. Workers at the site produce steel tube products from steel made at the company's Port Talbot works.

Now manufacturing processes on the site will be brought closer together as part of the £25 million scheme which is being paid for in part with the sale of land freed up by the changes as well as savings from operational improvements.

The Chairman of Tata Steel UK Ltd, Sandip Biswas, declared: "Steel is, and will continue to be, an essential part of the UK's plans to decarbonise for the future.

"We need to ensure we are able to make and supply the products right here in the UK which will help transition to a net-zero future."

The Tata Steel Corby Works Manager, Gary Blackman, remarked: "The programme is essential to ensuring a sustainable future for our site and generations of steel workers to come. It will enable us to reconfigure our operations and achieve the highest levels of operational efficiency."

The two-year investment project will see the creation of a single high-tech warehouse, the relocation and upgrading of the important rectangular hollow section (RHS) processing line and the cold mill (CFM). These are where many of the most important products produced by the Corby site are made.

Sustainability is at the core of the improvements with material from old concrete floors being recycled on site to help create the sub-base for the warehouse. Meanwhile the relocation of the RHS and CFM processes will see improved efficiency and reduced energy consumption.

At the same time Tata Steel will work closely with construction partners and the local authority to ensure minimal impact on the surrounding community during the project.

The new warehousing system will bring significant advantages to the current system – enabling the Tubes operation to rotate stock much more efficiently and reduce stock losses.

TATA STEEL

This publication is from the Fifth International Iron and Steel Congress Ironmaking Proceedings Vol 45
Washington, DC 1986, Pages 163-173.

# The role of high thermal conductivity refractories in blast furnace linings

Keith Andrews*, Charles Cooper* and John Evans+

* Morgan Materials Technology Limited
+ British Steel Corporation, Port Talbot

## Introduction

The following is an extract from the final summing-up of the XXVth International Colloquium on Refractories, held in Aachen, Fed. Rep. Germany, October, 1982:

'. . . . In large blast furnaces of high output premature wear is found in the lower stack and on the lower hearth walls, the greatest factors of lining wear being <u>thermal stresses</u> caused by temperature variations and <u>alkali attack</u>. . . . . Through the use of specially developed carbon, graphite, high-alumina and SiC brick and the adaption of commonly used cooler systems to the improved properties of the refractories, it is possible to markedly reduce the wear in the critical regions. . . . . '[1]

## Review

### Hearths

The first carbon hearth in Europe was installed in Germany almost 120 years ago. The first known use of a high thermal conductivity refractory in a British blast furnace dates back almost 45 years to an experimental installation of carbon bricks in the hearth of a furnace at Appleby Frodingham[2]. This was followed by the first complete carbon hearth two years later, whilst America did not enter the field until shortly after Britain, with the first big beam carbon.

Throughout the 50's carbon developments concentrated on applications for the hearth with the aim of reducing Salamander penetration into the bottom and hearth wall break-outs. The big-beam American carbon proved successful in providing radial hearth cooling with reduced joint penetration and virtually eliminated the floatation effect often found with smaller blocks.

The principle behind the installation of these first carbon linings is still used today and is generally known as the 'thermal approach'. In essence the concept is that the refractory itself acts as a solid refractory cooling system to transfer heat away from the hot-face of the lining and reduce the rate of wear. In the hearth of the blast furnace this approach has proved successful because wear is governed chiefly by chemical and solution effects. As furnace diameters have increased, peripheral cooling was shown to be inadequate to prevent hearth pad wear and developments with air or water undercooling, or cooling via a sub-hearth pad of highly graphitic material (K = 100 W/mK), has occurred.

Today almost without exception carbon is used in the hearth annulus, and generally in the pad. In Europe the lower conductivity carbons (K = 4-5 W/mK) have been generally favoured compared to the higher K materials in Japan and the USA.

The occurrence of a 'cut-back' or hearth annulus wear has resulted in further developments in hearth design and materials. These have involved the

(i) use of high K (K = 18 W/mK) hot pressed bricks which have given excellent performance in American furnaces.

(ii) use of large semi-graphite blocks (K = 25 W/mK) in the cut-back area.

(iii) use of high alumina ceramic inner linings in front of the carbon walls and on top of the pad.

(iv) use of a composite lining composed of a graphitic or Plumbago lining at the shell and separated by a ramming gap from the main carbon lining. This design is favoured in Britain.

(v) use of carbon with a finer pore texture.

(vi) combinations of the above.

### Bosh and Stack

Initial results in the U.K. with relatively low K carbon boshes in the 1950's were good, relative to experiences at that time. One advantage was that thinner linings, with increased furnace volumes could be employed[2], Unfortunately, during the 50's and 60's carbon boshes were to suffer several setbacks in Britain and this has resulted in a general movement to plate-cooled designs. Despite the setbacks, some operators have persisted with carbon in the bosh and have taken advantage of the improvements in carbon technology[3].

The advantage of using high thermal conductivity products was recognised in the late 50's and resulted in the use of Plumbago in the bosh of the No.4 Furnace at Port Talbot, in the early 1960's. Plumbago at that time was a clay-bonded material, formed from 35% natural flake graphite with 12% silicon carbide. The green mix was extruded to align the graphite flakes and produce a maximum thermal conductivity along the grain of around 40 W/mK. The original product has since been reformulated[4] to improve CO resistance (see Table 1). Although a significantly improved performance was achieved over conventional carbon materials, the required furnace campaign life was not attained. Nevertheless, the concept influenced the granting of a patent in 1967[5] on the use of Plumbago in composite construction behind a low conductivity facing refractory to reduce chemical and thermo-mechanical stressing, principally for application in the lower stack and upper bosh of plate-cooled blast furnaces. Since that first bosh lining, Plumbago has been used in over 100 installations worldwide, usually in composite construction.

Although the 'thermal approach' had been used in furnaces throughout the world for some time it was not until early in the 1970's that the reasoning was expressed quantitatively by König of ATH in West Germany[6]. As a result of his work and also, that of Van Laar at IJmuiden in Holland[7] [8], semi-graphite became the favoured bosh material in Europe in the mid-70's. In general, results with semi-graphite in small (9m hearth diameter) externally cooled furnaces were good but were extremely disappointing in the large (13-14m diameter) furnaces constructed in the early 70's often with double shell cooling.

As a result, developments since have tended to concentrate either on the use of oxide-based refractories, (especially

| Material | Oxides | | | | Graphitics | | | | Silicon Carbides | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Super Duty Firebrick | Corundum | $Al_2O_3$/ $Si_3N_4$ | $Al_2O_3$/ $Cr_2O_3$ | SiC/ Graphite | Semi Graphite | Electro Graphite | Clay/ Graphite | SiC/ Graphite | SiC/ $Si_3N_4$ | SiC/ βSiC | SiC/ Sialon |
| Free carbon % | - | - | - | - | 61 | 98 | 98 | 42 | 18-21 | - | 1-4 | - |
| $SiO_2$ | 50-55 | - | - | - | 11 | - | - | 31 | 6-8 | - | - | - |
| $Cr_2O_3$ | - | - | - | 8-14 | - | - | - | - | - | - | - | - |
| $Al_2O_3$ | 43-45 | 94-99 | 76 | 78-85 | 1.7 | - | - | 14 | <1 | - | - | 9.5 |
| $Fe_2O_3$ | 1.0-1.5 | 0.4 | - | - | - | - | - | 1.3 | <1 | - | - | - |
| SiC | - | - | - | - | 21 | - | - | 9 | 74 | 76 | 90-94 | 66.5 |
| $Si_3N_4$ | - | - | 22.5 | - | - | - | - | - | - | 22.5 | 1-4 | 21.5 |
| Alkali oxide | 1.8 | - | - | - | 0.3 | - | - | - | 1.4 | - | - | - |
| Ash | - | - | - | - | - | 1.0 | 1.0 | - | - | - | - | - |
| Apparent Porosity % | 10-14 | 12 | 17 | 15 | 19 | 20 | 20 | 18 | 16 | 16 | 14-18 | 15-17 |
| Bulk density g/cm³ | 2.29-2.37 | 3.25 | 3.05 | 3.35 | 1.95 | 1.62 | 1.59 | 1.95 | 2.64 | 2.65 | 2.6-2.7 | 2.6-2.7 |
| Abrasion resistance mm | 100 | - | - | 50 | 240 | 240 | 183 | 300 | - | 38 | 48 | 53 |
| Crushing strength (cold kg/cm² | 790-1240 | 900-2000 | 1000 | 1000 | 360 | 250 | 163 | 229 | 1910 | 1300 | 1020 | 1000 |
| Reversible thermal expansion % 0-1000°C | 0.7 | 0.7 | 0.47 | 0.86 | 0.45 | 0.31 | 0.21 | 0.36 | 0.44 | 0.38 | 0.32 | 0.46 |
| Alkali resistance* Volume change % | very | +14.7 | - | +4.3 | +0.5 | +1.5 | - | +4.3 | - | -31.6 | +3.4 | -15.3 |
| Change in cold MR % | poor | -45.2 | - | -59.2 | +7.8 | +0.2 | - | -21.5 | - | 51.3 | -45.8 | -39.2 |
| Thermal conductivity W/mK 200°C | 1 | - | - | - | 66 | 34 | 114 | - | 28 | 27 | - | - |
| 400°C | 1 | - | - | - | - | 31 | 82 | 65 | - | 18 | 26 | - |
| 600°C | 1 | 2.9 | - | - | - | 29 | 61 | - | - | 11 | 17 | - |
| 800°C | 2 | - | - | - | - | 26 | 57 | - | - | 10 | 13 | - |
| 1000°C | 3 | - | 2.4 | 2.3 | - | - | - | - | - | 10 | 12 | 9 |
| Pore size distribution % open pores <4μ | - | 70 | - | - | 96 | - | - | 92 | 96 | 87 | 96 | 96 |
| Main constituents | $Al_2O_3$ $SiO_2$ | $Al_2O_3$ | $Si_3N_4$ | $Al_2O_3$/ $Cr_2O_3$ solid sol'n | Graphite SiC | Partially graphitised petroleum coke | Fully graphitised petroleum coke | Clay graphite SiC | SiC graphite | $Si_3N_4$ bonded βSiC | SiC bonded βSiC | Sialon bonded βSiC |

***Table 1: Properties of some modern blast furnace refractories for the lower stack and bosh***

* Test carried out in $K_2OO_3$ melt/vapour of Bethlehem Steel Method

| | Ramming | | | Mouldable | Cement |
|---|---|---|---|---|---|
| | High K | Medium K | Compressible | | |
| Density g $cm^{-3}$ (Installed) | 1.9 | 1.85 | 1.4-1.6 | 1.9 | 1.6 |
| Density (dried) | 1.7 | 1.7 | - | 1.97 | 1.2 |
| Shrinkage % 110°C | 0.4 | 0.5 | - | 6 | - |
| Thermal Conductivity W/M°C | 18-15 | 10-14 | 6-7 | 12-16 | 10 |
| Compressibility % | | | | | |
| 20 psi | - | - | 4 | - | - |
| 50 psi | - | - | 11 | - | - |
| 100 psi | 10 | - | 18 | - | - |
| 150 psi | - | - | 23 | - | - |
| C% LOI 800°C | 62 | 37 | 47* | 47 | 40 |
| $SiO_2$ | 21 | 28 | 4 | 39 | 34 |
| $Al_2O_3$ | 13 | 16 | - | 8 | 14 |
| $Fe_2O_3$ | 1.5 | 3 | - | 0.7 | - |
| SiC | - | 6 | 35 | - | - |
| $B_2O_3$ | - | 4 | 3 | 0.1 | - |
| Si | - | - | 6 | - | - |

***Table 2: Typical properties of some graphitic blast furnace cements and rammings as used in British furnaces***

* including 15% organic volatiles

in Germany), silicon carbide, or carbons and graphitics in composite construction in plate-cooled furnaces, such as at Hoogovens. In fact, a recently completed campaign on the 11m No.6 Furnace (plate-cooled) at IJmuiden, achieved nearly 13M tonnes of iron, a record campaign in Europe, for this size of furnace.

An important consequence of the König work was the emphasis placed on the correct integration of refractories, cooling system and the structural engineering. In addition, the importance of joints and gaps to the success of the 'thermal approach' prompted the generation of a whole new range of cements and rammings, with thermal conductivities designed to match closely with the high conductivity bricks they contacted (see Table 2).

In the bosh, modern furnace burdening operation and monitoring have created more stable conditions[9] than in the past and here the theory of König fits reasonably well today, especially in plate-cooled designs. In these arrangements theoretical wear profiles can be achieved and lining wear approaching an equilibrium situation can be obtained.

In Europe, graphitic and Plumbago materials have been used successfully in the bosh of the plate-cooled furnaces of hearth diameter 8-10m. Almost invariably, a high conductivity ramming has been used around the plate-cooler, to maximise heat transfer.

Unfortunately, experience has shown that the König theory cannot be strictly applied in the lower stack. This is because the theory is based on chemical wear concepts and cannot cater for the violent temperature and heat load fluctuations experienced in practice.

Nevertheless, in BSC, the use of Plumbago in composite construction, with a firebrick facing, has provided a satisfactory means of establishing a stable lining in the lower stack of plate-cooled furnaces. It is now recognised that the combination of a good thermal profile, following the König concept, together with the excellent thermal shock resistance of the graphitic material used, are the significant features in the designs employed.

## Experiences with high conductivity linings in plate-cooled furnaces in the Strip Products Group BSC

### Introduction

In the late 1960's, the lower stack was identified as being a potential problem area in BSC furnaces. Trials, in the zone above the lintel, with plate-cooled composite linings based on high conductivity refractories with firebrick facing, were successful. Consequently all Strip Products Group furnaces in Ravenscraig (Scotland) and in Port Talbot and Llanwern (both in Wales) now employ such designs in the lower stacks[10], The composite design is used generally to a height of about 5m above the lintel, i.e. from the lintel to about 10m above the centre line of the tuyères. The development of the designs was aided by mathematical models of wear process based on the König 'Tu' principle.

The high thermal conductivity material employed in all furnaces is Plumbago - a refractory composed of clay, natural flake graphite and silicon carbide. This was derived from materials developed to produce ladles for melting both ferrous and non-ferrous metals, where thermal shock resistance, 'toughness', and slag and metal resistance are critical properties.

### Experiences with high conductivity linings

The experiences are best illustrated by reference to two furnace campaigns, viz:

No.4 Furnace at Port Talbot.

No.2 Furnace at Llanwern.

### No.4 Furnace at Port Talbot (9.2m hearth diameter)

1978-1985 Campaign

The lower stack of this furnace was virtually identical in design to that employed in its sister, No.5 Furnace, whose construction and performance has been described previously[10]. Thus the composite lower stack was cooled by 7 rows of coolers on 495mm vertical centres followed by 2 rows of coolers on

654mm centres. Above the composite zone a firebrick lining with coolers on 654mm centres was installed. Thus the cooler intensity in the lower and upper parts was 1.6 and 1.3 coolers/$m^2$ of shell area respectively, which by modern standards is low.

The furnace was blown-in in September 1978. No problems were experienced until January 1981 when a series of routine shell temperature surveys unexpectedly located a band of relatively high temperature (300°C maximum), which coincided with the transition from the composite to conventional firebrick lining (cooler row 8-10). Core drilling exercises during that year showed the lining to be at or near the predicted equilibrium wear thickness and the high shell temperatures were considered to be a function of the then current furnace operating conditions.

The higher than expected shell temperatures contrasted with the previous experience with the sister No.5 Furnace. Here very low, lower stack shell temperatures were maintained during the whole campaign[10].

Continued monitoring during 1982 however confirmed a deteriorating situation in the firebrick lining immediately above the composite zone and in the upper part of the composite zone. External water cooling was applied in mid '82.

As the planned reline date for the Furnace was mid-1985, it was considered prudent to grout those areas showing higher than expected temperatures. Consequently, a series of five grouting operations were carried out in late 1982 and in 1983, two of these being in the upper part of the composite lined zone.

During the last 21 months of furnace operation no further problems were experienced and no further grouting operations were carried out. The furnace was blown-out for a scheduled reline in July 1985, having produced 5M tonnes of iron. The rate of lining wear determined from the various core drilling exercises, and furnace lines at blow-out is shown in Figures 1 and 2. It should be noted that the core drillings tend to give the 'worst' case as drillings were made at the locations where shell temperatures were highest.

The major features arising from these Figures are:

(i) Inadequacies in cooler densities and materials in the firebrick zone above the composite zone.

(ii) Although the Plumbago remaining in the upper part of the composite zone stabilised in thickness, it is considered that the cooler intensity is inadequate for longer campaigns at higher driving rates.

(iii) The performance of the lower more densely cooled lower stack was excellent, the lining thickness and stability achieved during the last two years showing that a much longer life potential was available from this zone of the furnace.

(iv) The excellent condition of the residual bricks in the Plumbago lining and the cores recovered before blowing out. These showed, especially in the lower part, that little alteration to the Plumbago refractory had occurred, with a thin firebrick facing often being retained.

In the reline of No.4 Furnace it was not possible to alter cooler arrangements due to constraints imposed by the requirement for a rapid reline. The lining design changes to give longer campaigns are restricted to the lower stack. Thus:

| | |
|---|---|
| Cooler rows 1-7 | Plumbago/firebrick composite design unchanged other than 'improved' Plumbago used. |
| Cooler rows 7-9 | 'improved' Plumbago/silicon carbide composite used. |
| Cooler rows 9-13 | silicon carbide/firebrick composite used in place of all firebrick. |

A further change was to use high conductivity (K = 15W/mK) back fill ramming between the lining and shell up to cooler row 13, with the intention of water spray cooling from the start of the campaign.

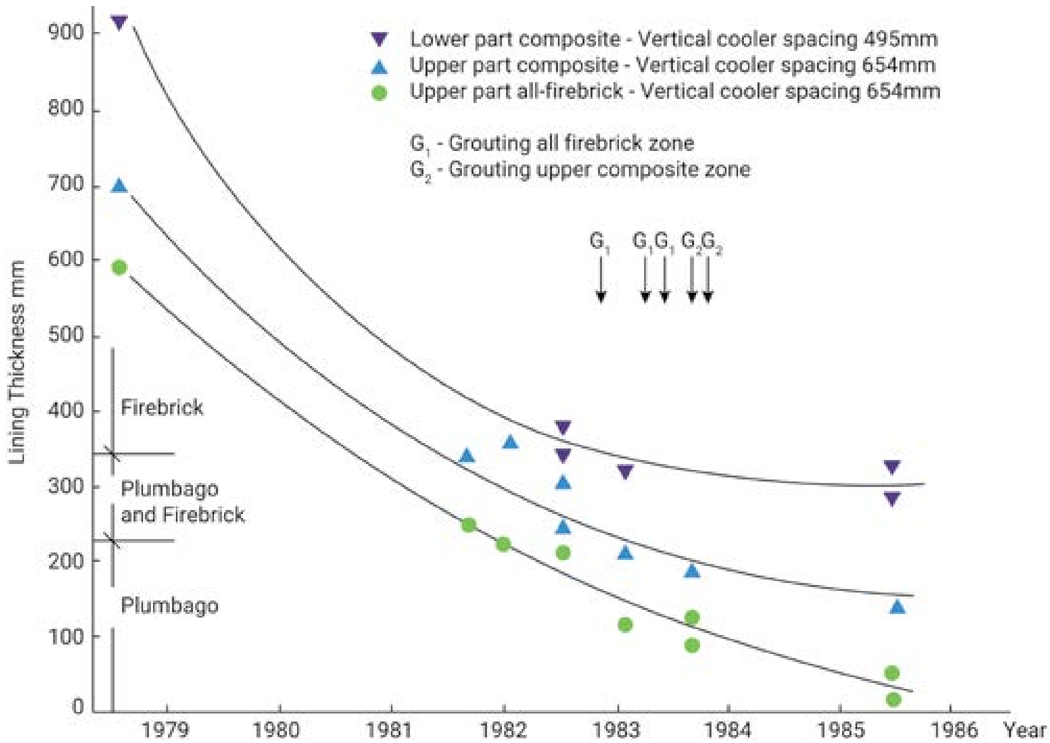



*Figure 1: Change in lining thickness with time - No.4 Blast Furnace, Port Talbot*

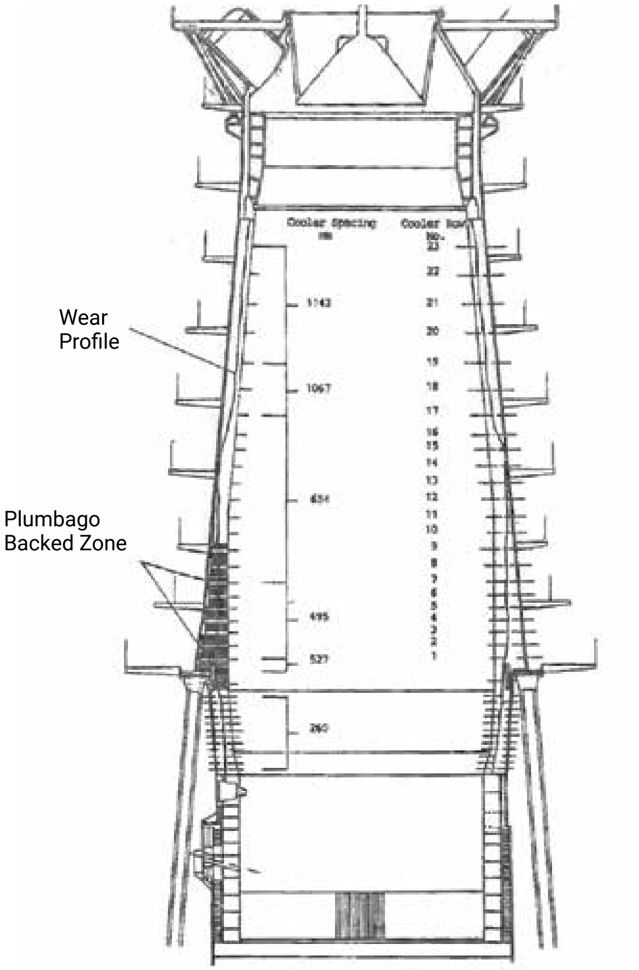



***Figure 2: Blow-out lines - Port Talbot No.4 Blast Furnace, 1978-85 campaign***

## No.2 Furnace Llanwern (9.1m hearth diameter)

1980 - to date

During the 1979 reline of this furnace the lower stack was constructed of 12 rows of coolers with a composite Plumbago firebrick lining of overall height 5.1m. The cooler vertical spacing is variable (381 - 533mm) but averages 464mm. The average cooler intensity is 1.6m$^2$ of shell area[10].

Since blowing-in on 11.8.80, this furnace has produced 4M tonnes to date (Dec. 85). No problems of any sort have been experienced and very low shell temperatures have been maintained.

Core drilling exercises have confirmed that the lining is in excellent condition. Figure 3 shows a photograph of the cores. Like those obtained from the lower part of Port Talbot No.4 Furnace, the Plumbago was virtually unaltered, indicating that very low temperatures were maintained in the lining which allowed retention of a thin firebrick facing.

This result and that obtained in the lower part of the lower stack at Port Talbot indicates that with cooler spacings of 450mm vertical centres, the composite lining based on Plumbago/firebrick gives a virtually indestructible lining for current operating practices. It is probable that design employing other highly conductive materials currently available, and which give the same thermal profiles, would achieve similar results.

### Arrangements at junction of refractory and cooler

There is much debate regarding the best arrangements to be

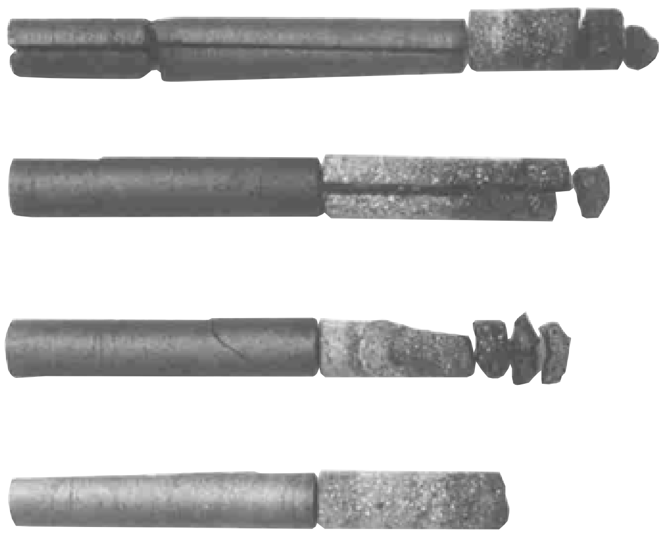


***Figure 3: Condition of cores recovered from Llanwern No.2 Blast Furnace lower stack***

employed to thermally link the refractory being cooled to the heat sink. There are basically three systems employed.

(i) Machined coolers and refractory to give an 'engineering standard' fit and surface contact.

(ii) Relatively thin (<13mm) rammed or trowelled joints using high conductivity cements or plastic materials.

(iii) Relatively wide (>13mm) rammed gaps[11]. These may be applied after the lining is constructed by ramming ultra high conductivity materials (K = 27W/mK) into the gap between a cooler, cantilevered from the shell, and the surrounding brickwork. The advantage is that by ramming in a direction at right angles with the inner face of the lining, the flakes of natural graphite align themselves at right angles to the cooler surface giving maximum conductivity.

Measurements of the area of contact between machined surfaces have shown that even if precision machining is employed, the surface area of contact is very very small indeed. Based on these studies, and calculations of the effects on heat transfer of the gaps which inevitably exist, it has been concluded that rammed gaps will give improved heat transfer[12].

Nevertheless systems based on the machined cooler/machined refractory approach have given excellent results and are being increasingly adopted. On the other hand, experiences in British furnaces, reported here, have shown that the use of relatively thin rammed gaps using plastic ramming material (K = 14W/mK) give satisfactory results and there are no plans to change this approach.

## The thermal approach vs. refractory approach

The main problem area of the modern, high output blast furnace remains the lower stack/belly area. The principal refractory wear mechanisms are well known and documented.

These may be summarised as follows:

(i) Abrasion from the burden.

(ii) Thermal shock, due to widely fluctuating temperatures.

(iii) Reaction with hot metal, slags and gases.

In respect of (iii) the factors are chemical and hence temperature dependent, so that wear rates based on these mechanisms will be virtually zero below a certain temperature. This temperature was defined by König[6] in the early 1970's, as the Lower Reaction Limit Temperature, 'Tu'. König postulated that wear will take place until the temperature, Tu, is reached at the retreating hot face, whereupon wear by chemical attack will cease.

When selecting refractories for lower stack and bosh, therefore, one should aim for a high thermal conductivity, to dissipate the heat from the hot-face and a high Tu value. This has generally been, known as the 'Thermal Approach'. However, it is today suggested that there are two approaches to chemical wear known as the 'thermal approach' and the 'refractory approach'. König[13] suggests that the former places emphasis upon the thermal conductivity of the refractory system, whilst the latter lays emphasis on the Tu value, with low to medium thermal conductivity.

König further suggests that it was an over-emphasis on the thermal conductivity which led to the failure of the semi-graphite boshes in West Germany in the mid-70's. However, it is also conceded that the 'thermal approach' in fact brought about improved service lives in many furnaces, but that heat losses were invariably higher.

Experience within the Strip Products Group of BSC has shown that furnaces with high density plate-cooling, lined with high-K refractories, do not necessarily show higher heat losses compared with conventional low-K linings. However, it is also suggested that the heat losses are dictated more by the furnace burdening/operation than by the lining/cooler design.

The 'refractory approach' suggested by König aims to increase the 'slag' resistance of the refractory, i.e. effectively increasing the lower reaction temperature Tu. Tu is suggested as being primarily determined by the chemical composition of the brick, for similar furnace conditions. König further suggests that the inevitable dissolution of the refractory which takes place must be slowed down by <u>additional refractory measures</u> (due to the relatively low K of these materials) influencing the kinetics of the chemical process. Measures to achieve this are suggested as:

(i) large crystal structure.

(ii) fine pores.

(iii) chemically resistant bond.

However, the main purpose of these refractory measures must be to inhibit or even prevent the infiltration of gases and liquids. There are various techniques used today to achieve this, viz. pitch or tar impregnation, impregnation of phosphates and/or ultrafine alumina. These techniques are being applied not only to the oxide refractories, but also to the carbon and graphite based materials (the latter being the principal materials used in the 'thermal approach').

In the light of this modern approach, it is perhaps surprising, therefore, that a refractory such as Plumbago, with an apparent porosity of around 30%, could achieve a 7 year campaign (1964-1971) in the bosh of the Piombino No.1 Furnace, Italy. It is postulated that the large open texture of Plumbago is able to take up the expansion associated with the alkali reaction products. In practice, large quantities of alkali have been detected in used Plumbago bricks without loss of structural integrity (see Section 5). On the other hand, if the temperature of the refractory lining is kept low enough, the extent of alkali attack can be minimised, and is a fundamental principle of the 'thermal approach'. Measurements on furnaces within BSC have indeed shown that the temperature of the Plumbago backing lining in a lower stack construction can be maintained below 500°C throughout a campaign. Nevertheless, in view of the apparent failure of the 'thermal approach' in West Germany in the 1970's, it is perhaps not surprising that the emphasis there has been on a 'refractory approach', based on oxide refractories.

Perhaps the attraction of the silicon-carbide refractories is that they appear to offer a compromise between the 'thermal' and 'refractory' approaches, having generally a good thermal conductivity and corrosion resistance. Certainly, silicon-carbide refractories are being used in many furnaces around the world today. Nevertheless, it will be interesting to monitor the performance of these products in the light of recent findings in Europe[13] and Japan[14], which describe the susceptibility of some silicon carbides to oxidation and subsequent thermal shock.

## The durability of graphitic refractories in the blast furnace

The use of graphitic* and carbonaceous refractories in the blast furnace, particularly in the lower stack, has developed primarily through their high thermal conductivity, and hence their suitability as a heat transfer medium. It is appropriate, therefore, to consider their characteristics in relation to other blast furnace refractories. There is an obvious need in the graphitic materials for refractory properties which are adequate to assure survival in the operating environment, to maintain both structural integrity and thermal continuity. Furthermore, as the hot-face refractory in a composite lining deteriorates, a point occurs where the backing graphitic takes over the hot-face role. There is considerable evidence from observation of the lining refractories at wrecking that materials such as Plumbago can adequately assume this role, providing they are sufficiently cooled and due cognizance is taken of the cooling configuration and furnace engineering construction. Failure to recognise the importance of the engineering parameter and mechanical abrasion on the wear of refractories, led to the failure of carbon and semi-graphite in Europe in the mid-70's.

In considering the merit of graphitics, the thermo-mechanical properties have to be brought into focus. Thermal shock cracking has long been recognised as a contributor to the failure of linings, although for many years it seems to have been considered secondary to chemical attack. There has been more recently a recognition that the thermal fluctuations in a furnace can be very significant[7], and that thermal shock may indeed have to be ranked with chemical corrosion, especially in the bosh and stack, as a factor determining refractory life. As mentioned earlier, the 1982 Aachen conference highlighted that the greatest factors contributing to premature wear were thermal stresses and alkali attack.

Of all the modern refractories, those which contain significant amounts of graphite have to be seen as having superlative resistance to thermal stress, matched only by fused silica. De Boer et al[8] reported that in core drillings from furnaces at IJmuiden only two qualities of brick were crack-free, graphite and semi-graphite. Silicon carbide was in some cases cracked but sometimes crack-free. Calculations of the critical heating rate which could be tolerated by various refractories, before cracking, showed that graphitic materials were far superior to all others, including silicon carbide. Bell, Palin and Padgett[16]

* The term graphitics is used loosely throughout this section and embraces carbon rich refractories since most, whether graphitic or carbonaceous, exhibit similar advantageous properties.

have made a study of the relative tolerable heating rates based on theory and with some experimental confirmation. By means of acoustic emission they demonstrated failure at a heating rate as low as 15°C/min with an aluminosilicate in line with mathematical prediction. By comparison, it was predicted that SiC would tolerate a heating rate of up to 100°C/min but further that there would be little likelihood of damage to semi-graphite under these conditions. Aratani et al[17] using acoustic emission during a panel test demonstrated failure in a variety of silicon carbides at temperature changes in the region of 20-35°C/min. Similarly, Miyamoto et al[18] obtained spalling of aluminosilicate bricks at rates as low as 5-10°C/min. Indeed, they attribute lining wear in the Fukuyama furnaces as deriving primarily from thermal spalling.

Larson et al[19] have demonstrated the validity of the theoretical approach of Hasselman in relating thermal shock to the modulus of elasticity, the work of fracture and the thermal expansion as given by a thermal resistance parameter

$$R_{ST} = \sqrt{\frac{\gamma wof}{\alpha^2 E}}$$

where $\gamma wof$ = work of fracture
$\alpha$ = thermal expansion
E = elastic modulus.

Graphite is able to influence radically all of the parameters in this equation when it is incorporated into a refractory body. It engenders low thermal expansion, low modulus and interestingly high work of fracture. Table 3 lists $R_{ST}$ for a number of graphitic materials, together with other refractories, most of which are employed in blast furnaces. The effect upon work of fracture is probably due in fact to a situation equivalent to fibre reinforcement, where energy can be dissipated by pull out and fracture of graphite flakes and by slip and dislocation movement within flakes[20].

There is additionally the recognition that thermal conductivity also contributes to the level of thermal stress within a body, in that it will help minimise the temperature gradient and limit thermal strain. Highly graphitic materials are, of course, good thermal conductors, the very reason they are used as solid coolants in blast furnaces. By comparison, aluminosilicates generally have a lower value of $R_{ST}$ and a much lower thermal conductivity and thus in relation to graphitics are theoretically far worse in thermal shock, as borne out in practice. With respect to silicon carbides, they have acceptable values for conductivity, expansion and work of fracture. However, the modulus is high which is counter productive to a high $R_{ST}$ value, as can be seen from Table 3.

The Hasselman parameter relates to materials which are already microcracked and hence is a measure of the energy required to propagate cracks. There is, however, a second parameter, R '''' which is defined as

$$R'''' = \frac{E\,\gamma wof}{\sigma f^2}$$

where $\sigma f$ is the fracture stress of the material.

This relates to materials which are structurally more coherent and is a measure of the propensity to crack initiation. Thus it may not be valid to compare the modern direct bonded silicon carbides with the micro cracked graphitics and aluminosilicates in respect of $R_{ST}$ values, although the porosity of the silicon carbide has to be seen as a structural defect in the body.

Even so, R '''' for silicon carbide also appears to be low by comparison with graphitics. Thus both parameters are suggestive of a lower thermal shock resistance of the silicon carbide.

Practical demonstration of the extent of superiority of graphitic refractories over others is difficult because of the virtual impossibility of causing them to crack, except by subjecting them to extreme conditions. As demonstrated by Bell et al, graphitics should survive any thermal strain likely to be

| Material | $\gamma$ J/m² | E GPA | $\alpha$ 200-500 x $10^{-6}$ | $R_{ST}$ °Cm$^{1/2}$ | R '''' (mm) |
|---|---|---|---|---|---|
| Fused Silica | 25 | 20.8 | 0.62 | 57 | 2.3 |
| B.F. Carbon | 70 | 6.8 | 2.5 | 40 | 7.0 |
| $A1_2O_3$/Graphite Carbon-bonded | 48 | 3.3 | 3.9 | 31 | 6.3 |
| Pressed (with grain)<br>Plumbago (across grain) | 130<br>24 | 10.7<br>1.1 | 4.5<br>5.9 | 24<br>25 | 5.6<br>5.2 |
| Extruded (with grain)<br>Plumbago (across grain) | 59<br>49<br>74 | 5.1<br>3.2<br>9.1 | 4.5<br>4.5<br>3.2 | 24<br>27<br>28 | 4.2<br>4.8<br>6.0 |
| Graphite-SiC Carbon-bonded | 73<br>68 | 15.2<br>10.5 | 3.3<br>- | 21<br>24 | -<br>- |
| Graphite-SiC Clay-bonded | 107<br>55 | 13.7<br>6.9 | 4.5<br>4.5 | 20<br>22 | 6.7<br>5.0 |
| 63% $A1_2O_3$ Firebrick | 8 | 1.7 | 4.9 | 14 | 3.2 |
| 45% $A1_2O_3$ Firebrick | 7 | 1.8 | 4.9 | 13 | 3.3 |
| Nitride-bonded SiC | 109 | 53 | 4.4 | 10 | 3.7 |
| Zircon Brick | 40 | 27.9 | 4.5 | 8 | 4.0 |
| Clay-bonded SiC | 44 | 37 | 5 | 7 | 5.1 |

*Table 3: Thermal shock parameters of a variety of graphitic and non-graphitic refractories*

generated in a blast furnace environment. Taking this point further, it is the failure strain which is probably most important. At room temperature graphitic refractories can withstand a strain of 0.2 - 0.3% before failure which is several times that which is tolerated by aluminosilicates and silicon carbides. As temperatures increase, higher strain can be accepted. Miyamoto has shown that in compression aluminosilicates are able to move by viscoelasticity and accept strains up to 0.2 - 0.4%. Similar measurements on carbon brick suggest compressional failure strains of several percent at both room temperature and 1000°C.

The ability to accept strain may also be appropriate to the resistance to chemical failure. In an oxide system, such as an aluminosilicate, there is an inevitability of diffusion of other oxides phases, such as potash, due to thermodynamic driving forces. The penetration of these materials must be accommodated through a volume change in the body. Thus it might be considered that the concept of using fully dense materials such as fusion-cast refractories, could be misconceived, since they of all materials would be most prone to chemically induced growth. There is an alternative reasoning in which it could be claimed that in the absence of porosity the diffusion will be limited to the surfaces. All such considerations should be borne in mind when developing the modern trend to densification of refractories through impregnation and changes in texture.

Accepting that chemical penetration will cause volume expansion and hence strain, a high strain to failure will give a material more tolerant to chemically induced failure. An example of such a situation was observed in samples of Plumbago retrieved from Port Talbot No.3 Furnace where in spite of the deposition of 4-12% secondary carbon due to CO attack, the material suffered no structural damage.

Furthermore, samples of Plumbago retrieved from Cockerill No.5 and Llanwern No.3 Furnaces at the end of their respective campaigns were found to contain up to 4% $K_2O$ and yet retained total structural integrity.

It is suggested therefore that the thermo-mechanical properties of graphite-rich refractories are a significant factor in their survival in a blast furnace environment.

## The Future

In the modern blast furnace the bosh and hearth are no longer major problems. Nevertheless, design developments will continue in the hearth aimed primarily at reducing cut-back in the hearth wall. In the hearth itself, it is expected that the use of a ceramic basket, to reduce iron penetration, will increase. This system is presently favoured in Europe.

In the bosh there has been no serious problem reported over the past decade, due to changes in the chemical/thermal regimes and to improvements in design and materials.

The lower stack remains the principal area of concern in the furnace and some of the many solutions used to reduce the refractory wear have been discussed here. Certainly, a major factor in reducing the problems will come with advancements in operational and process control of the furnace.

With regards to refractory materials, perhaps the most significant change over the past 5 years has been the widespread use of silicon carbide. The material is being used in many of the large furnaces around the world, either alone, or in composite construction (in both stave and plate-cooled furnaces).

Despite the current trend towards silicon carbide, the superiority in thermal shock of graphitics may ensure their future in blast furnace construction, if only as a highly tolerant cooling medium. Furthermore, if thermal fluctuations are likely to be prevalent, particularly in those furnaces subject to difficult working conditions, it may give rise to reservations on the suitability of silicon carbides. However, in view of the recent developments, such materials will be considered in future relines of BSC furnaces. Nonetheless, the successful performances of Plumbago in U.K. furnaces has meant that, to date, it has been a premier material considered for lower stacks, in composite construction with firebrick facings.

With a single exception, no serious problems have been experienced in lower stacks of furnaces employing the Plumbago composite design. The occasion when greater than expected wear occurred was directly associated with inadequacies in the quality and quantity of the cooling water. Certainly, this event did not alter design philosophy for future relines.

## References

1. A. Majdic, M. Koltermann and W. Krönert, "Summary" XXVth International Colloquium, Aachen, 1982, Interceram Vol. 32 1983.
2. G. M. Workman, "A Critical Look at Twenty-One Years of Development in Blast Furnace Refractories", I.M. Conf. Proc. Vol. 28, 1968 pp 1-13.
3. K. A. Graham, "Bosh Design in Scunthorpe", A.I.M.E. Ironmaking Procs., Vol. 38, 1979, pp 187-192.
4. K. Andrews, "Salamander Plumbago in the Modern Blast Furnace", World Steel and Metalworking, Fachberichte, 4, 1982.
5. "Blast Furnaces Provided with Refractory Linings", U.K. Patent No.1,126,076 (filed 28.03.67).
6. G. König, C. Weidermüller and G. Pietzko, "Verschleiß Feuerfester Hochofenwandungen", Stahl und Eisen, Vol. 91, No.2, 1971, pp 63-69.
7. J. Van Laar, J. Maes and V. Van der Vliet, "Bosh and Stack Refractory and Cooling Design and Their Interaction with Blast Furnace Operations", Ironmaking Proc., Vol. 37, 1978.
8. J. de Boer, J. A. Butter, J. Van Laar and R. Vogel, "History and Actual State of Research and Development of Blast Furnace Bosh/Stack Linings and Cooling Systems at the Estel Hoogovens BV IJmuiden Plant", Interceram Vol. 32, 1983 pp 16-18.
9. G. Winzer, K. R. Hüsig, and M. K. Beseoglu, "Blast Furnace Technology and Its Demands on the Refractory Lining", Interceram Vol. 32, 1983, pp 7-12
10. J. L. Evans, "Bosh Parallel and Lower Stack Designs in Blast Furnaces in South Wales" Ironmaking Procs. Vol. 39, 1980 pp 31-37.
11. M, Parker, Carborundum Co., Private Communication.
12. R. Elderfield, Carblox Co., Private Communication.
13. G. König, "Fundamental Considerations on the Refractory Lining of Blast Furnaces", Interceram Vol. 32, 1983 pp 13-15.
14. J. M. Bauer, R. D. Schmidt-Whitley, D. Dumas, B. du Mesnildot and J. P. Kiehl, "New Solutions for Problem Areas of Blast Furnace Linings", Interceram Vol. 32, 1983 pp 25-32.
15. T. Hirota, T. Higashihara, T. Kawakami and Y. Kadota, "High Temperature Behavior of Silicon Carbide Refractories for the Blast Furnace Lower Stack", Interceram Vol. 32, 1983 pp 43-47.
16. D. A, Bell, F. T. Palin and G. C. Padgett, "Effects of Rapid Heating on Blast Furnace Refractories", Steel Times Vol. 212, 1984 pp 65-66.
17. K. Aratani, M. Saito, M. Kumagai, T. Emi, Y. Watanabe, M. Marushima, G. Yasuno and T. Nakamura, "Wear of Blast Furnace Refractories" Interceram Vol. 32, 1983 p 87.
18. M. Miyamoto, T. Onoye and K. Narita, "Deformation and Failure Behaviours of Blast Furnace Refractories with Joints at Elevated Temperature" Interceram Vol. 32, 1983 p 107.
19. D. R. Larson, J. A. Coppola and D. P. H, Hasselman, "Fracture Toughness and Spalling Behaviour of High-$Al_2O_3$ Refractories", J. Am. Ceram. Soc. Vol. 47, No.10, 1974 pp 417-421.
20. C. F. Cooper, "The Role of Graphite in the Thermal Shock Resistance of Refractories", Br. Ceram. Trans. J., 84, pp 57-62, 1985.






## Refractory Business Directory

### Refractory Business Directory:

Suppliers who wish to be included under any of these or their own headings should call 0044 (0) 7496 194585 or email advertising@ireng.org.

### Advertisers please note:

We would remind advertisers running for more than one insertion that it is their responsibility to inform the publisher of any inaccuracies in their advertisement from the first issue. The publisher cannot accept responsibility for mistakes that appear in subsequent issues.

### ACID LINING

ACCS LTD
International specialists in Industrial Protective Linings

**ACCS Ltd**

Scott Lidgett Industrial Estate, Scott Lidgett Road, Longport, Stoke-on-Trent ST6 4NQ
Tel: 01782 817107 Fax: 01782 824979
Website: www.accsltd.co.uk

Ancorite SURFACE PROTECTION

**Ancorite Surface Protection Ltd**

Unit 40A & 40B, Cadcam Centre, High Force Road, Riverside Business Park, Middlesbrough TS2 1RH
Tel: +44 (0)1642 909680
Fax: +44 (0)1642 909680
Mobile: +44 (0)7717 684858
Email: jill.wales@ancorite.co.uk
Website: www.ancorite.co.uk

## ALUMINA - CALCINED

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

## ALUMINA - FUSED

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

## ALUMINA - TABULAR

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

## ANALYTICAL SERVICES

**Lucideon**
Queens Road, Penkhull, Stoke-on-Trent
Staffordshire ST4 7LQ
Tel: (01782) 764444
Fax: (01782) 412331
Email: enquiries@lucideon.com
Website: www.lucideon.com

## BASIC BRICKS

**RHI Magnesita**
Kranichberggasse 6, 1120 Vienna, Austria
Tel: +43 50213 0
Email: office@rhimagnesita.com
Website: www.rhimagnesita.com

**Trent Refractories Ltd**
Menasha Way, Queensway Industrial
Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## BURNER BLOCKS

**Trent Refractories Ltd**
Menasha Way, Queensway Industrial
Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## CALCIUM ALUMINATE CEMENT

**Imerys Aluminates Ltd**
Dolphin Way, Purfleet, Essex RM19 1NZ
Tel: (01708) 863333
Fax: (01708) 861033
Email: paul.bottomley@imerys.com
Website: www.imerys.com

## CERAMIC FIBRE FIXINGS

**Mach One (International) Ltd**
Unit 8, Norfolk Business Park, Foley
Street, Sheffield S4 7YW
Tel: (0114) 270 0545
Fax: (0114) 276 7438
Email: anchors@mach-int.com
Website: www.mach-int.com

## CONSULTANTS/RESEARCH

**Lucideon**
Queens Road, Penkhull, Stoke-on-Trent
Staffordshire ST4 7LQ
Tel: (01782) 764444
Fax: (01782) 412331
Email: enquiries@lucideon.com
Website: www.lucideon.com

## DEMOLITIONS

**Gnat (UK) Ltd**
5 Jackson Close, Olympic Way,
Gallowfields, Richmond, North Yorkshire
DL10 4FD
Tel: 01748 826046
Fax: 01748 826056
Website: www.gnatuk.com

## DIATOMITE INSULATING BRICKS

**Robert Lickley Refractories Ltd**
P.O. Box 24, Dudley, West Midlands
DY1 2UF
Tel: (01902) 880123
Fax: (01902) 880019
Website: www.robertlickley.co.uk

## DOLOMITE BRICKS

**RHI Magnesita**
Kranichberggasse 6, 1120 Vienna, Austria
Tel: +43 50213 0
Email: office@rhimagnesita.com
Website: www.rhimagnesita.com

## DRY VIBRATION RAMMABLE REFRACTORIES

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## DRYING AND CURING OF PRE-CAST REFRACTORY BLOCKS UP TO 1250°C (IN HOUSE)

**Irisndt Ltd**
Middleplatt Road, Immingham,
North Lincolnshire DN40 1AH
Email: immingham@irisndt.com
Website:
www.irisndt.com/uk/heat-treating/

**Thermal Hire Ltd**
Unit 12, Pagefield Industrial Estate, Miry Lane, Wigan, Lancashire WN6 7LA
Tel: +44 (0)1942 620062
Fax: +44 (0)1942 620156
Email: sales@thermalhire.com
Website: www.thermalhire.com

## DRYING AND CURING OF REFRACTORIES (ON SITE)

**Irisndt Ltd**
Middleplatt Road, Immingham,
North Lincolnshire DN40 1AH
Email: immingham@irisndt.com
Website:
www.irisndt.com/uk/heat-treating/

**Thermal Hire Ltd**
Unit 12, Pagefield Industrial Estate, Miry Lane, Wigan, Lancashire WN6 7LA
Tel: +44 (0)1942 620062
Fax: +44 (0)1942 620156
Email: sales@thermalhire.com
Website: www.thermalhire.com

## FOUNDRY PRODUCTS

**Capital Refractories Ltd**
Station Road, Clowne, Chesterfield
S43 4AB, United Kingdom
Tel: +44 (0) 1246 811163
Fax: +44 (0) 1246 819573
Email: info@capital-refractories.com
Website: www.capital-refractories.com

## FURNACE REFRACTORY PREHEATING (ON SITE)

**Irisndt Ltd**
Middleplatt Road, Immingham,
North Lincolnshire DN40 1AH
Email: immingham@irisndt.com
Website:
www.irisndt.com/uk/heat-treating/

**Thermal Hire Ltd**
Unit 12, Pagefield Industrial Estate, Miry Lane, Wigan, Lancashire WN6 7LA
Tel: +44 (0)1942 620062
Fax: +44 (0)1942 620156
Email: sales@thermalhire.com
Website: www.thermalhire.com

## FURNACE REPAIRS

**Gnat (UK) Ltd**
5 Jackson Close, Olympic Way,
Gallowfields, Richmond, North Yorkshire
DL10 4FD
Tel: 01748 826046
Fax: 01748 826056
Website: www.gnatuk.com

**Gunform International Ltd**
33 Carsthorne Road, Carr Lane Industrial Estate, Hoylake, Wirral, Merseyside
CH47 4FB
Tel: (0151) 632 6333
Fax: (0151) 632 6444
Email: info@gunform.com
Website: www.gunform.com

**S.H.L. Refractories (U.K.) Ltd**
Celcius House, Lawn Road Industrial Estate, Carlton in Lindrick, Worksop, Nottinghamshire S81 9LB
Tel: (01909) 731959
Fax: (01909) 731579
Email: sales@shl-refractories.co.uk
Website: www.shl-refractories.co.uk

## FURNACE WRECKING

**Gnat (UK) Ltd**
5 Jackson Close, Olympic Way,
Gallowfields, Richmond, North Yorkshire
DL10 4FD
Tel: 01748 826046
Fax: 01748 826056
Website: www.gnatuk.com

## HIGH ALUMINA BRICKS AND SHAPES

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

**RHI Magnesita**
Kranichberggasse 6, 1120 Vienna, Austria
Tel: +43 50213 0
Email: office@rhimagnesita.com
Website: www.rhimagnesita.com

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## HIGH ALUMINA FIREBRICKS

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

**Trent Refractories Ltd**
Menasha Way, Queensway Industrial Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## INCINERATOR REFRACTORY INSTALLATIONS

**Gunform International Ltd**
33 Carsthorne Road, Carr Lane Industrial Estate, Hoylake, Wirral, Merseyside
CH47 4FB
Tel: (0151) 632 6333
Fax: (0151) 632 6444
Email: info@gunform.com
Website: www.gunform.com

## INDUCTION FURNACE LINING

**Trent Refractories Ltd**
Menasha Way, Queensway Industrial Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## INDUCTION FURNACE REFRACTORIES AND SUPPLIERS

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## KILNS AND DRYERS

**Therser (UK) Ltd**
Walley Street Buildings, Walley Street, Burslem, Stoke-on-Trent, Staffs ST6 2AH
Tel: 01782 824453
Fax: 01782 813227
Email: info@therseruk.com
Website: www.therseruk.com

## KYANITE

**Kyanite Mining Corporation**
30 Willis Mountain Plant Lane, Dillwyn, VA 23936, USA
Tel: +1 434 983 2085
UK & Europe Tel: +44 (0) 746 207 8847
Email: lbertram@kyanite.com
Website: www.kyanite.com

## MICROPOROUS INSULATION

**Promat UK Ltd**
B1 The Innovation Centre, Heywood Distribution Park, Pilsworth Road, Heywood, Lancashire, OL10 2TS
Tel: 0800 588 4444
Email: industryuk@promat.co.uk
Website: www.promat-industry.co.uk

**Siltherm Europe Ltd**
Paramount Court, Corrig Road, Sandyford Business Park, Sandyford, Dublin 18, D18 R9C7, Republic of Ireland
Tel: +353 1 255 1800
Fax: +353 1 495 9201
Email: sales@siltherm.eu
Website: www.siltherm.eu

## MIXERS

**Gunform (Equipment Supplies) Ltd**
33 Carsthorne Road, Carr Lane Industrial Estate, Hoylake, Wirral, Merseyside
CH47 4FB
Tel: (0151) 632 6333
Fax: (0151) 632 6444
Email: info@gunform.com
Website: www.gunform.com

**Markham (Sheffield) Ltd**
Marspal House, Lawn Road Industrial Estate, Carlton-in-Lindrick, Worksop, Nottinghamshire S81 9LB
Tel: (01909) 730861
Fax: (01909) 733584
Email: sales@markham-sheffield.co.uk
Website: www.markham-sheffield.co.uk

*Batching plant and mixing equipment 250-6000 litres*

**Pemat U.K. Ltd**
28 Culley Court, Orton Southgate, Peterborough, Cambridgeshire PE2 6WA
Tel: +44 (0) 1733 390432
Mobile: +44 (0) 7553 374974
Fax: +44 (0) 1733 530002
Email: dan.spencer@pemat.uk
Website: www.pemat.uk

*MIXERS continued . . .*

*Removable and tiltable drum, forced action mixers 3-500 litres*

**Pemat U.K. Ltd**

28 Culley Court, Orton Southgate, Peterborough, Cambridgeshire PE2 6WA
Tel: +44 (0) 1733 390432
Mobile: +44 (0) 7553 374974
Fax: +44 (0) 1733 530002
Email: dan.spencer@pemat.uk
Website: www.pemat.uk

## MONOLITHIC REFRACTORIES

**RHI Magnesita**

Kranichberggasse 6, 1120 Vienna, Austria
Tel: +43 50213 0
Email: office@rhimagnesita.com
Website: www.rhimagnesita.com

**Saint-Gobain Performance Ceramics & Refractories**

Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## MONOLITHIC REFRACTORIES - CASTABLE

**Capital Refractories Ltd**

Station Road, Clowne, Chesterfield
S43 4AB, United Kingdom
Tel: +44 (0) 1246 811163
Fax: +44 (0) 1246 819573
Email: info@capital-refractories.com
Website: www.capital-refractories.com

**Robert Lickley Refractories Ltd**

P.O. Box 24, Dudley, West Midlands
DY1 2UF
Tel: (01902) 880123
Fax: (01902) 880019
Website: www.robertlickley.co.uk

**Saint-Gobain Performance Ceramics & Refractories**

Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

**Trent Refractories Ltd**

Menasha Way, Queensway Industrial Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## MONOLITHIC REFRACTORIES - GUNNING

**Robert Lickley Refractories Ltd**

P.O. Box 24, Dudley, West Midlands
DY1 2UF
Tel: (01902) 880123
Fax: (01902) 880019
Website: www.robertlickley.co.uk

**Saint-Gobain Performance Ceramics & Refractories**

Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

**Trent Refractories Ltd**

Menasha Way, Queensway Industrial Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## MONOLITHIC REFRACTORIES - PUMPABLE

**Trent Refractories Ltd**

Menasha Way, Queensway Industrial Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## MULLITE

**Kyanite Mining Corporation**

30 Willis Mountain Plant Lane, Dillwyn, VA 23936, USA
Tel: +1 434 983 2085
UK & Europe Tel: +44 (0) 746 207 8847
Email: lbertram@kyanite.com
Website: www.kyanite.com

## PRE-CAST REFRACTORY SHAPES

**Robert Lickley Refractories Ltd**
P.O. Box 24, Dudley, West Midlands
DY1 2UF
Tel: (01902) 880123
Fax: (01902) 880019
Website: www.robertlickley.co.uk

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

**Trent Refractories Ltd**
Menasha Way, Queensway Industrial Estate, Brigg Road, Scunthorpe DN16 3RT
Tel: (01724) 858684
Fax: (01724) 281577
Email: enquiries@trentrefractories.co.uk
Website: www.trentrefractories.co.uk

## REFRACTORIES ENGINEERING CONSULTANTS

**Quartis Ltd**
PO Box 138, Cranbrook, Kent TN17 9AF
Tel: (01580) 754747
Fax: (01580) 754949
Email: quartis@fccu.com
Website: www.fccu.com

## REFRACTORIES ENGINEERS

**Quartis Ltd**
PO Box 138, Cranbrook, Kent TN17 9AF
Tel: (01580) 754747
Fax: (01580) 754949
Email: quartis@fccu.com
Website: www.fccu.com

## REFRACTORIES FOR ALUMINIUM

**Capital Refractories Ltd**
Station Road, Clowne, Chesterfield
S43 4AB, United Kingdom
Tel: +44 (0) 1246 811163
Fax: +44 (0) 1246 819573
Email: info@capital-refractories.com
Website: www.capital-refractories.com

## REFRACTORY AGGREGATES

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

## REFRACTORY ANCHORAGE SYSTEMS

**Mach One (International) Ltd**
Unit 8, Norfolk Business Park, Foley Street, Sheffield S4 7YW
Tel: (0114) 270 0545
Fax: (0114) 276 7438
Email: anchors@mach-int.com
Website: www.mach-int.com

## REFRACTORY ANCHORS

**Diamond Anchor Company Ltd**
Unit 2a, Foxwood Road, Dunstan Industrial Estate, Sheepbridge,
Nr. Chesterfield S41 9RF
Tel: (01246) 452617
Fax: (01246) 451787
Email: sales@diamondanchor.co.uk

**Flouch Engineering Co. Ltd**
Hazelhead, Stocksbridge, Sheffield
S36 4HH
Tel: (01226) 763239
Fax: (01226) 370205
Email: contact@refractory-anchors.co.uk
Website: www.refractory-anchors.co.uk

**Mach One (International) Ltd**
Unit 8, Norfolk Business Park, Foley Street, Sheffield S4 7YW
Tel: (0114) 270 0545
Fax: (0114) 276 7438
Email: anchors@mach-int.com
Website: www.mach-int.com

**Thermal Hire Ltd**
Unit 12, Pagefield Industrial Estate, Miry Lane, Wigan, Lancashire WN6 7LA
Tel: +44 (0)1942 620062
Fax: +44 (0)1942 620156
Email: sales@thermalhire.com
Website: www.thermalhire.com

## REFRACTORY BRICKWORK INSTALLATIONS

**S.H.L. Refractories (U.K.) Ltd**
Celcius House, Lawn Road Industrial Estate, Carlton in Lindrick, Worksop,
Nottinghamshire S81 9LB
Tel: (01909) 731959
Fax: (01909) 731579
Email: sales@shl-refractories.co.uk
Website: www.shl-refractories.co.uk

## REFRACTORY GUNNING EQUIPMENT

**Gunform (Equipment Supplies) Ltd**
33 Carsthorne Road, Carr Lane Industrial Estate, Hoylake, Wirral, Merseyside
CH47 4FB
Tel: (0151) 632 6333
Fax: (0151) 632 6444
Email: info@gunform.com
Website: www.gunform.com

**Markham (Sheffield) Ltd**
Marspal House, Lawn Road Industrial Estate, Carlton-in-Lindrick, Worksop, Nottinghamshire S81 9LB
Tel: (01909) 730861
Fax: (01909) 733584
Email: sales@markham-sheffield.co.uk
Website: www.markham-sheffield.co.uk

## REFRACTORY GUNNING INSTALLATIONS

**Gunform International Ltd**
33 Carsthorne Road, Carr Lane Industrial Estate, Hoylake, Wirral, Merseyside
CH47 4FB
Tel: (0151) 632 6333
Fax: (0151) 632 6444
Email: info@gunform.com
Website: www.gunform.com

**S.H.L. Refractories (U.K.) Ltd**
Celcius House, Lawn Road Industrial Estate, Carlton in Lindrick, Worksop, Nottinghamshire S81 9LB
Tel: (01909) 731959
Fax: (01909) 731579
Email: sales@shl-refractories.co.uk
Website: www.shl-refractories.co.uk

## REFRACTORY RECLAMATION AND RECYCLING

**Richmond Reclamation Ltd**
325 Coleford Road, Sheffield S9 5NF
Tel: +44 114 243 3141
Fax: +44 114 256 0088
Email: richmondreclaim@gmail.com

## REFRACTORY SHOTCRETE EQUIPMENT

**Gunform (Equipment Supplies) Ltd**
33 Carsthorne Road, Carr Lane Industrial Estate, Hoylake, Wirral, Merseyside
CH47 4FB
Tel: (0151) 632 6333
Fax: (0151) 632 6444
Email: info@gunform.com
Website: www.gunform.com

**Markham (Sheffield) Ltd**
Marspal House, Lawn Road Industrial Estate, Carlton-in-Lindrick, Worksop, Nottinghamshire S81 9LB
Tel: (01909) 730861 Fax: (01909) 733584
Email: sales@markham-sheffield.co.uk
Website: www.markham-sheffield.co.uk

## SILICON CARBIDE BRICKS

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## SILICON CARBIDE INCINERATION TILES

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## SILICON CARBIDE TILES AND BRICKS FOR INCINERATION, ALUMINIUM AND BLAST FURNACE MARKETS

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## SILICON CARBIDE TILES / SHAPES

**Saint-Gobain Performance Ceramics & Refractories**
Mill Lane, Rainford, Saint Helens
WA11 8LP, United Kingdom
Tel: +44 1744 882941
Email:
ceramics.refractories@saint-gobain.com
Website:
www.ceramicsrefractories.saint-gobain.com

## SILICON METAL POWDER

**S+A Blackwell Ltd**
10 Market Square, Lytham, Lancashire
FY8 5LW
Tel: +44 (0)1253 738121
Fax: +44 (0)1253 735831
Email: sb@sandablackwell.com
Website: www.sandablackwell.com

## SILLIMANITE BRICKS

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

## SPINEL-FUSED AND SINTERED

**DSF Refractories & Minerals Ltd**
Friden, Newhaven, Nr Buxton, Derbyshire
SK17 0DX
Tel: (01629) 636271
Fax: (01629) 636892
Email: sales@dsf.co.uk
Website: www.dsf.co.uk

## STEEL FIBRES

**Fibercon UK Ltd**
Unit 30 Loughborough Technology
Centre, Epinal Way, Loughborough,
Leicestershire LE11 3GE
Tel: +44 (0)1509 211860
Fax: +44 (0)1509 211862
Website: www.fiberconfiber.com

**Fibre Technology Ltd**
Brookhill Road, Pinxton, Nottingham
NG16 6NT, United Kingdom
Tel: (01773) 863100.
Fax: (01773) 580287
Email: info@fibretech.com
Website: www.fibretech.com

## SULPHUR RECOVERY UNITS

**ACCS Ltd**
Scott Lidgett Industrial Estate, Scott
Lidgett Road, Longport, Stoke-on-Trent
ST6 4NQ
Tel: 01782 817107. Fax: 01782 824979
Website: www.accsltd.co.uk

## SUPERVISION/INSPECTION SERVICES

**Quartis Ltd**
PO Box 138, Cranbrook, Kent TN17 9AF
Tel: (01580) 754747
Fax: (01580) 754949
Email: quartis@fccu.com
Website: www.fccu.com

## TESTING AND ANALYSIS

**AMG Analytical Services**
Fullerton Road, Rotherham,
South Yorkshire S60 1DL, England
Tel: (01709) 828500
Fax: (01709) 830391
Email: amg-analytical@amg-s.com
Website: www.amg-s.com

**Lucideon**
Queens Road, Penkhull, Stoke-on-Trent
Staffordshire ST4 7LQ
Tel: (01782) 764444
Fax: (01782) 412331
Email: enquiries@lucideon.com
Website: www.lucideon.com

Seicrim Holdings Ltd
PO Box 133, Cranbrook, Kent TN17 9AF
Tel: (01580) 754747
Fax: (01580) 754949
Email: SHL@fccu.com

## THERMAL INSULATION

**Promat UK Ltd**
B1 The Innovation Centre, Heywood
Distribution Park, Pilsworth Road,
Heywood, Lancashire, OL10 2TS
Tel: 0800 588 4444
Email: industryuk@promat.co.uk
Website: www.promat-industry.co.uk

**Siltherm Europe Ltd**
Paramount Court, Corrig Road,
Sandyford Business Park, Sandyford,
Dublin 18, D18 R9C7, Republic of Ireland
Tel: +353 1 255 1800
Fax: +353 1 495 9201
Email: sales@siltherm.eu
Website: www.siltherm.eu

## ZIRCON BASED REFRACTORY BRICKS CEMENTS AND COATINGS

**Minchem HMP Ltd**
Scott Lidgett Industrial Estate, Scott
Lidgett Road, Longport, Stoke-on-Trent
ST6 4NQ
Tel: (01782) 819616
Fax: (01782) 837174
Email: minchemhmp@btconnect.com

## President:

Mrs K. Moss, M.I.Ref.Eng.

## Senior Vice-President:

Awaiting appointment

## Past Presidents:

1962/63* R. Mayorcas, B.Sc., F.Inst.E., F.I.Ref.Eng.
1963/64* A. J. Mann, F.I.Ref.Eng.
1964/65* H. M. Richardson, B.Sc., F.R.I.C, F.I.Ceram., F.I.Ref.Eng.
1965/66* H. Jones, F.I.Ref.Eng.
1966/67* R. Malcolm, B.Sc., A.R.I.C, F.I.Ref.Eng.
1967/68* G. Deans, F.I.Ref.Eng.
1968/69* R. Lickley, F.I.Ref.Eng., M.I.B.F.
1969/70* F. Brunt, F.I.Ref.Eng., M.I.B.F.
1970/71* D. J. Quirk, B.Eng., F.I.Ref.Eng.
1971/72* J. F. Clarke, F.I.Ref.Eng.
1972/73* J. Cairns, DRTC, F.I.Ref.Eng.
1973/74* W. G. Bullock, F.I.Ref.Eng.
1974/75 C. K. Walker, F.I.Ref.Eng.
1975/76* E. Staton, F.I.Ref.Eng.
1976/77* W. B. Black, F.I.Ref.Eng.
1977/78 M. J. Mason, F.I.Ref.Eng.
1978/79* K. D. Hunter, C.Eng., M.I.Mech.E., F.I.Ref.Eng.
1979/80 W. H. Hawkes, F.I.Ceram., F.I.Ref.Eng.
1980/81 C. W. Hardy, F.I.Ref.Eng.
1981/82* N. W. Hinchcliffe, F.I.Ref.Eng.
1982/83* E. Pinder, F.I.Ref.Eng.
1983/84* G. T. Sutton, F.I.Ref.Eng.
1984/85* G. C. Padgett, BSc., PhD., M.I.Ceram., F.I.Ref.Eng.
1985/86 P. Greenwood, F.I.Ref.Eng.
1986/87 J. F. Casewell, F.I.Ref.Eng.
1987/88* J. L. Evans, B.Met., Ph.D., F.Inst.E., F.I.Ceram., F.I.Ref.Eng., C.Eng.
1988/89* T. J. Partridge, F.I.Ref.Eng.
1989/90 P. W. Atthis, C.Eng, F.I.Ceram., F.I.Ref.Eng., M.I.M.
1990/91* J. M. Thornton. M.B.E., F.I.Ref.Eng., F.I.B.F., F.I.M.
1991/92 S. Smith, Dip.Ceram., F.I.Ceram., F.I.Ref.Eng.
1992/93* J. W. Harold, Dip.Ceram., F.I.Ref.Eng.
1993/94 P. K. Manser, F.I.Ref.Eng.
1994/95 B. Sansby, M.I.M., M.I.B.F., F.I.Ref.Eng.
1995/96 F. T. Palin, Eur Ing, C.Eng., Dip.Ceram., M.Phil, Ph.D. F.I.M., F.I.Ref.Eng.
1996/97* C. M. Hunt, F.I.Ref.Eng.
1997/98 B. M. Davies, F.I.Ref.Eng.
1998/99 R. M. Hanley, F.I.M., F.I.Ref.Eng.
1999/2000 D. A. Jarvis, Eur Ing, C.Eng., F.I.M., F.I.Ref.Eng.
2000/01 J. May, B.Sc, A.R.S.M., F.I.Ref.Eng.
2001/02 D. C. Woodhead, F.I.Ref.Eng.
2002/03 M. R. Clark, F.I.Ref.Eng.
2003/04 A. J. Baylay, F.I. Ref.Eng.
2004/05 P. C. Stevens, B.Sc., F.I.Ref.Eng.
2005/06 P. Bottomley, M.Sc, M.I.MMM, F.I.Ref.Eng.
2006/07 S. A. Franklin, C.Eng., B.Sc., Ph.D., F.I.M.M.M.,
2007/09 T. Staton, C.Eng., B.Tech., M.I.MMM, F.I.Ref.Eng.
2009/11 P. Rooney, M.Sc., F.I.Ref.Eng.
2011/13 C. Windle, BSc Hons, F.I.Ref Eng., MIM3, FSGT.
2013/15 K. Andrews, B.Met., B.Sc., M.Sc., F.I.Ref.Eng.
2015/17 C. Arthur, F.I.Ref.Eng.
2017/19 J. D. Theron, B.Tech Chem Ing, F.I.Ref.Eng.

* Deceased

## General Secretary & Treasurer:

575 Trentham Road, Blurton, Stoke-on-Trent, Staffs ST3 3BN, UK
Email: secretary@ireng.org

## Branch Secretaries:

M. Walton (Australia)

## Council (Elected Members):

P Bottomley (Chairman)
S. Smith
P. Rooney
D. C. Woodhead
P. F. Bell
D. Oates
M. Lamkin
M. Prince (Australia)

Institute of Refractories Engineers

The Refractories Engineer is published six times a year and is circulated to Members of the Institute of Refractories Engineers.

Whilst every effort is made to ensure the accuracy of material submitted, the Institute of Refractories Engineers cannot be held responsible for comments made by contributing authors.

**Advertisement Sales:**
Email: advertising@ireng.org

**Editorial Content:**
General Secretary & Treasurer
Email: secretary@ireng.org

**Design & Artwork:**
Advertising Matters Ltd



Website: www.irengineers.co.uk