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THE REFRACTORIES ENGINEER

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The Official Journal of the Institute of Refractories Engineers

September 2019

THE
REFRACTORIES
ENGINEER

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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.

General Secretary's Report

Dear Members

For most of us in the UK, the holiday season is coming to the end and the nights are starting to draw in, were has the year gone? Time seems to fly past.

We are now in full swing preparing for the conference, training day and AGM. We published the first draft of our accounts in the last journal, there were a few minor errors mainly due to incorrect codes on some of the costs, these have now been corrected, they do not change the final bottom line only where some of the cost have occurred, we have still lost £2167 in the year to Dec 18 although £1720 of this is what I call a virtual loss, it is a loss on converting Australian dollars to pounds, as we report our accounts in pounds we have to convert the value of the money held in Australia in Australian dollars to pounds and any difference in exchange rate used means there is a positive or negative compared to last year even though there could be the same number of dollars in the bank.

The big difference in accounts for 2018 compared to 2017 is the bad debts we had a company go out of business owing for a front cover and many members who did not pay their subs and as a result they have been removed from our membership list, and no longer receive the journal.

We have almost completed the preparations for the conference. This year we are at Aston Hall Hotel which is just off junction 31 of the M1, but it is a smaller hotel and therefore there are fewer rooms available so please book as soon as possible, I have rooms reserved but we will soon reach a point where we have to pay for them or let the hotel have them back.

Our next council meeting is in October where we will be having a presentation by a marketing company following our recent survey, we are looking at how best to increase the Institutes profile and increase membership numbers, I think this will interesting.

If anyone has any ideas on this subject please put them on an email to me. This is a subject that is very important to us all.

Jayne Woodhead
General Secretary & Treasurer
Institute of Refractories Engineers

President's Column

Dear Members and Colleagues

Last time I complained about the summer weather, and indeed there was a slight improvement with the rare occurrence of having a brilliant summer bank holiday weekend! I know that many of you reading this in Australia, South Africa and some other parts of the world do not suffer from the same weather fever than those of us living in the UK, and therefore may not appreciate our obsession with the weather. All of you in the Southern hemisphere will be looking forward to the fast approaching summer, I guess? - whilst I will be installing a wood burner!

In the previous journal I touched on the aspect of incompetence (if I am allowed to use such a strong word) due to a lack of proper training. I suppose this has been an ongoing topic over the last two years. The fact that there are no fixed regulations around refractory design and installation (something we touched on during the 2018 conference as an open discussion), does not make it any easier to drive and implement training programs.

Soon we hope to have a plan on the table on how to approach training in a better way. It, however, does seem from preliminary discussions that there may be a need for changes in the structure and offering of the Institute. We are signing up new members every year, but so do we lose just about as many due to retirement. Without knowing the exact details, I would guess that the average age of the current members are most probably above 50. Could be an interesting exercise to actually calculate this even though it is mostly just for general interest. What we do know is about to happen, is that this average age will most likely stay there, or even slowly creep up, in the foreseeable future. Then there will be either a complete collapse of the Institute to the extent of non-existence or a complete change over in the way it operates as the remaining members will be young and from a different generation. This sounds familiar? It reminds me of the same discussions about climate change; we either going to destroy the planet and die or we will have to change the way we live.

The age distribution of refractory engineers has a somewhat odd shape and in some way this is going to influence the way any change is going to occur. We have a gap with very little middle age people. In the make-up of refractory engineers, the industry as a whole (in the Western world for sure) has not had a regular intake of young engineers over time. A large number of refractory engineers dates from the 1950's to 1970's and that is clearly seen in the amount of research that was done during that time. However, the industry has changed and a large number of these people had to find other professions whereas at the same time it limited the prospects of undergraduates to be attracted to the life of a refractory engineer. This unfortunately created a bit of a gap in the age range of active refractory engineers.

I have asked some of the younger engineers involved in refractories why they are not interested in joining the IRE. The answers so far have been very vague, and I am not even sure they know the exact reasons. It is almost as if it is just not something that they even consider doing. Receiving a journal and attending a conference just do not seem to excite them at all. The world out there has a new face for the younger generation (the ones younger than 35 or is it even lower?) and it is all about information readily available in the palm of your hand. Do we as the Institute provide this kind of service? I had a look at Google, and you can find about anything there; how to pack and light a tobacco pipe, how to sharpen a knife on a wet stone, and the list goes on and on…. However, when it comes to refractory questions, the information is much less and more difficult to obtain. We have found a very old "Good Practices Guide for Installing Monolithics", and the challenge is now to modernise it.

At the moment I have the privilege to work with a young graduate on a project involving lithium attack on refractories. Two things strike me, one is her enthusiasm for the subject and the other is how little is known about it. I could see the IRE being involved in these type of things, but it is the "how" that boggles my mind.

A few words about the conference in November 2019. We have a full program with interesting papers. A list of the speakers are given in the journal. Make sure you come join this event. It has always been considered a very sociable day and a good time to make a few new friends and learn a few more new things.

Until next time, take care.

Jan DuPlessis Theron
President
Institute of Refractories Engineers

Advances in the use of Refractories in the Petrochemical Industry

Wednesday 13 November

Confirmed speakers include:

Title	Name	Company
Solutions in Practice	Ing. Wim A J Kastelic	W/mKastelic Refractories Services
Waste Heat Boiler tube sheet solutions	Joost Meeuwissen	Calderys, Netherlands
Real Time Monitoring of Refractory Lining Status	Mr Steven Reumschuessel	Saveway, Germany
Stuck in the 90's (alumina)	Chris Windle	DSF
Refractory Design in Petrochemical Industries in relation to Thermal Shock	Peter Plaizier	Gouda
Raw Material concepts for For SiO2 free high Performance castables in Petrochemical application	Sebastian Klaus	Almatis
SRU Reaction Refractory Furnace Lining design	Guiseppe Pattenati	Harbison Walker International Limited

TRAINING DAY 2019

Thermal Shock & Thermal Stresses - Thursday 14 November

The Institute of Refractories Engineers has run a Training Day since 2008, in line with the Institute aims which include the promotion of education and training in refractories. Our training days have always received positive feedback with many companies sending people on the courses each year.

Thermal shock damage occurs when refractories are heated or cooled too rapidly and thermal stresses develop which are high enough to cause cracking and failure. Thermal shock is different to damage due to insufficient expansion allowance (eg pinch spalling) or from steam generation in monolithic refractories (explosive spalling).

This course provides an insight into an important aspect of refractory wear and degradation, thermal stresses and thermal shock.

Topics covered will include:

- What is thermal shock
- Understanding thermal stresses
- Predicting thermal shock
- Thermal modelling
- Other types of thermal stress related damage

The course will be made up of lectures and small group exercise work. Some prior knowledge of refractory materials and their properties is assumed.

We provide those attending with a certificate of attendance and a copy of the presentations.

Venue: Aston Hall Hotel, Worksop Road, Aston, Sheffield S26 2EE

Notice is hereby given that the

58th Annual General Meeting of the Institute of Refractories Engineers

will be held at 12.30 pm on Wednesday 13th November at

Aston Hall Hotel, Worksop Road, Aston, Sheffield S26 2EE, UK

President Mr J Theron will preside
By order of the General Council

Agenda

1. To receive apologies.

2. To approve the Minutes of the 57th Annual General Meeting held on 14th November 2018 at Tankersley Manor, Barnsley.

3. To approve the General Council's appointment of Officers of the Institute for the year 2019/2020

   President 2019/2021 Mrs Katy Moss (becomes President after election as Senior Vice President in 2018)
   Senior Vice President 2019/20 Mr Jan Theron.

4a. To re-elect, elected Members of Council.

4b. To elect any other members of Council nominated prior to the meeting date.

5. To receive a joint report from the Chairman of the Executive Committee and the General Secretary on the Management and Operations of the Institute.

6. To approve General Council's recommendation that the published audited accounts for the period ending 31st December 2018, to be accepted.

7. To approve the General Council's recommendation that the subscriptions for 2020 is as follows:

   Full Members £75.00
   Members under 25 undergoing training £37.50

8. To appoint Short's Accountants (Sheffield) as the Institute's accountants for the financial year 2020.

9. AOB.

Any amendments to this agenda will be posted on the Institute's website www.irengineers.co.uk not later than two weeks prior to the meeting

Members who wish to record votes on any item on the Agenda and who cannot themselves be present at the Annual general Meeting may arrange with the General Secretary, or with any members of the Council, to vote on their behalf by proxy.

If it is any member's intention to vote they should furnish the General Secretary with instructions, in writing, giving full details of the item on the Agenda they are concerned with. And whom they wish to appoint as their proxy.

Any member not attending the Annual General Meeting, and not arranging such a proxy vote, will be deemed to be in favour of all resolutions, approved at the Annual General Meeting by the members there present.

DRAFT INCOME AND EXPENDITURE ACCOUNT
YEAR ENDED 31 DECEMBER 2018

	Note	2018 £	2018 £	2017 £	2017 £
INCOME					
Subscriptions and entrance fees			20,336		17,528
Journal advertising			24,811		25,495
E-directory			4,863		1,650
Conference fees UK/Australia			10,453		19,821
Training			2,990		2,015
Bank interest received			370		408
Publishers licence fees			602		758
Branch social fund raising			-		-
Dinner dance			-		-
			64,425		67,675
EXPENSES					
Meeting expenses		-		-	
National Dinner Dance		-		-	
Branch social events		-		-	
		-		-	
Journal					
Journal printing and distribution		22,434		23,859	
Journal e-directory		-		-	
Editorial costs		-		-	
		22,434		23,859	
Depreciation					
President's regalia		-		-	
		-		-	
Other expenses					
Telephone		527		550	
Computer expenses		2,718		1,665	
Printing, stationery and postage		367		312	
General Secretary and office expenses UK/Australia		663		3,085	
Insurance		816		812	
Conference and exhibition costs		9,659		17,702	
Credit card and bank charges		497		787	
General Secretary		13,368		11,568	
Branch Secretaries' honoraria		100		-	
Presidents/Chairman's honoraria		850		850	
Marketing costs		295		569	
Training		-		178	
Accountancy support fees		1,410		953	
Audit & accountancy fees		2,150		2,500	
Bad and doubtful debts		8,001		700	
Mileage		499		1,218	
Exchange rate difference		1,720		303	
		43,248		43,752	
			65,682		67,611
NET SURPLUS/(DEFICIT) FOR THE PERIOD			(1,257)		64
Capital account at the beginning of the year			164,964		164,900
Surplus/(deficit) for the period			(1,257)		64
Capital account at the end of the year			163,707		164,964

DRAFT BALANCE SHEET
31 DECEMBER 2018

	Note	2018 £	2018 £	2017 £	2017 £
FIXED ASSETS	2		-		-
CURRENT ASSETS					
Debtors	3	22,671		11,784	
Bank deposit accounts		27,608		17,352	
Cash at bank	4	116,239		139,733	
		166,518		168,869	
CURRENT LIABILITIES					
Creditors	5	2,811		3,905	
NET CURRENT ASSETS		163,707		164,964	
NET ASSETS		163,707		164,964	
FINANCED BY:					
CAPITAL ACCOUNT					
Original balance brought forward			164,964		164,900
Net surplus / (deficit) for the period			(1,257)		64
			163,707		164,964

The Members of the Council acknowledge their responsibilities for:

(i) ensuring that the Institute keeps proper accounting records which comply with the Rules; and

(ii) preparing financial statements which give a true and fair view of the state of affairs of the Institute as at the end of the financial year and of its surplus/(deficit) for the financial year in accordance with the requirements of the Rules.

The financial statements have been prepared in accordance with the provisions applicable to companies subject to the small companies' regime and in accordance with the provisions of FRS 102 Section 1A - small entities.

The finalised audited accounts will be published in the November 2019 issue of The Refractories Engineer.

P. Bottomley. Chairman of the Executive Committee.

NOTES TO THE FINANCIAL STATEMENTS
FOR THE YEAR ENDED 31 DECEMBER 2018

1. Accounting policies

Basis of accounting

The financial statements have been prepared under the historical cost convention, and in accordance with Section 1A of Financial Reporting Standard 102, the Financial Reporting Standard applicable in the UK and the Republic of Ireland and the Companies Act 2006.

Cash flow statement

In the opinion of the Council the Institute qualifies as a small entity and accordingly a cash flow statement is not required.

Income

The subscription and entrance fees income represents the amounts due from members for the period after adjusting for subscriptions in advance.

The journal advertising income represents the amounts due for the period for services provided, exclusive of Value Added Tax.

All other income represents amounts due for the period for services provided.

Depreciation

Depreciation is calculated so as to write off the cost of an asset, less its estimated residual value, over the useful economic life of that asset as follows:

Presidents regalia - 5% straight line basis.

UK Branches
All income, expenses, assets and liabilities for the UK branches for the year ended 31 December 2018 and 2017 are recognised in full within the financial statements.

Australia Branch
All income, expenses, assets and liabilities for the Australian branch for the years ended 31 December 2018 and 2017 are recognised in full within the financial statements after being translated at the appropriate exchange rate.

South Africa Branch
The net contribution paid to the UK is recognised as income. No assets or liabilities of the branch are shown within the financial statements

2. Tangible fixed assets

	President's regalia
	£
Cost	
At 31 December 2017 and 31 December 2018	788
Depreciation	
At 31 December 2017 and 31 December 2018	788
Net book value	
At 31 December 2017 and 31 December 2018	-

3. Debtors

	2018	2017
	£	£
Trade Debtors		
Advertising debtors	6,017	4,872
Subscriptions overdue	8,903	3,378
Buyers Guide debtors	3,286	340
Training	48	-
Conference fees debtors	2,798	705
	21,052	9,295
Other debtors	1,619	2,489
	22,671	11,784

4. Cash at bank

	2018	2017
	£	£
Main	104,535	115,720
Stoke	1,920	1,920
North West	-	-
Sheffield	1,496	1,496
Australia	8,288	20,597
	116,239	139,733

5. Creditors: Amounts falling due within one year

	2018	2017
	£	£
Creditors and accrued charges	2,811	3,905

6. Contributions in the event of a winding up
Every member of the Institute undertakes to contribute to the assets of the Institute in the event of its being wound up. This applies while he is a member or within one year afterwards for payment of the debts and liabilities of the Institute contracted before he ceases to be a member and of the costs, charges and expenses of winding up and for the adjustment of rights of the contribution amongst themselves such amount as may be required not exceeding one year's annual subscription.

7. Taxation
The Institute's mutual income (subscriptions and conference fees) is not chargeable to corporation tax.
No tax charge arose on the remaining income in the year and as at 31 December 2018 corporation tax losses carried forward totalled £129,755 (2017 - £123,513).

8. Related party transactions
The related parties are the members of The Institute of Refractories Engineers. During the year the following expenses will have been paid to members:

	£
General Secretary and office expenses	1,511
General Secretary	13,368
Mileage	153

BRANCH INCOME AND EXPENDITURE ACCOUNTS YEAR ENDED 31 DECEMBER 2018

	Main Institute	NW Branch	Sheffield	Stoke	Australia	Cons.Adj	Total
	£	£	£	£	£	£	£
INCOME							
Subscriptions and entrance fees	20,336						20,336
Journal advertising	24,811						24,811
E-directory	4,863						4,863
Conference fees	9,652				801		10,453
Training	2,990						2,990
Bank interest received	-				370		370
Publishers Licence Fees	602						602
Branch social fund raising							-
Dinner Dance							-
Total Income	63,254	-	-	-	1,171	-	64,425
EXPENSES							
Meeting expenses							-
National Dinner Dance							-
Branch social events							-
Journal							
Journal printing and distribution	22,434						22,434
Journal E-Directory	-						-
Editorial costs	-						-
Other expenses							
Telephone	75						75
Computer expenses	2,522				102		2,624
Printing, stationery and postage	301						301
General Secretary and office expenses	848				663		1,511
Insurance	607				209		816
Payments/Grants to branches	-						-
Conference and exhibition costs	9,563				96		9,659
Credit card and bank charges	373				124		497
General Secretary	13,368						13,368
Presidents honoraria	850						850
Branch Secretaries' honoraria	100						100
Marketing costs	-						-
Training	13						13
Accountancy support fees	1,100				310		1,410
Audit and accountancy fees	2,150						2,150
Bad and doubtful debts	8,001						8,001
Mileage	153						153
Exchange rate difference					1,720		1,720
Total Expenses	62,458	-	-	-	3,224	-	65,682
NET SURPLUS/ (DEFICIT) FOR THE PERIOD	796	-	-	-	(2,053)	-	(1,257)

Institute of Refractories Engineers

CONFERENCE & TRAINING DAY BOOKING FORM

ANNUAL CONFERENCE 2019

Advances in the use of Refractories in the Petrochemical Industry

Wednesday 13 November

TRAINING DAY 2019

Thermal Shock & Thermal Stresses

Thursday 14 November

Venue: Aston Hall Hotel, Worksop Road, Aston, Sheffield S26 2EE

Name.....Company.....

Tel.....Email .....

Postal Address .....

.....

.....

.....Postcode.....

Conference Day

Wednesday 13/11/19 (Includes lunch)

Member..... ☐ £95.00

Non-member ..... ☐ £120.00

Student/Retired..... ☐ £50.00

Conference Dinner

Wednesday 13/11/19 (Includes wine) 7-00 for 7-30 pm

All Welcome ..... ☐ £35.00 inc. VAT

1 Night Bed & Breakfast..... ☐ £85.00

Training Day

Thursday 14/11/19 (Includes lunch & refreshments)

Member ..... ☐ £75.00

Non-member ..... ☐ £100.00

Total .....

On the receipt of your booking an invoice will be issued so that you can pay by card using sage pay

Places are limited so please book early

To reserve a place please contact the IRE General Secretary - email secretary@ireng.org or send the booking form to:

Mrs J. Woodhead, General Secretary & Treasurer
Institute of Refractories Engineers
575 Trentham Road, Blurton, Stoke-on-Trent, Staffordshire ST3 3BN

Tel: 0044 (0) 1782 310234

steeluniversity

steelChallenge-14

Regional Championship | 27 November 2019

Join the challenge

The World Steel Association (worldsteel) opened registration for the 14th edition of steelChallenge. steelChallenge is the biggest steel industry competition where students and industry employees can test their skills using the sophisticated online process simulations delivered by steeluniversity.

steelChallenge-14 will be take place over two rounds. The Regional Championship will take place online on 27 November 2019 from 12.00 UTC. Participants will access the competition from the steeluniversity website and will have 24 hours to record at least three successful runs of the electric arc furnace and secondary steelmaking simulations; producing the required steel at the lowest cost.

The finalists for the World Championship will include the top student and industry person in each of the following regions:

Americas,
Asia – East and Oceania,
Asia – North,
Asia – West, and
Europe and Africa.

The World Championship will be in person on 21 April 2020 in London, United Kingdom.

The Regional Champions receive a cash prize, a travel allowance to attend the World Championship in London, a tablet and a certificate. They will also gain recognition as the global industry's promising new generation of metallurgists and will be featured on steeluniversity's website. The World Champions will take home the steelChallenge trophy and receive an additional cash prize and certificate.

Participants can register for steelChallenge-14 now at steeluniversity.org. Registration is free for students. There is a small fee for industry employees.

Vesuvius' Employee app V.LINK was awarded bronze at the Internal Communications and Engagement Awards 2019

This achievement at the first annual awards recognises Vesuvius' excellence in internal communications.

Held at the iconic Brewery, in central London on 13 May, the 2019 event welcomed attendees from a variety of companies and agencies, all vying for the coveted prizes on offer.

"V.LINK – Stronger, Faster, Together"

Operating across 38 countries, many of Vesuvius' employees work away from desks and so do not have access to the normal channels of communications. The challenge was how to enable global communications that would reach and engage all colleagues, communications from the top down and peer to peer to enable collaboration.

Working very closely with Black Sun, V.LINK was developed. An employee App that would enable global communications and that all employees would be able to access. Through consultation with the business leadership and employees it was ascertained which content would be the most engaging for colleagues and an App structure and content was developed that would deliver this content both for launch and ongoing.

The App name, icon and design were developed to live the Vesuvius brand and encourage engagement. We also established an editorial board with broad representation to facilitate the ongoing production of content and to have local 'champions' in the business.

A successful launch was key to the success of the programme, and so the "Stronger, Faster, Together" campaign was created that raised awareness and encouraged colleagues to download the App. This included a launch video, posters, animated screen savers, and emails. We also ensured that through the App colleagues could access the key internal systems such as holidays or staff awards which also drives visits.

"The V.Link App has been a great success, with employees downloading and engaging with the content. Adoption by the senior management team has also encouraged broader use, and the content has been sustained since the App was launched. Highly positive feedback has been received internally" - Saida Berrahal.

UK Steel welcomes climate funding

The British Government is to spend an estimated £250 million on cleaning up the steel industry, according to a number of online media reports.

The aim of the expenditure is to gun for zero greenhouse gas (GHG) emissions by 2050 and there are also plans to encourage business to match the funding and support other methods of reducing emissions, such as industrial carbon capture and alternative fuels, such as biomass.

According to Reuters, a total of £390 million will be available, £250 million of which will come from the Clean Steel Fund, and a further £100 million to develop the production of hydrogen, which emits no GHGs when burned.

Gareth Stace, director-general of UK Steel, said the Clean Steel Fund was 'extremely positive news' for UK steelmakers and the whole of the UK's decarbonisation efforts. He added that the fund was a vital step towards further reducing 'our carbon footprint' in the UK and 'will cement our position in a future low-carbon world'.

"Recent years' Government policy of carbon taxation and renewables funding has added costs to steel production through higher energy bills," said Stace. "As steel is an intensively traded product, this has had a negative impact on the sector's competitiveness and leads to fears that we are exporting steel production, its jobs, and emissions, rather than lowering emissions at home.

"It is crucial that the Clean Steel Fund is designed in a manner that can be best used by the steel sector and make maximum use of funds allowed by state aid. This is not a time to be too cautious, as UK steelmakers face an uncertain business environment. The Government needs to move swiftly to secure a bright future for the sector while addressing the elements which undermine our competitiveness."

- There are a number of important facts that readers need to know regarding the price of energy for UK steelmakers. In a report entitled The Energy Price Scandal, published in December 2018, it was pointed out that:-

1. UK steel producers pay twice as much for electricity as their competitors in France and 50% more than in Germany.
2. The electricity price disparity between German and UK power prices faced by steelmakers has increased from £18/MWh in 2017/18 to £22/MWh in 2018/19; and between French and UK power prices from £17/MWh in 2017/18 to £34/MWh in 2018/19.
3. The difference between German and UK electricity costs is the equivalent of £55 million a year to the sector.
4. Consistently higher UK electricity prices deter investment, ultimately endangering UK steel production and jobs.
5. Achieving parity with Germany could deliver a £55 million investment in the sector, a 30% increase in capital investment.

Published September 02, 2019 by Matthew Moggridge, Steel Times International.

Salzgitter AG builds new hot dip galvanizing line

- Qualitative growth in the strip steel business
- Reinforcing of the premium segment for automotive customers
- Contribution to securing Salzgitter as a steel location

Salzgitter Flachstahl GmbH (SZFG), a subsidiary of Salzgitter AG, has launched its "Hot Dip Galvanizing 3" (FV3) project and one of its largest single investments of the last decade. The plant engineering SMS Group based in Düsseldorf is the company's project partner.

The new production facility, with an annual capacity of 500,000 tons, supplements SZFG's already existing hot dip galvanizing lines. "This project is a key component in the strategy of the Salzgitter Group that focuses on qualitative growth for its strip steel business. It will help us strengthen our market position as a producer of premium products for national and international customers from the automotive industry. We have decided to make this investment, even though the political and social framework conditions for major industrial projects in Germany and Europe are currently going in an unfavorable direction," explains Prof. Dr.-Ing. Heinz Jörg Fuhrmann, Chief Executive Officer of Salzgitter AG.

FV3 is due to become operational in 2022. Advanced-high strength steels for chassis and body applications that play an important role in lightweight automotive construction and in vehicle security are then to be produced.

Ulrich Grethe, member of the Group Management Board and CEO of SZFG's Management Board: "At the same time, FV3 is also important for securing the sustainability of Salzgitter as a steel location and the jobs there, as this investment will enable us to further optimize our already high quality product portfolio." The new facilities will produce hot-dip galvanized strips with thicknesses of between 0.7 and 2.5 millimetres and width of between 900 and 1,700 millimetres. The strip that is wound into coils has a maximum weight of 32 tons.

The production of high-strength and advanced-high strength steel grades is enabled through the very high cooling rates and the integration of an oxidization/reduction process in FV3's furnace. "The range of materials will cover advanced-high strength dual-phase steels through to complex phase steels and on to quench and partitioning steels," explains Dr.-Ing. Michael Brühl, General Manager of cold-rolled flat products at Salzgitter Flachstahl GmbH. The configuration of the facilities as a whole offers the structural and technical prerequisites for realizing further innovative materials concepts.

RHI Magnesita robust performance despite difficult end markets

RHI Magnesita, the leading global supplier of refractory products, systems and services, today announces its results for the six months ended June 30, 2019. "I am pleased to announce a robust financial performance in the first half of 2019," says Stefan Borgas, CEO RHI Magnesita. "Despite difficult end markets, we have seen a very strong performance from our Industrial Division, offsetting a slightly softer performance from the Steel Division in more challenging market conditions."

- The uncertainty in the steel markets is increasing. The results show lower volumes and a selective market share loss in Steel in Europe and North America, partly driven by customer destocking after a strong 2018. "Against this backdrop, we have seen the benefits of both our geographic and market diversification, as well as the strength of our operating platform. As a result, these challenges have so far been offset by our strategic initiatives. These include the benefits generated by our growth strategies, particularly in the Industrial Division and across Asia, as well as our ability to secure price increases," explains Borgas.
- Growth markets continue to perform strongly. In China, RHI Magnesita won its first major solutions contract alongside revenue growth of 17%. The Indian revenue grew by 16%.
- The company shows good margin performance, despite less supportive raw material backdrop.
- The expected additional €20 million synergy benefit for 2019 is firmly on track. Improvement plans to recover €20 million in 2019 of the €40 million operating under performance during 2018, relating to four plants, are progressing in line with expectations. Some working capital expansion in H1 2019 is expected to be partly recovered by year end.

Future Steel Forum • 25-26 September 2019
Budapest • Hungary

Industry 4.0 and the steelmaking process

If you want to know what's happening in the world of ultra-high technology and the production of steel, then look no further than the steel conference dedicated 100% to Industry 4.0 and how it – and its related technologies – can aid and optimise the steel manufacturing process.

UNITECR 2019

The 16th United International Technical Conference on Refractories (UNITECR) will be held 13-16 October in Yokohoma, Japan.

UNITECR is the international technical refractories conference established in 1987 founded by four member associations: the American Ceramic Society, the German Refractories Association, Association Latinoamericana de Fabricantes de Refractarios and the Technical Association of Refractories, Japan. Three other associations, the Chinese Ceramic Society, the Indian Refractory maker's Association and Fédération Européenne des Fabricants de Produits Réfractaires, have also joined as principal members to successfully organize the conference.

The concept of the UNITECR 2019 is: "Refractories for the Future: Collaboration among Customers, Manufacturers and Academia in pursuit of Future High-Temperature Technology." UNITECR 2019 will present the world with the future of high-temperature technologies, to help making environmentally friendly world with conserving natural resources.

International Colloquium on Refractories

The International Colloquium on Refractories is a world renowned event held in the imperial city of Aachen, Germany.

Alternating annually between the topics "Suppliers Industries enabling Refractories" and "Refractories enabling High Temperature Technologies", this event takes place with up to 600 attendees.

The congress is accompanied by a trade exhibition at which 30 worldwide operating national and international companies exhibit.

The 62nd International Colloquium on Refractories is taking place on 25 to 26 September 2019.

July 2019 crude steel production

World crude steel production for the 64 countries reporting to the World Steel Association (worldsteel) was 156.7 million tonnes (Mt) in July 2019, a 1.7% increase compared to July 2018.

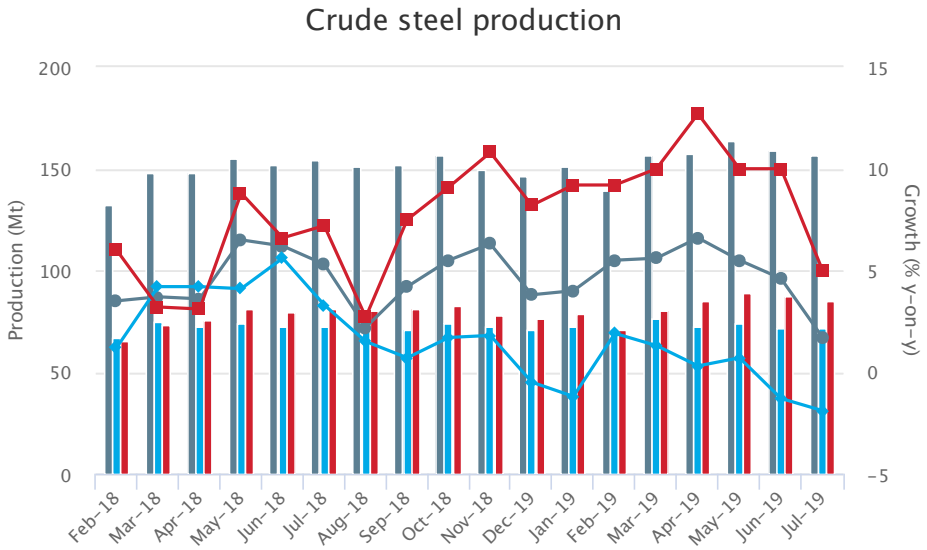
China's crude steel production for July 2019 was 85.2 Mt, an increase of 5.0% compared to July 2018. India produced 9.2 Mt of crude steel in July 2019, an increase of 1.7% compared to July 2018. Japan produced 8.4 Mt of crude steel in July 2019, down 0.4% on July 2018. South Korea's crude steel production was 6.0 Mt in July 2019, a decrease of 2.1% on July 2018.

The US produced 7.5 Mt of crude steel in July 2019, an increase of 1.8% compared to July 2018.

Brazil's crude steel production for July 2019 was 2.4 Mt, down by 20.7% on July 2018.

Turkey's crude steel production for July 2019 was 2.9 Mt, down by 10.6% on July 2018.

Crude steel production in Ukraine was 1.8 Mt this month, down 1.7% on July 2018.



Lucideon sets sights on global expansion and jobs growth

World-leading materials technology company Lucideon is on course for major expansion with plans to grow its team of scientists, researchers and support staff by more than 20 per cent this year.

The organisation, which has its headquarters in Stoke-on-Trent, has already brought on board 34 new members of staff this year with a further 20 new recruits expected to join by the end of the year.

It brings the team to 240, with the majority of the new jobs created at Lucideon's global headquarters in Stoke-on-Trent.

Tony Kinsella, Lucideon's Chief Executive, said: "Lucideon is world-renowned for its expertise in the aerospace, defence, construction, nuclear, healthcare and technical ceramics sectors, and we have ambitions to grow globally.

"We are currently a £20 million business but are confident we can develop to between £60 million and £80 million over the next few years.

"Since January we have welcomed 34 new members of staff to the company and we anticipate a further 20 people will join us by the end of the year."

Among the new recruits joining Lucideon are three accomplished PhD graduates working from the company's Stoke-on-Trent HQ - Dr Samira Bostanchi, Dr Agata Lapa and Dr Elliot Douse.

Dr Bostanchi is a PhD graduate of the University of Sheffield and joins Lucideon's Flash Sintering team as a Ceramics Technical Consultant.

She has a background in Physics (BSc) and Nanoscience (MSc) which she further explored during her PhD, and is focussing on ceramics processing for artificial hip replacement applications.

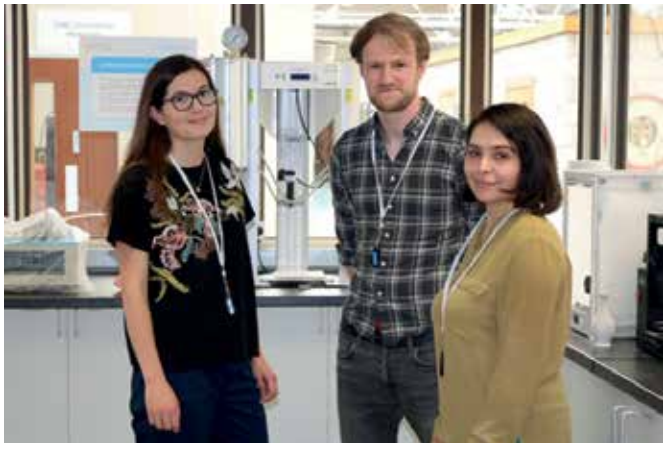
Dr Lapa joins the Advanced Materials and Processes team working on healthcare, agriculture and geopolymers projects, exploring new applications for glass and ceramics.

After finishing a degree in Biomedical Engineering in Kracow, Poland, she was a PhD student in the European Funded Project HyMedPoly - a European collaboration between universities and industrial institutions such as Lucideon.

Finally, Dr Douse joins the organisation as a technical consultant following his research in ceramics for aerospace applications.

A Chemistry graduate from University of Surrey he furthered his studies at the University of Birmingham with a research fellowship exploring ceramic materials in manufacturing.

Tony Kinsella added: "These are exciting times for the organisation and we are delighted to welcome these three highly accomplished scientists, who bring great expertise and fresh thinking to our business."



L-R Agata Lapa, Elliot Douse, Samira Bostanchi

Turkish army pension fund to buy British Steel

Turkey's military pension fund has reached a tentative deal to buy British Steel out of insolvency.

The Turkish Armed Forces Assistance Fund (known as Oyak) says it plans to take over British Steel, which employs 5,000 people, by the end of the year.

British Steel owns the Scunthorpe steel works where 3,000 people work and it employs another 800 on Teesside.

But the firm was put into compulsory liquidation in May after rescue talks with the government broke down.

Another 20,000 jobs in the supply chain were put at risk by the collapse of the talks between the government and British Steel's owner, Greybull, prompting a parliamentary inquiry.

The company was transferred to the Official Receiver because British Steel, its shareholders and the government were not able to, or would not, support the business.

The news was welcomed by trade association UK Steel.

"British Steel's production facilities in Scunthorpe and elsewhere in the North East represent one third of the UK's steel production and are a major strategic asset to our country," the body's general secretary, Gareth Stace, said.

"Their loss would leave our manufacturing, construction and infrastructure capability in a considerably poorer state."

But he called on the government to partner with the steel industry "to help deliver a level playing field" by subsidising energy prices and lowering business rates.

The Business Secretary, Andrea Leadsom, described the news as an "important step" to secure the future of British Steel.

"The UK has a long and proud history of steel manufacturing and I am committed to a modern and sustainable future for the industry," she said.

But Ross Murdoch from the GMB union said: "Our members are staring redundancy in the face as uncertainty continues to hang over the company.

"This dedicated and loyal workforce must not be an afterthought amidst all of the speculation," he said, adding that they were put in the position "through no fault of their own".

Steelworkers' union Community said the deal was "hugely encouraging" and an "important milestone".

"As we have said from the outset, we believe the business must be kept together and the future of steelmaking at Scunthorpe secured," said the union's general secretary, Roy Rickhuss.

"We will want to be assured that Ataer has a long-term strategy to invest in the assets and develop the business going forward."

Exclusive rights

The Official Receiver said it had received "several" bids for the firm, but described Ataer, Oyak's investment arm, as its "preferred buyer".

Ataer's accountants have exclusive rights to the insolvent firm's books, so that they can examine the state of its finances.

"Following discussions with a number of potential purchasers for the British Steel group over the past few weeks, I am pleased to say I have now received an acceptable offer from Ataer," the Official Receiver said, adding that the focus was now on finalising the sale.

"I will be looking to conclude this process in the coming weeks, during which time British Steel continues to trade and supply its customers as normal."

Ataer owns nearly 50% of Erdemir, Turkey's biggest steel producer, which employs 11,530 people.

Together, Ataer-owned companies make about a quarter of Turkey's steel, making it the third-largest producer in Europe, according to the firm's site.

Hundreds of steel jobs could go at Newport Orb plant

Hundreds of jobs could go with the closure of a Tata steel plant in Newport

There has been a factory at the site since 1898 but Orb Electrical Steels has not been in profit for four years.

Up to 380 jobs could go although Tata hope to offer jobs elsewhere in Wales.

The factory, which makes electrical steel used in power transmission, was put up for sale in May 2018, with Tata wanting to concentrate on its core steel business.

Tata Steel's European operations head Henrik Adam said: "I recognise how difficult this news will be for all those affected and we will work very hard to support them."

Unions said Tata - which employs nearly 6,000 workers in Wales - was breaking its commitments over job guarantees.

Orb Electrical Steels is part of Tata's Cogent division, part of which is being sold to the Japanese steel company JFE Shoji Trade Corporation.

Tata is also closing its Wolverhampton Engineering Steels service centre, with up to 26 jobs at risk.

The Orb site makes electrical steel used in generators, transformers, motors and magnetic products, including for the car industry.

But the sector has been suffering from over-capacity over the last 10 years, and struggling to compete in particular with big volume producers in China.

"This business is the smallest volume electrical steel manufacturer in the world - and we've only been able to make a profit in two of the last 10 years and no profit in the last four years," Tor Farquhar, Tata Steel Europe's HR director, told BBC Wales.

Meanwhile, converting the Orb plant would have cost Tata more than £50m.

Mr Adam added: "Continuing to fund substantial losses at Orb Electrical Steels is not sustainable at a time when the European steel industry is facing considerable challenges."

But he said workers would be offered alternative employment at other Tata sites in Wales where possible and consultations with staff and unions would start shortly.

thyssenkrupp Materials Services invests over 70 million euros in European sites

- Expansion of warehousing and logistics capacities in Germany, Poland and Hungary
- Automation and digitalization significantly boost productivity

thyssenkrupp Materials Services, the distribution and service provider of the thyssenkrupp Group, is investing around 70 million euros in the modernization and expansion of its European warehousing and logistics network. A state-of-the-art logistics centre and new warehouses are to be built in Germany, Poland and Hungary.

The investments are an important part of thyssenkrupp Materials Services' strategy. Under its "Materials as a Service" approach, the western world's biggest materials distributor is focusing on expanding its portfolio of services supplementing its core business.

"Expanding and modernizing our capacities are important elements of our growth," says Klaus Keysberg, Chief Executive Officer of thyssenkrupp Materials Services. "Innovative logistics, automation and digitalization will help us improve our performance and our productivity. That means we can cater even better to the individual requirements of our customers while they can concentrate on their core business." Connected processing equipment and the digital integration of the company's sites will ensure flexible and perfectly coordinated logistics processes and services.

New logistics centre in Germany, expansion of eastern European sites

A state-of-the-art logistics centre with around 36,000 square metres of storage space is to be built in Rotenburg/Wümme (Lower Saxony). The company is investing around 60 million euros in the site, which will store up to 20,000 tons of materials to guarantee maximum material availability. The groundbreaking is planned for the end of the year. Serving customers in the north of Germany, the new logistics and processing centre is scheduled to go into operation in 2021.

Nowe Marzy, Poland

thyssenkrupp Materials Services is investing a total of 11 million euros in the expansion of its sites in Nowe Marzy, Poland and the Hungarian capital Budapest. Two new modern warehouses are to start operation at the end of September. With around 13,500 square metres of storage space, the new warehouse in Nowe Marzy is an addition to the hub in north Poland, which was built in 2017. The new facility in Budapest will cover a space of around 6,500 square metres.

source: thyssenkrupp Materials Services

Liberty Steel Hartlepool pipe mill extends global reach with milestone Saudi contract

Liberty Steel Hartlepool has secured a milestone contract to manufacture more than 16 kilometres of heavy-duty steel pipe for a multi-billion-dollar offshore Saudi Arabian oil and gas development.

The order to supply SAWL Linepipe for an expansion of the Saudi Aramco Marjan field is the first major contract the Hartlepool mills have won from the Middle Eastern Kingdom since being acquired by Liberty almost two years ago.

Since then the plant has fulfilled major orders from North Sea oil and gas producers and a range of American customers but the latest contract represents a breakthrough in efforts to establish a presence in the world's largest oil and gas producing region.

Saudi Aramco is the world's biggest oil and gas company by revenue and Liberty is hopeful the prestigious Marjan contract will lead to further opportunities in Saudi Arabia and the wider Gulf region. Saudi Aramco is planning to boost the Marjan and Berri fields' production capacity by 550,000 barrels per day of crude oil and 2.5 billion standard cubic feet a day of gas.

Liberty in conjunction with Sumitomo Corporation Middle East FZE, will supply the Marjan project with more than 16 kilometres of Submerged Arc Welded Linepipe (SAWL) from its 42-inch UOE mill, one of two mills it operates at Hartlepool. The offshore Linepipe, suitable for highly-resilient 'sour service' application, is due for delivery in the final quarter of 2019.

Martyn Curnow, Commercial Director, Liberty Steel Hartlepool commented: "Our facility has a proven global track record of managing projects with stringent technical requirements. The team, led by Steve Brooke in the UK and Saad Jakani in the United Arab Emirates, worked tirelessly with the client to ensure that the demanding specification was fully understood and delivered a robust technical proposal which we are sure was a key consideration in the evaluation and acceptance of our offer."

"It is extremely pleasing to re-establish the Hartlepool mill as a supplier in the region following a significant period of absence. This success is testament to the hard work and commitment shown by our employees in all areas of the business."

Masaki Nakagaki, General Manager of Tubular Products Unit, Sumitomo Corporation Middle East FZE said: "Sumitomo Corporation Middle East has a strong presence in Middle East for supply of Tubular products and this recent success is testimony of our efforts to contribute to growth of the Oil & Gas sector in the region with partners like Liberty Pipes Hartlepool."

Colin Jones celebrates over 40 years' service at Ancorite

Back in the late 70s following an apprenticeship with British Steel, Colin Jones joined Ancorite as a refractory/acid brick layer. Today – four decades later – he remains a solid and trusted member of the team.

Over the years Colin has played an instrumental part in many of the major brick lining projects undertaken by Ancorite in South Wales, including the Dragon and Genesis major expansion projects at Dow Corning in Barry.

His skill set has been passed down the family line through to his son – and hopefully through to his Grandson. Whilst Colin now refrains from working full time, he still plays a pivotal role in the heavy industrial work that the team undertakes in the region.

At Ancorite Surface Protection, we marked his achievement with vouchers presented by Managing Director, Andy Cummings, near his home in Cwm, Ebbw Vale.

The team would like to once again thank Colin for his dedication and commitment to Ancorite over the past 40 years.

Morgan Molten Metal Systems launches a next generation, 'game-changing' crucible for holding molten Aluminium - VAluStar™

Backed by Morgan's expertise and experience of over 160 years in manufacturing crucibles for nonferrous metals, VAluStar™ crucibles are highly resistant to oxidation at low temperatures, thanks to Morgan's proprietary glazes. These crucibles are particularly best suited for holding Aluminium and Aluminium alloys in electric resistance furnaces.

VAluStar™ are high density, clay-bonded, iso-statically pressed crucibles containing graphite and silicon carbide. Morgan MMS team has recorded highly encouraging trial results for VAluStar™ in European region foundries. When compared with best available crucibles in the market for Aluminium holding application in electric resistance furnaces, VAluStar™ has:

- Better crucible life by 50% or higher
- Lowered production downtime due to reduced frequency of crucible changeover
- Increased production capacity per crucible upwards of 50%
- Generates a significant cost saving for the customers

Morgan MMS is confident that it is offering a 'game changer' product, which can significantly improve the 'value' obtained by the crucible users. MMS team will be happy to answer your queries and explain more details about 'VAluStar™'.

Primetals Technologies receives FAC for automation upgrades at Gerdau Ouro Branco and conducts Industry 4.0 study

- New level 1 and level 2 systems for billet caster improve quality, reduce maintenance efforts and operating costs
- New level 2 system for two blast furnaces saves fuel and reducing agents while improving hot metal quality
- Industry 4.0 study assesses digital maturity level and provides roadmap to digital steel plant

In late March, Primetals Technologies received the Final Acceptance Certificates (FACs) for automation upgrades conducted on a third-party 6-strand billet caster and two blast furnaces of Gerdau Ouro Branco in Minas Gerais, Brazil. The caster project included the upgrade of outdated level 1 and level 2 systems, resulting in quality improvements, reduced maintenance requirements and operating cost savings. Blast furnaces #1 and #2 were outfitted with a new level 2 process optimization system with a short payback period of several months. On the one hand the solution saves fuel and reducing agents, and on the other hand it improves the hot metal quality. In addition, Gerdau contracted Primetals Technologies to assess two of their facilities regarding their digital maturity level within the scope of an Industry 4.0 study, and to provide a roadmap towards a smart steel production.

The level 2 system installed at a 6-strand billet caster encompass basic functionalities like material tracking, heat pacing, cutting schedule and process set-point generation as well as the implementation of the Equipment Expert, which is a preventive maintenance tool for the caster equipment. Advanced process models for the caster include the DynaSpeed secondary cooling model, Quality Expert Express Edition used for product quality rating, a billet cut-length optimization and the Intermix model for calculation of the heat volume concentration and incompatible strand portions along the strand.

In the course of upgrading the billet caster's level 1 system, Primetals Technologies undertook the migration of an obsolete third-party platform to the latest state-of-the-art controllers, using a special migration kit in order to reduce risk and consequently shortening the shutdown period. Existing frequency converters were replaced by new components. A new HMI(Human Machine Interface) system, using a virtual server concept was also supplied. In addition, the existing low performance field networks were replaced by Ethernet IP, and the operation desks and panels were modernized.

The level 2 systems for the two blast furnaces #1 and #2 enables all optimization functions to work within a virtualized server concept, allowing for high-availability hardware redundancy. The system offers data recording, data visualization and long term data archiving functionality. Control of blast furnace raw material supply and material distribution within the shaft is model based, as is the optimized control of the hot stoves system. Also, expert systems for automatic operation of blast furnace in closed-loop mode, and for preparing the blast furnaces for intermediate maintenance shut-downs were introduced. Finally, a recently developed slag optimization model was included in the level 2 system.

The Industry 4.0 Study conducted by Primetals Technologies consisted of the assessment of an integrated process route from blast furnace to continuous casting and the assessment of an EAF route from scrap handling to long rolled products. The assessments were performed in a holistic manner, including an investigation of metallurgical models and tools for better and more repeatable process execution, automation and system requirements, production planning and digital assistance systems, all with regards to product quality, traceability and consistency. Based on the results of this assessment a roadmap was provided by Primetals Technologies, which will assist Gerdau to further transform its production site in Ouro Branco to meet their goal of becoming a smart steel production.

Gerdau S.A., headquartered in São Paulo, is the largest Brazilian steel producer and one of the major suppliers of long steel in the Americas and of special steel in the world and possesses an installed capacity of 21.7 million tons of steel per year. The company is present in 10 countries in the Americas. Gerdau Ouro Branco, located in the Brazilian state of Minas Gerais, is Gerdau's largest steel mill. Its product mix includes billets, slabs, blooms, beam-blanks, wire-rod, carbochemicals, hot coils and plates. The installed capacity of the Ouro Branco plant is 4.5 million metric tons per year.

The new level 1 and level 2 systems from Primetals Technologies for the billet caster of Gerdau Ouro Branco in Brazil improve the quality, reduce maintenance efforts and operating costs.

Grants for Growth

Langley Alloys approached the Grants for Growth team at Stoke-on-Trent City Council for help with funding for a new capital expenditure project. Langley Alloys were looking to purchase an additional CNC lathe to increase the company's capacity and allow them to provide extra services to their customers. As part of their investment, the company created 4 new high skilled jobs in the Stoke and Newcastle area. Langley Alloys secured £40,000 worth of grant funding enabling them to move forward with their project.

Kevan Sawyer, Finance Director of Langley Alloys said,

"As a company, we are keen to expand our current offering to include additional value-added services. Having been based in the local area for so long, we also wanted to retain a skilled workforce in the area. The funding provided by the Grants for Growth programme has not only allowed us to purchase new equipment but also expand our workforce accordingly to meet customer demand."

This investment means that Langley Alloys have been able to broaden the range of services on offer to its customers. Besides in-house testing and inspection, they are now able to offer a range of first-stage machining, including deep hole boring, CNC machining and milling. This enables them to save their customers time and cost, by bringing more of the operations together under one roof.

Stoke-on-Trent and Staffordshire Grants for Growth is delivered by Stoke-on-Trent City Council and is part-funded by the European Regional Development Fund (ERDF). It provides gap funding for capital projects to companies across the whole of Staffordshire.

Parkinson-Spencer Refractories at Gulf Glass 2019 in Dubai

Gulf Glass is the region's largest Glass event, showcasing over 170+ leading brands of glass machinery, glass processing technology, tools, finished products and so much more. Attracting thousands of architects, consultants, operation managers, procurement heads and other key decision makers within the industry, Gulf Glass receives visitors from over 60 countries around the world who are actively looking for glass related products, technology and services.

PSR's Managing Director, Simon Parkinson, will be in attendance in the Sheikh Maktoum Hall on Stand A127, 24-26 September 2019.

Seven Refractories Russia repairs biggest blast furnace to date

The record-breaking blast furnace repair was suitably conducted by the largest organisation within Seven Refractories. "Our Russian team has done a truly great job and surpassed itself", comments Roman Cheglov, Group VP Sales and Technique, with pride. "A blast furnace of 5.500 cubic metres is a huge beast. In that order of magnitude, a repair it is an enormous task."

Severstal had prepared the repair of its Blast Furnace 5 called Severyanka in Cherepovets thoroughly, going through a meticulous tender process. In the end, Seven Refractories was chosen above all national and international competitors to plan, supervise, and perform the repair.

"We are of course proud that we beat all competitors in the tender for this huge project. Severyanka is the biggest blast furnace in Russia", explains Denis Smirnov, Managing Director of Seven Refractories Russia

The sheer numbers alone speak for themselves:

A diameter of 12 metres.

100 tons of shotcreting material.

A gigantic size of 5.500 cubic metres.

A daily output of 15.000 tons of pig iron.

Seven Refractories teamed up with its trusted partner Refracon Installations for the shotcreting of the blast furnace's upper lining. In addition to sheer size, the repair was the very first robotic repair of the non-cooled stack of the furnace.

After finalization of the project and thorough checks, the blast furnace was started up again to full performance. Smirnov adds: "Due to the size and difficulty we selected only the very best and experienced colleagues to ensure everything worked perfectly. I wish to thank everyone involved for getting Severyanka back to work so quickly and perfectly and for exceeding our client's expectations."

"We are very proud that our largest organisation performed this project and that we managed to save the client 12 hours of repair time. Time is money. The normal rule of thumb is that every day a blast furnace is standing still equals roughly a million US dollars. So you can do the math", adds Cheglov.

CO Resistance of Monolithic Refractories

Goutam Bhattacharya*, Christoph Wöhrmeyer, Florian Ahouanto, Chris Parr

*Imerys Aluminates, Kolkata, India

INTRODUCTION:

Carbon monoxide gas often formed during metallurgical and petrochemical processes, combustion of fuel or during coal gasification penetrates and reacts on refractory pore walls in presence of metallic (free) iron or iron oxides with deposition of carbon and destruction of refractory structure. This reaction, i.e. decomposition of gaseous carbon monoxide to solid carbon and carbon di-oxide is known as Boudouard reaction:

$$2CO\ (g) \rightarrow CO_2\ (g) + C\ (s)$$

The reaction rate is maximum between 400° to 600°C [1]. Metallic iron or iron oxide catalyses the reaction depositing carbon, which develops enormous pressure in the pore or microstructure (?) structure as they grow leading to disintegration of refractory [2].

MECHANISM OF REACTION:

Pure CO gas participates in the Boudouard reaction through following steps [3]:

$3Fe_2O_3\ (s) + 9CO\ (g) \rightarrow 6Fe\ (s) + 9CO_2\ (g)$
$3Fe\ (s) + 2CO\ (g) \rightarrow Fe_3C\ (s) + CO_2\ (g)$
$Fe_3C\ (s) \rightarrow 3Fe\ (s) + C\ (s)$

The reaction progresses via continuous formation and decomposition of cementite (Fe_3C). In addition to cementite, iron percarbide ($Fe_{20}C_9$) is formed by the reaction of cementite and CO and gets decomposed to cementite and carbon.

$20Fe_3C\ (s) + 14CO \rightarrow 3Fe_{20}C_9\ (s) + 7CO_2\ (s)$
$3Fe_{20}C_9\ (s) \rightarrow 20Fe_3C\ (s) + 7C\ (s)$

Hydrogen gas, often present together with CO in several applications including biomass and coal gasification, can accelerate carbon deposition significantly – 2 to 5% H_2 gas in CO test can reduce the reaction time from 200h to 24h [4]. The rate of carbon deposition in presence of iron or iron oxide catalyst in CO-H_2 gas mixture remains significant in the temperature range 400°-750°C, with the maximum from 500° to 600°C [5]. The main reactions may be summarised as follows [6]:

$Fe_xO_y\ (s) + nH_2\ (g) \rightarrow Fe_xO_{y-n}\ (s) + n\ H_2O\ (g)$
$Fe_xO_y\ (s) + mCO\ (g) \rightarrow Fe_xO_{y-m}\ (s) + mCO_2\ (g)$
$2CO\ (g) \rightarrow CO_2\ (g) + C\ (s)$
$Fe_xO_y(s) + pC[Fe_xC]\ (s) \rightarrow Fe_xO_{y-p}(s) + CO\ (g)$

Morphology of the deposited carbon depends on the content of H_2 gas in the mix of CO-H_2. With only CO, polyaromatic carbon deposits on Fe_xO_y catalyst in the form of continuous layers, whereas in CO-H_2 environment carbon nanofibers with high content of sp^2 carbon forms [5].

FACTORS INFLUENCING THE REACTION:

Carbon deposition by CO attack inside refractory lining in blast furnace is accelerated by alkali metal and Zn vapour [7].

$2K + CO = C + K_2O$
$Zn + CO = C + ZnO$

Ammonia and sulphur blocks this carbon deposition reaction. Castables with low gas permeability are more resistant to CO attack. However, alkali vapour can activate iron catalysed CO disintegration [3]. Catalysts play a key role in the reaction. The rate of carbon deposition in pure CO gas is proportional to the amount of iron catalyst present [8]. Bost et al. [5] studied the effect of oxidation state of the catalyst (Fe_xO_y) with x=1-3 and y=0-4 and their grain size on the rate of carbon deposition by Thermo-Gravimetric Analysis (TGA) in a gas mixture with CO (71%), H_2 (11%), CO_2 (3%) and N_2 (15%) that was introduced at 600°C. A weight loss associated with reduction of Fe_2O_3 was first observed, which was followed by a weight gain due to dominant carbon deposition reaction. No clear correlation was observed between the catalyst grain size and reaction rate, although catalyst with smallest gran size (<35 nm) was found to be more reactive yielding carbon deposit faster than those with the largest. Metallic iron catalyst, unlike other oxide catalysts showed no initial weight loss, gained weight at the fastest rate. However, oxidation states of Fe cannot be easily related with rate of carbon deposition. However, Krause et al. [7] observed that in pure CO atmosphere carbon formation was influenced by the grain size and specific surface area of the catalyst. In this article CO resistance of castable compositions was investigated as a function of their metallic iron and iron oxide content.

STANDARDS OF CO RESISTANCE TESTING:

CO resistance of refractories is generally assessed at 450°C by BS 1902.3.10:1981 and at 500°C by ASTM C288-87 and ISO 12676:2000. Refractory prisms are introduced in the sealed furnace and CO gas is introduced. The prisms are observed visually at regular interval. The experiment is continued nominally 200h or until the disintegration takes place.

According to ASTM C288-87 the prisms are carefully inspected after the experiment for pop outs, cracks and following criteria are used for their classification:

A = no CO- attack
B = no cracks or pop outs with max. 13mm diameter
C = cracks and/or pop outs with >13mm diameter
D = breakable by hand, brittle with severe cracks

EFFECT OF CASTABLE COMPOSITIONS ON CO RESISTANCE:

Experiment 1:

To understand the effect of a 50% alumina-containing calcium aluminate cement (CAC 50) on CO resistance of a castable composition, two batches of CAC 50 with a large difference in Fe_2O_3 content were chosen together with a pure aggregate (tabular alumina) (Table 1)

		Weight %	
Castable	Fe_2O_3 (wt%)	A	B
Tab. Alumina	Negligible	80	80
CAC 50 L	1.38	20	0
CAC 50 H	2.12	0	20
Total		100	100

Table 1: Iron oxide% of raw materials and composition of castables

Prisms (64 x 56 x 230mm) were prepared by vibration and cured 24h at 20°C, 24h 110°C, 6h at 550°C followed by CO resistance test according to ASTM C288 for 200h at 500°C in DIFK. Although dark spotting was

observed in the castable prisms, they showed no pop out or cracks (Fig. 1). Therefore, CAC 50 despite a wide difference in iron oxide content developed CO resistant castables (ASTM -Class A), when used with tabular alumina aggregates.

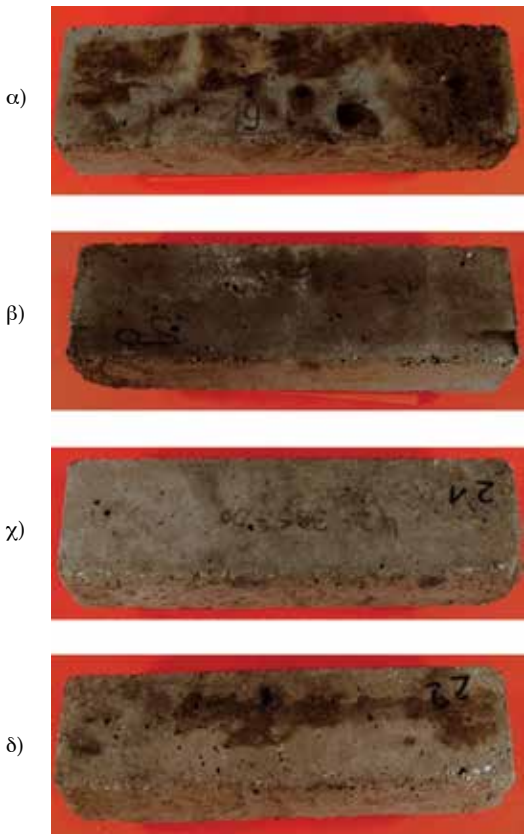


Fig. 1: Castable prisms after CO resistance test according to ASTM C288 for 200h at 500°C in DIFK – a) & b) with CAC 50 L – Fe_2O_3 1.38%, c) & d) with CAC 50 H - Fe_2O_3 2.12%

Experiment 2:

A range of castable compositions (Table 2) was prepared with tabular alumina, 50% alumina-containing calcium aluminate aggregate (R50), CAC 50 and CAC 70. R50 and CAC 50 were produced from the same fused clinker. Despite having the same chemistry (Fe_2O_3-1.5%) R50 contained more metallic iron than CAC 50, caused by crushing of the former. CAC 70 was produced by sintering and had lower Fe_2O_3 (0.2%) and metallic iron than CAC 50. Each composition was cast with same amount of water (8.5%). The metallic iron content of each composition showed a clear relation with its CO resistance classification (Table 3, Fig. 2) [9]. Composition 2 and 7 showed Class A, although CAC 50 in composition 7 contributed higher Fe_2O_3 than CAC 70 in composition 2, primarily because the overall limit for more sensitive metallic iron [10] had not crossed for composition 7. Iron compounds present in CAC 50 include Fe_2O_3 in solid solution with CA, $C_{12}A_7$ and Perovskite, FeO in solid solution in C_2AS and metallic iron generated during milling operation. FeO and Fe_2O_3 are not readily available to catalyse the reaction, whereas metallic Fe can react immediately.

	Weight %					
Castable	1	2	7	8	9	10
R50	75	0	0	28	20	27
Tab. Alumina	10	85	85	57	65	58
CAC 50	15	0	15	0	0	0
CAC 70	0	15	0	15	15	15
Total	100	100	100	100	100	100

Table 2: Compositions of regular castables for CO resistance test

Castable	1	2	7	8	9	10
Water %	8.5	8.5	8.5	8.5	8.5	8.5
Metallic iron (ppm)	293	26	69	113	78	153
Classsification of CO resistance - ASTM	C-D	A	A	A-B	B	B-C

Table 3: Metallic iron content of regular castables and their CO resistance after 100h at 500°C

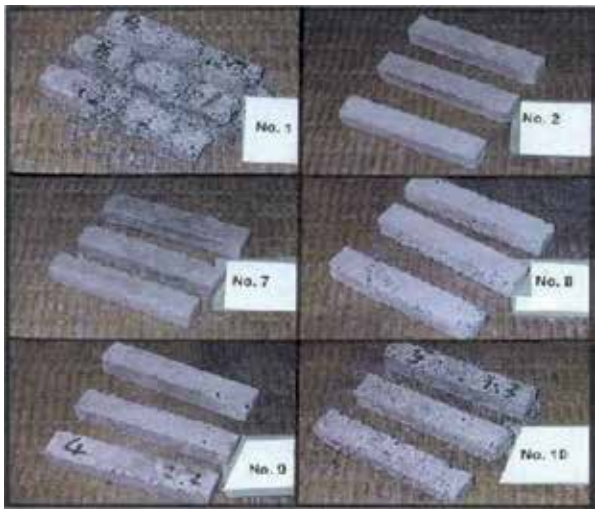


Fig. 2: Castable test prisms after CO resistance test according to BS 1902 for 100h at 500°C

Experiment 3:

The effect of the free iron and iron oxide content in aggregates can further be observed in the following experiment [11]. Andalusite grades with various chemistry was used to make a regular castable composition with 70% alumina-containing calcium aluminate cement as shown in Table 4. The castable prisms after curing and drying were prefired 5h at 540°C before exposing to CO- test as per ASTM 288 for 200h at 500°C. The results showed a clear relation with the total iron content (metallic iron + iron oxides, expressed as total iron oxide %) of andalusite grades by XRF. Purer grades of andalusite such as Durandal (D59 and D60) performed significantly better than others with higher iron content (Table 5, Fig. 3).

Castable	Weight %
Andalusite 3-5mm	20
Andalusite 1-3mm	20
Andalusite 0-1mm	20
Andalusite 0-0.5mm	20
CAC 70	20
Total	100

Table 4: Composition of regular castable with different grades of Andalusite for CO resistance test

Andalusite	Total iron content % of Andalusite aggregates	ASTM Class
Durandal D60	0.42-0.45	A/B
Durandal D59	0.56-0.58	A/B
Andalusite A	0.71	C
Andalusite B	0.96	C
Andalusite C	0.86	C
Andalusite D	1.12	D

Table 5: Total iron content (metallic iron + iron oxides expressed as iron oxide %) of andalusite grades and CO resistance classification (ASTM) of respective castable compositions

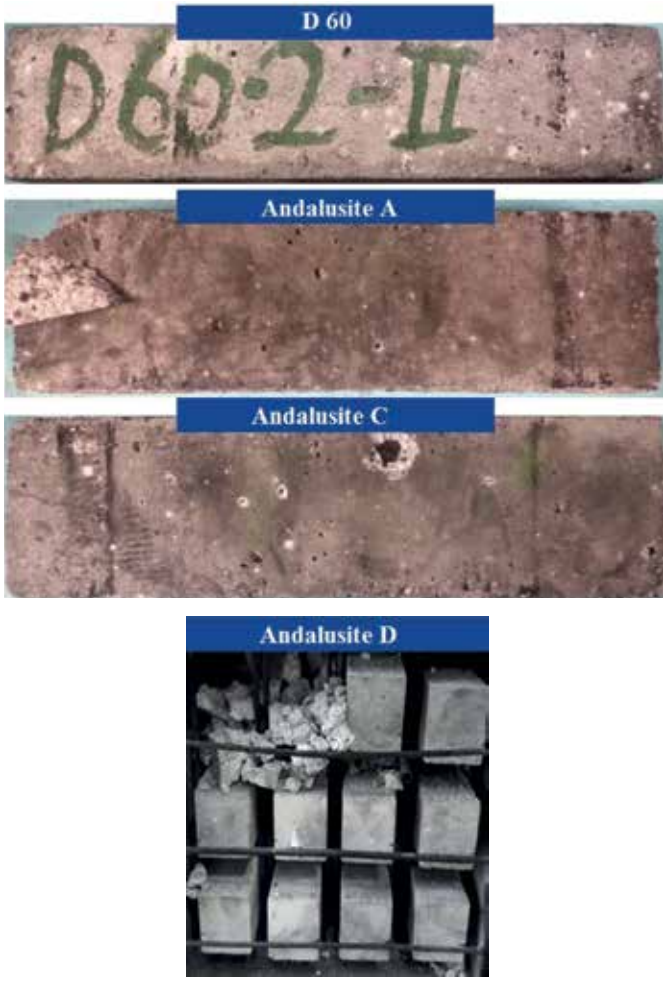


Fig. 3: Castable prisms after CO resistance test (ASTM C288) 200h at 500°C

Based on the works [12] conducted by Lafarge Aluminates on CO resistance the following guidelines on maximum limits of iron and iron oxide in castable have been established:

- metallic iron (250ppm)
- free iron oxide (0.2%)

CONCLUSION:

CO-resistance is a critical feature that is essential in refractories for several industries including petrochemical. DRI, coal gasification, blast furnace and aluminium. The reaction is catalysed by metallic iron as well as iron oxide present in the refractories. Metallic iron catalyses the reaction more dominantly than iron oxides. The latter is often present in solid solution together with other oxides. Therefore, total iron content and more importantly its free iron part should be reduced to save refractories from CO-attack. For monolithic refractories, the iron content of the whole composition should be considered instead of only one component. Products from same clinker chemistry can show significantly different CO-resistance due to their specific method of crushing or milling. CAC 70 with lower iron oxide (around 0.2%) and free iron content offers a wider choice of aggregates than CAC 50 with higher iron oxide content (around 1.5%) and free iron. The correct selection of aggregate is important as their CO-resistance shows a clear link with total iron % and aggregates constitute major part of the composition.

REFERENCE:

[1] Baxendale S: Testing of refractory materials in Refractories Handbook. Ed. Schacht C., Marcel Dekker, New York. pp 452-453.

[2] Bartha P, Koehne V, Kurjat J: Carbon disintegration in refractory building materials, T. I. Z, vol. 97 no.7, 1973, p 244-7

[3] Tassot, P, Bachmann E, Johnson RC: The influence of reducing atmospheres on monolithic refractory linings for petrochemical service, UNITECR, Cancun, Mexico, 2001, Proc. Vol. II, pp. 858-871.

[4] Shiang L et al: Influence of hydrogen on CO corrosion resistance of gunning material in blast furnace, 43th International Colloquium on Refractories, Aachen, Germany 2000, pp. 185-189

[5] Bost N, Ammar MR, Bouchetou ML, Poirier J: The catalytic effect of iron oxides on the formation of nano-carbon by the Boudouard reaction in refractories. J. Eu. Ceram. Soc., Vol. 36, 2016, p 2133-2142

[6] Towhidi N, Szekely J: The influence of carbon deposition on the reduction kinetics of commercial grade hematite pellets with carbon monoxide, hydrogen, and nitrogen. Metall. Trans. B 14, 1983, p 359-367

[7] Wear mechanisms of monolithic refractories in Technology of Monolithic Refractories, Plibrico Japan, 1984, Tokyo. pp 225-226.

[8] Krause O, Potschke J: The predictability of CO resistance of refractory materials by state-of-the-art test methods - a technical and scientific approach, Interceram (2008), 57(3), 176-180

[9] Wöhrmeyer C, Kreuels N, Parr C, Bier TA: The use of calcium aluminate solutions in the aluminium industy, UNITECR, Berlin, 1999, pp. 386-388

[10] Schnabel M: Ungeformte feuerfeste Erzeugnisse für den Einsatz unter CO- und Abriebbeanspruchung, 40th International Colloquium on Refractories, Aachen, Germany 1997, pp. 185-189

[11] Ahouanto F, Frulli D, van der Heever D: Andalusite based raw materials for refractory castable: Properties and application, IREFCON. New Delhi, India, 2018, pp. 102-107

[12] Conjeaud M, Schmitt J: SECAR 50, a new carbon monoxide-resistant calcium aluminate cement, Interceram, Vol. 22, Issue 4, 1973, p 286-7

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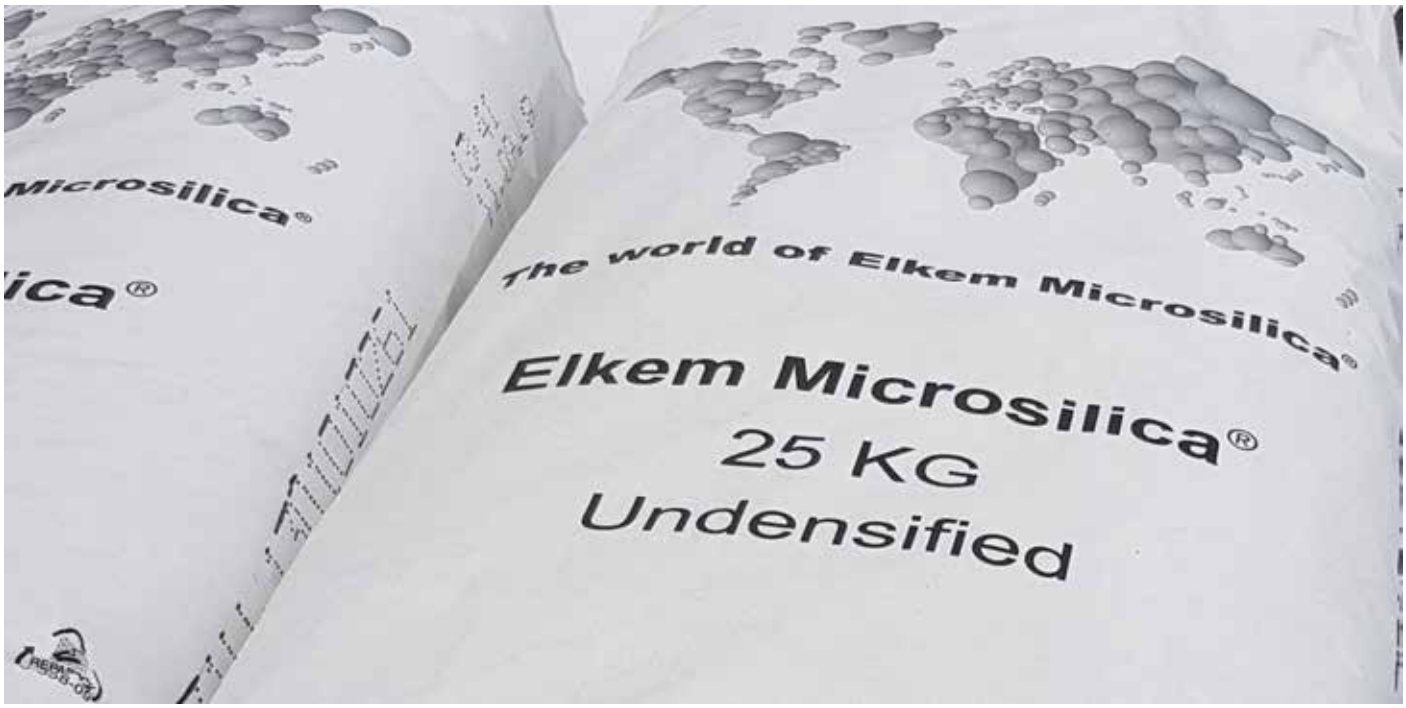

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Recent development in microsilica-gel bonded no-cement castable technology

Hong Peng* and Bjørn Myhre
Elkem Silicon Materials, Kristiansand, Norway
*Email: hong.peng@elkem.no

ABSTRACT

Silica-sol bonded no-cement castables (NCCs) have been used in the refractory industry for many years due to their fast dry-out and excellent high temperature performance compared to low cement castables (LCCs). Nevertheless, their use has been limited due to challenges such as long set-time/complex set-behaviour and handling problems due to inadequate green strength. This paper focuses on a technology with a "dry-version" silica binder, using microsilica powder as a valuable alternative to silica-sol. A microsilica-gel bond system has been designed using microsilica powder and a tailor-made speciality product (SioxX®-Zero) as dispersant package to give excellent flow and to control the setting behaviour of the NCCs. The flow, set-behaviour and mechanical properties have been studied in comparison with silica-sol bonded NCCs and cement-bonded ultra-low and low cement castables (ULCC and LCC). The microsilica-gel bonded NCCs with SioxX-Zero not only exhibit higher flow, better workability and adequate green strength compared to the silica-sol bond system, but also entail easier handling, storage and transportation thanks to the all-in-the-bag solution. The microsilica-gel bond system contains only a minor amount of cement as coagulating agent; hence, the hot properties are much better than that of ULCCs and LCCs. Phase transformations and bond mechanism were investigated by SEM and XRD techniques after pre-firing at 1400 and 1500°C. Furthermore, the explosion resistance was studied. The drying behaviour and explosion resistance of microsilica-gel bonded NCCs was further significantly improved by using a speciality drying agent (EMSIL-DRY™); a perfect 400kgs block was produced with no problems using a fast firing program (20°C to 850°C at a heating rate of 50°C).

1. INTRODUCTION

Silica-sol bonded no-cement castables (NCCs) have been used in the refractory industry for many years. Compared to low-cement castables, they exhibit fast dry-out and excellent high temperature properties. However, the use has been limited due to long set-time/complex set-behaviour and inadequate development of green strength. Handling, storage and use of liquid silica-sol are logistic factors that must be dealt with, especially at lower temperatures[1-5].

Naturally, a technology of a "dry-version" silica binder, using microsilica powder, is of great interest to further develop NCCs. Microsilica is spherical, amorphous silicon dioxide (SiO_2) particles with an average particle size of 150nm. Recent reports disclose that a genuine bond based on microsilica coagulation is created, and that the setting of microsilica-gel bond castables is caused by cations[6-8], a similar set mechanism to colloidal silica. The cations not only contribute to the reduction of the net repulsion effect of microsilica, but also react with the negatively charged microsilica particles. If, e.g. calcium aluminate cement is used as coagulating agent, Ca^{2+} (and/or other polyvalent cations) released during dissolution of the cement will react at the negative sites on the microsilica surface to form a three-dimensional network of linked microsilica particles.

Microsilica-gel bond not only provides similar advantages as silica-sol but also eliminates many of the drawbacks of a two-component system. Furthermore, due to the spherical shape of microsilica, closer packing and consequently enhanced flowability/reduction in water demand are also important factors[6]. Despite this, refractories using microsilica-gel as binder are not currently widely used, even though the potential has been known for nearly 20 years. One of the major challenges is the lack of a suitable additive package to overcome the intrinsic weakness of relatively long set time and moderate/low green strength at demoulding.

Based on Elkem's experience and understanding of the characteristics of microsilica and its performance in refractory castables for the last thirty years, a new speciality product (SioxX®-Zero) has been developed for microsilica-gel bonded NCCs[9-10]. For ease of application and improved functionality, high-grade microsilica is used as carrier in the product; and the recommended dosage is approximately 3wt%. SioxX-Zero was compared to two other commercial available dispersants in bauxite based microsilica-gel bonded NCCs. It turned out that the type of dispersant has a strong impact on set-behaviour and green mechanical properties. The use of SioxX-Zero not only provides "well-defined" set and short time to "final" strength, but also give high self-flow and improved mechanical properties. By using SioxX-Zero in combination with polyvalent cations, the set time can be controlled.

Tabular alumina aggregate based NCCs exhibit outstanding physico-mechanical and refractory properties after firing at 1500°C due to the presence of mullite in the bond phase with very little CaO. This enables their use in a variety of applications such as in steel, aluminium, copper, glass, cement, chemical and ceramics production. In this paper, tabular alumina based microsilica-gel bonded NCCs were chosen as examples to present our recent progress in NCC technology. The paper covers the following aspects: i) the effects of dosage of microsilica on workability and hot properties of microsilica-gel bonded NCCs, ii) the advantages of using microsilica-gel binder in comparison with silica-sol and cement binders; iii) further improvement of explosion resistance and drying behaviour by using SioxX-Zero in combination with a speciality drying agent (EMSIL-DRY™).

2. EXPERIMENTAL

2.1 Composition design

Table 1 shows the overall compositions of the castables. In order to understand the mullite formation of microsilica-gel bonded NCCs and the benefits of using microsilica-gel binder, two series of recipes were purposely designed. I) Microsilica gel-bonded NCCs where microsilica (MS) content varied from 3% to 7% (labelled MSZ-3, MSZ-5 and MSZ-7 with the number giving the total content of silica in the full mix); II) Silica-sol bonded NCC, ULCC and LCC, all containing 7% of total silica (labelled SOL-7, ULCC-7 and LCC-7). SioxX-Zero and SioxX-Flow were chosen as dispersants for microsilica-gel and silica-sol bonded NCCs, respectively, while SioxX was used for both ULCC-7 and LCC-7. To improve the setting-behaviour of ULCC-7, SioxX-Set was used as accelerator. The SioxX product family is produced at Elkem Silicon Materials, Norway. Since SioxX-range products use some alumina and microsilica as carrier materials, the compositions of the mixes were adjusted accordingly. The silica-sol used was Bindzil 40/130 (40 mass% solids loading, surface area 130m^2/g, produced by Akzo Nobel, Sweden). The water content was 4.5 % for all mixes. Castable MSZ-7, both with and without the anti-explosion/fast drying agent EMSIL-DRY (Elkem, Norway) was used for both lab- and industrial-scale explosion resistance testing.

2.2 Properties and characterization

Self-flow and vibration-flow of the fresh mix were measured using the flow-cone described in ASTM C230 (height of 50mm, not the more recent cone of 80mm described in EN 1402-4:2003). The self-flow value

%	MSZ-3	MSZ-5	MSZ-7	SOL-7	ULCC-7	LCC-7
Tabular alumina, 0-5mm	82	82	82	82	82	82
Elkem 971U	1	3	5	3,3	5,5	5,5
Silica-sol (40% solid loading)				7,5		
Reactive alumina	7,2	3,6				
70% cacium aluminate cement (CA)	0,5	0,5	0,5		2	5
Calcined alumina fines	9	9	9	10,7	8	5,5
SioxX-Zero	3	3	3			
SioxX					2	2
SioxX-Set					0,5	
SioxX-Flow				1		
Water	4,5	4,5	4,5		4,5	4,5

Table 1: Composition (mass%) of refractory castables

is the % increase of the diameter of the fresh mix measured 90 seconds after removing the cone.

Cold modulus of rupture (CMOR) and cold crushing strength (CCS) at room temperature after demoulding, hot modulus of rupture (HMOR) and refractoriness under load (RUL) were also measured. The HMOR testing apparatus (Isoheat, UK) is equipped with a pre-heating chamber that keeps 10 samples at test temperature. The dried samples (25x25x150mm) were heated at 300 °C /hr. The moulds were kept at 20°C and RH>90% for 24hrs before de-moulding, then dried at 110°C for 24hrs. Refractoriness under load (RUL) was measured on cylinders with a height of 50 mm and a central bore of 12.5 mm diameter, as described in ISO R1893 (1970). The constant load on the test samples is 0.2MPa. The equipment is designed in accordance with ISO R1893 (1970) and the maximum testing temperature is 1800°C.

Lab-scale explosion resistance testing according to Chinese Standard YB/T4117-2003 were carried out for all mixes. 50mm cubes are placed into a furnace heated to a preset temperature. The cubes are inspected after 30 minutes exposure. The temperature at which cracks start to form or explosive spalling occurs is reported as the explosion resistance.

The samples after HMOR testing at 1400 and 1500°C were used for further characterization. XRD with CuKα radiation was used for the mineralogical phase analysis (x'Pert Pro, Philips, Netherlands). A Scanning Electron Microscope (SEM, Quanta 400, FEI Company, USA) was used for examination of the microstructure on polished surfaces after etched in HF solution to remove the glassy phase.

3. RESULTS AND DISCUSSIONS

3.1 Flowability and setting behaviour

Self- and vibration-flow values are summarised in Fig. 1**.** It was observed that the specimen MSZ-7 showed highest self-flow value (94%), and the flowability of microsilica-gel bonded NCCs dropped when the same vol% of microsilica was replaced by reactive alumina. Compared to MSZ-7, the self-flow value of castable SOL-7 was much lower (only 47%), while those of castables ULCC-7 and LCC-7 were fine, 79% and 75%, respectively.

As gel-bonded castables do not give good temperature readings using exothermic curves, the propagation of ultrasound was used to monitor the setting and hardening process. As stiffness and speed of sound are closely related the increase of velocity indicates end of working time and initial set. Fig. 2 shows the ultrasonic velocity development for the mixes. All NCCs had quick and "defined" setting as also seen for LCC-7, while ULCC-7 showed long set-time. The significance of "defined" here is that once the castable starts to set, the strength development is fast and the time to reach its final value (green-strength) is short. Time to final value

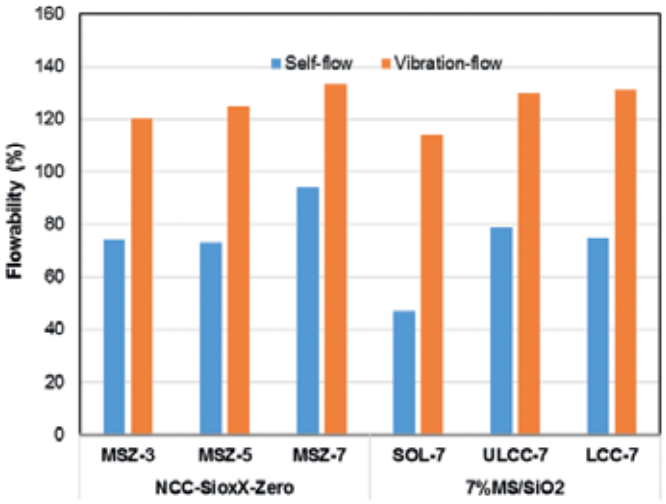

Fig. 1: Self-flow and vibration-flow of microsilica-gel/silica-sol NCCs, ULCC and LCC

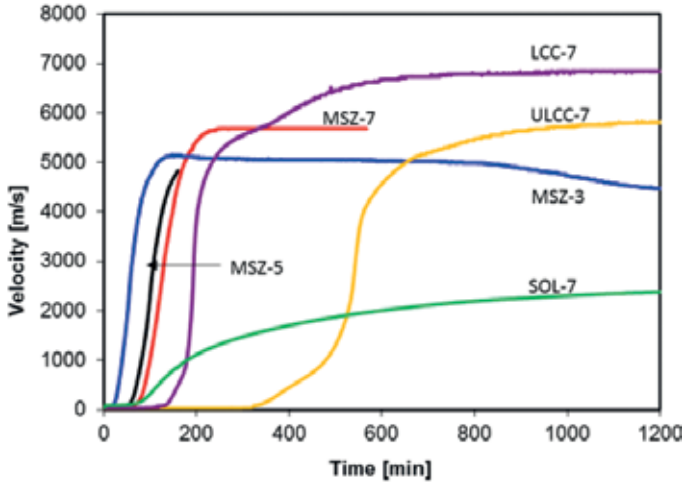

Fig. 2: Setting-behaviour of microsilica-gel/silica-sol bonded NCCs, ULCC and LCC

of NCCs was in the order of 5 to 6 hours. The silica-sol bonded castable with SioxX-Flow exhibited slower set-behaviour than the microsilica-gel bonded NCCs. Furthermore, the silica-sol bonded NCC never reached the strength level of the SioxX-Zero containing mixes.

Fig. 3 shows the green cold crushing strength (CCS) and cold modulus of rupture (CMOR) (24hrs at >90%RH and 20°C). The green CCS of MSZ-7 was approximately 8.4MPa, about four times higher than that of SOL-7 (which had less than 2MPa). With decreasing microsilica content, the green strength decreased slightly. Even though the green strength of

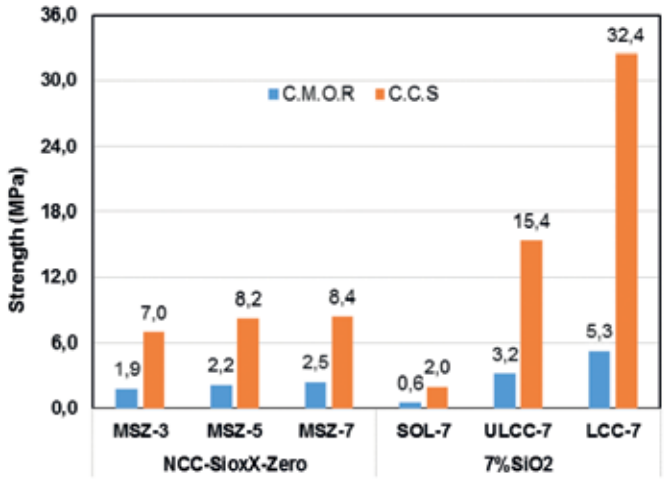

Fig. 3: Green strength of microsilica-gel/silica-sol bonded NCCs, ULCC and LCC

microsilca-gel bonded NCC is lower than ULCC and LCC, it is adequate for installation.

3.2 Hot Modulus of Rupture (HMOR)

HMOR vs. test temperature is shown in Fig. 4. At test temperatures in the range of 1200-1500°C, MSZ-7 showed the highest HMOR of the NCCs. At 1400 and 1500°C, the HMOR of MSZ-7 (with 7 mass% microsilica) was 14.3 MPa and 7.7MPa, respectively, while for MSZ-3 (containing 3 mass% microsilica) HMOR was only 3.6 and 2.6MPa, respectively. This indicates that the higher microsilica content, the more mullite forms. Compared to silica-sol bonded NCC (SOL-7), MSZ-7 had surprisingly slightly higher HMOR, probably attributed to the difference in sintering process and morphology/size of the formed mullite. Further investigation on the mechanism is ongoing, and will be reported in the future. MSZ-7 showed lower HMOR than ULCC-7 and LCC-7 at 1200°C. When the temperature was increased to 1400 and 1500°C, the HMOR values of MSZ-7 were higher than ULCC-7 and LCC-7. Especially, at 1500°C, the difference was dramatic. This indicates that liquid phase probably was formed in ULCC-7 and LCC-7, which indeed ruins the hot-properties.

3.3 Refractoriness Under Load (RUL)

Fig. 5 shows the RUL curves for microsilica-gel/silica-sol bonded NCCs, ULCC and LCC after prefiring at 1000°C for 24hrs. It is observed that the specimens softened at various temperatures. For the specimens with sufficient microsilica and low cement content (MSZ-5, MSZ-7, SOL-7 and ULCC-7), they softened at ~1300°C, but around 1400-1500°C the compression came to a halt. This RUL pattern is typical for castables with mullite strengthening. This indicates that for the castable with more than 5% microsilica and little cement, mullite formation occurs when the heating temperature is above 1300°C.

The mullite formation is irreversible and takes some time, so if the samples were pre-fired at a different temperature or duration, the results may have been different, as exemplified in Fig. 6. It can be observed that the typical mullite formation by softening around 1300°C followed by a plateau disappears, if the samples are pre-fired at a temperature above the mullitisation temperature. The pre-firing temperature of 1500°C has shifted the softening point from around 1300°C upwards to around 1500°C.

3.4 Mullite formation

It is important to understand the mullite formation since mullite is one of the significant factors concerning hot-strength of alumina-silicate systems. In this paper, selected specimens of microsilica-gel bonded NCCs, ULCC and LCC after HMOR testing at 1400°C and 1500°C, were used for mineralogical phase and morphology analysis using XRD and SEM characterisation. Fig. 7 shows the XRD patterns and Fig. 8 and 9 show the SEM micrographs of etched polished surfaces of specimens.

As shown in Fig. 7, the temperature has a strong influence on the content of mullite. The intensity peak of mullite in samples MSZ-5, MSZ-7 and ULCC-7 after HMOR testing at 1500°C is stronger than that at 1400°C. Moreover, the presence of microsilica has a strong influence on the

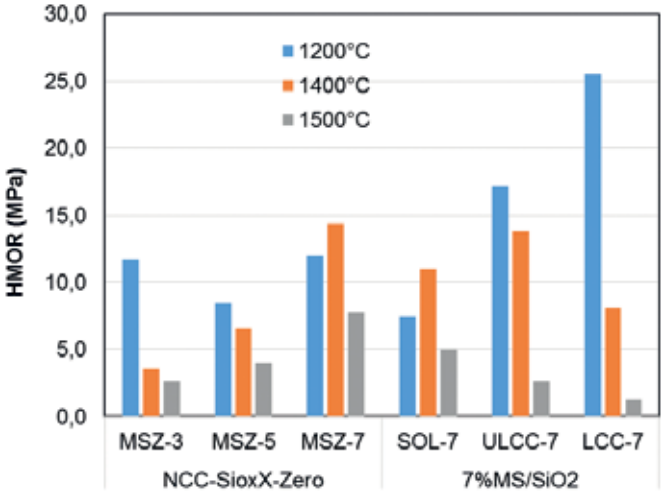

Fig. 4: HMOR of microsilica-gel/silica-sol bonded NCCs, ULCC and LCC

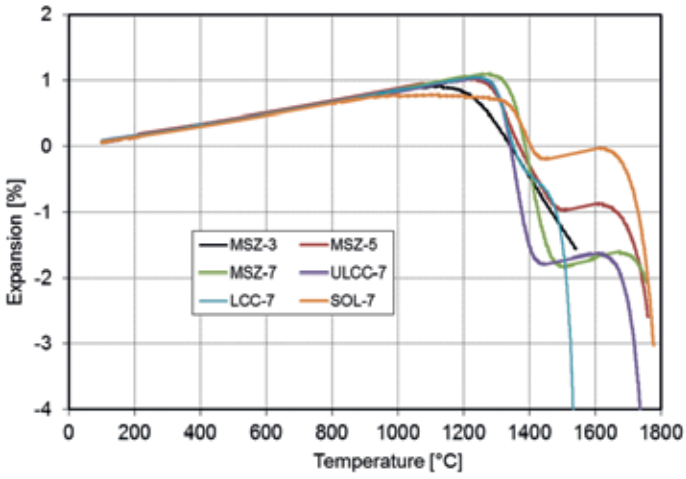

Fig. 5: RUL of microsilica-gel/silica-sol bonded NCCs, ULCC and LCC after prefiring at 1000°C

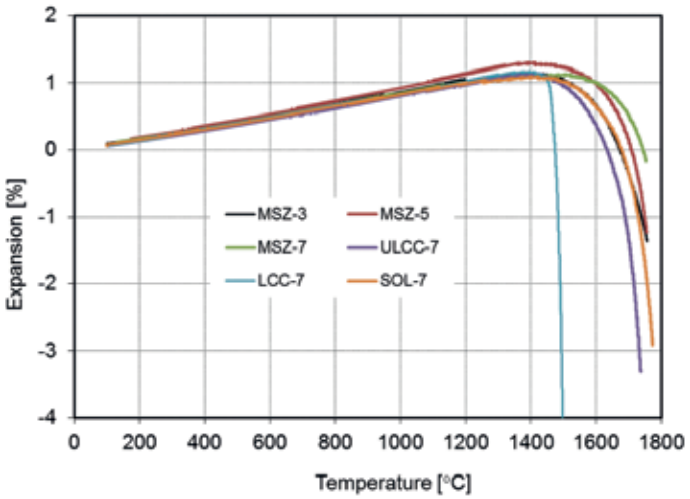

Fig. 6: RUL of microsilica-gel/silica-sol bonded NCCs, ULCC and LCC after prefiring at 1500°C

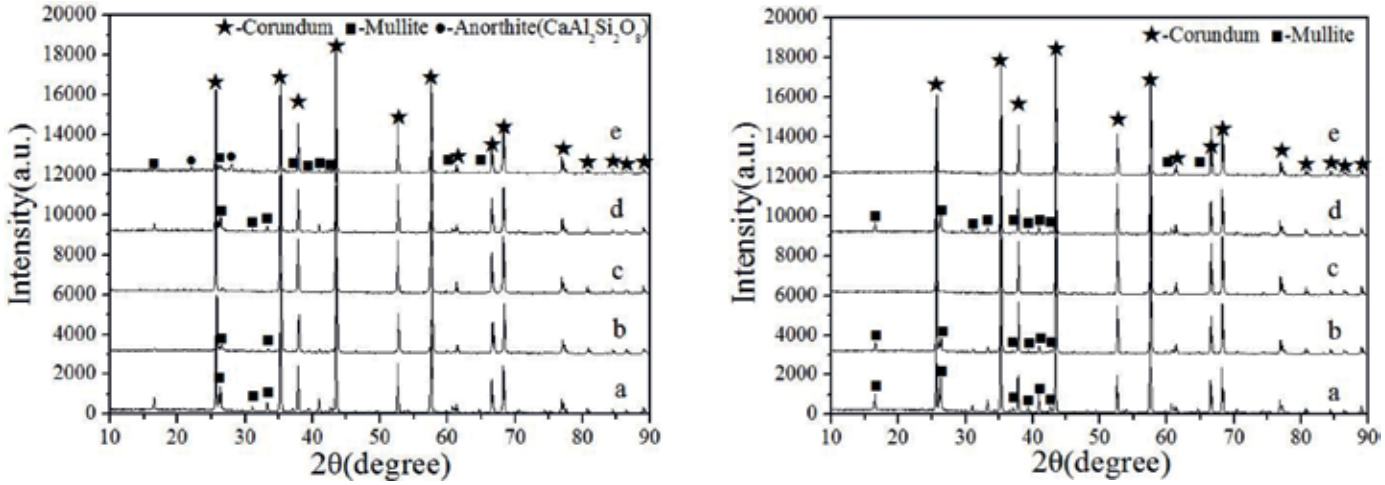

Fig. 7: XRD patterns of microsilica-gel bonded NCCs, ULCC and LCC, pre-fired at 1400 and 1500°C. a) MSZ-7, b) MSZ-5, c) MSZ-3, d) ULCC-7 and e) LCC-7

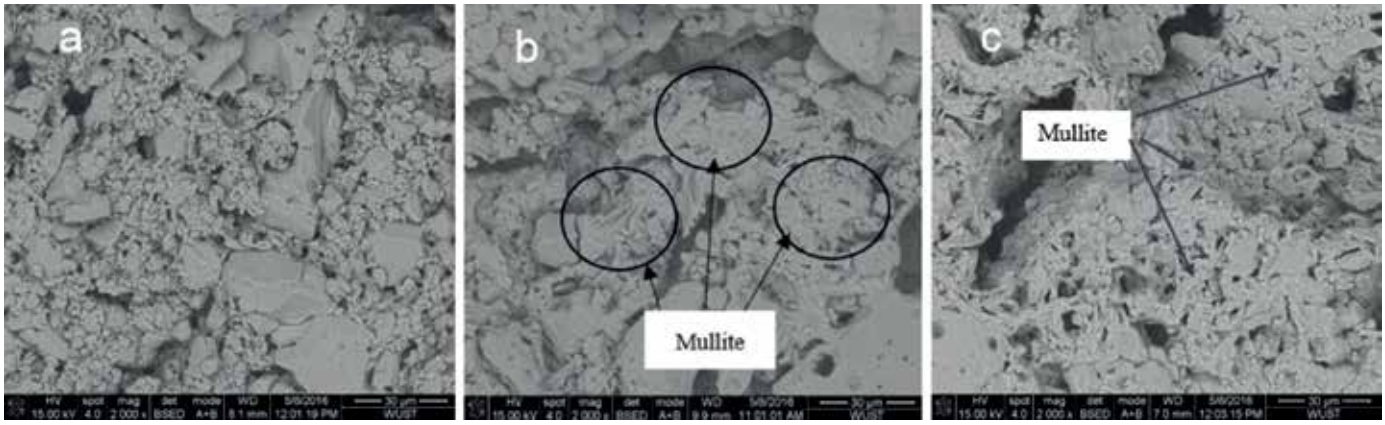

Fig. 8: SEM micrographs of etched polished surfaces of specimens fired at 1400°C. a) MSZ-3, b) MSZ-7 and c) ULCC-7

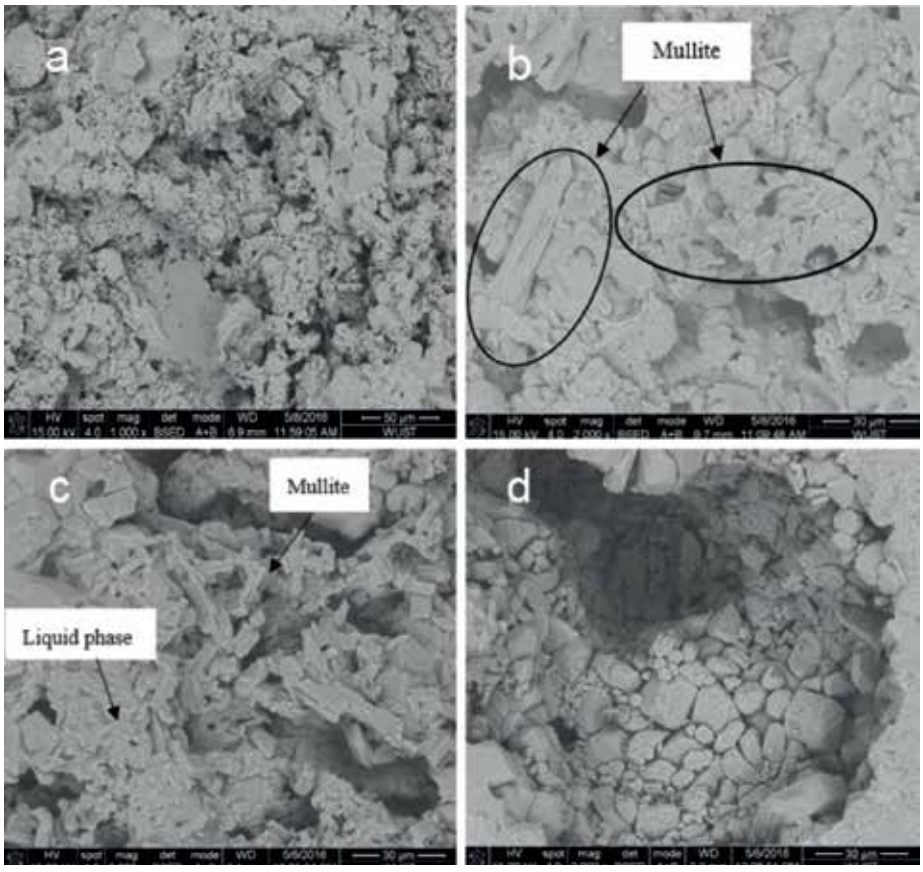

Fig. 9: SEM micrographs of etched polished surfaces of specimens fired at 1500°C. a) MSZ-3, b) MSZ-7, c) ULCC-7 and d) LCC-7

content of mullite in microsilica-gel bonded NCCs. MSZ-7 contains more mullite than MSZ-5 at both temperatures, while no trace of mullite can be detected in sample MSZ-3. This confirms that a relatively high level of microsilica is most important to develop mullite, and consequently to improve thermo-mechanical properties of alumina-silicate castables. It also implies that it may not be such a good idea to substitute microsilica by reactive alumina. In the LCC-7, some mineral phases besides corundum can be detected after prefiring at 1400°C. These are anorthite ($CaAl_2Si_2O_8$) and mullite. However, they disappear at 1500°C and corundum becomes the only mineral phase.

The microstructure of MSZ-3, MSZ-7 and ULCC-7 after HMOR testing at 1400°C are shown in Fig. 8. Needle-like mullite is clearly visible in MSZ-7 and ULCC-7, while no mullite can be detected in MSZ-3.

With an increase in temperature to 1500°C, more mullite is observed in MSZ-7 and ULCC-7, but the mullite changes its morphology from needle-like to columnar, as shown in Fig. 9. Furthermore, more glassy phase is observed in ULCC-7 and LCC-7 than at 1400°C, and no

mullite can be detected in LCC-7 at 1500°C, only corundum.

Based on both XRD and SEM characterization, it is clear why MSZ-7 shows the best thermo-mechanical properties at high temperatures and why LCC-7 collapses towards 1500°C (See Fig. 4 and Fig. 6). Obviously, if the microsilica content is too low or the cement content too high, mullite crystals will not form. As a consequence, instead of a strong and robust bond, liquid is formed which causes catastrophic lowering of hot-strength.

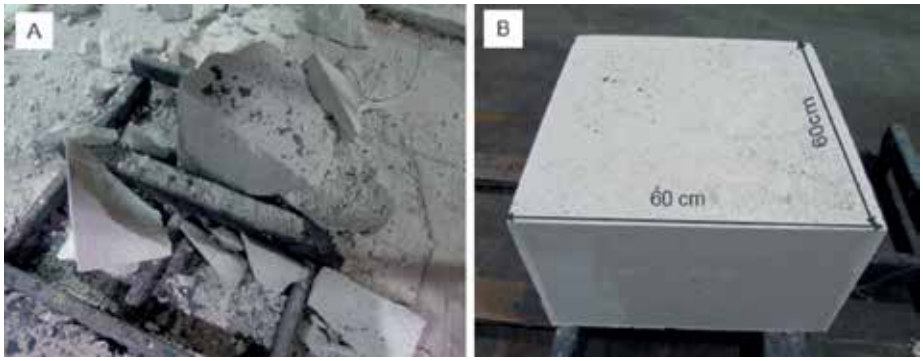

Fig. 10: ~400kgs blocks of MSZ-7 after explosion testing at 850°C A) without and B) with EMSIL-DRY

3.5 Explosion resistance of microsilica-gel bonded NCC

Drying behaviour of a microsilica-gel bonded bauxite NCC using SioxX-Zero cured at 20°C was reported in a recent paper[10]. Industrial-scale specimens, 800x600x200mm blocks (~300kgs), were produced and dried using two different rapid drying schedules. A block was heated according to a schedule holding at 160°C for 6hrs, then heated at a rate of 75°C/hr from160°C to 850°C. During this rapid heat-up the water vapour pressure caused complete disintegration since the block still contained more than 40% of the total water after the holding period at 160°C. Another block was perfect after heating according to a schedule where it was kept at 220°C for 10hrs before continuing to 850°C at a rapid rate of 100°C/hr. Approximately 97% of the free water is removed at 220°C so this block was essentially dry when the heat-up started. Obviously, it is critical to remove the free-water before rapid heat-up.

In this paper, in order to further improve the drying behaviour of microsilica-gel bonded NCCs, the effects of a speciality fast-drying product (EMSIL-DRY) on explosion resistance have been studied using both laboratory-scale specimens and industrial-scale blocks. Table 2 shows the explosion test results of both "wet" and "dried" specimens of MSZ-7 with and without EMSIL-DRY tested according to Chinese Standard YB/T4117-2003. The specimens were cured for 24hrs at room temperature and 100%RH before de-moulding. The freshly de-moulded samples are labelled "wet" and samples further dried for 24 hrs at 110°C are called "dried".

As shown in Table 2, all "dried" samples showed excellent explosion resistance and passed the test at 1200°C. The good performance is attributed to a stable bond phase and the low amount of residual water in the bond phase. When the "wet" samples were tested, good explosion resistance was achieved for MSZ-7 with EMSIL-DRY, which passed the test at 450°C. Without EMSIL-DRY, the specimens only survived the test at 275°C. This indicates that EMSIL-DRY causes a much faster dewatering.

Industrial-scale explosion resistance testing were also carried out for MSZ-7 with and without EMSIL-DRY. The dimensions of the blocks were 600x600x400mm (~400kgs). The blocks were demoulded after 24hrs curing at room temperature, and then put into the oven. A rapid heating schedule was used with heat-up from 20 to 850°C, at a rate of 50°C/hr, then cooling from 850 to 20°C at a rate of 50°C/hr. The block without EMSIL-DRY disintegrated whereas the one with EMSIL-DRY was perfect, as shown in Fig. 10.

This demonstrates that the explosion resistance/drying behaviour of microsilica-gel bonded NCC was significantly improved by adding EMSIL-DRY. EMSIL-DRY contributes to fast dewatering during firing and consequently improves explosion resistance. It indicates that rapid heating in an industrial environment is possible. The mechanism is further investigated, and more results will follow.

4 CONCLUSIONS

Based on our study comprising flowability, setting-behaviour, hot-properties, XRD and SEM characterisation of microsilica-gel bonded NCCs, ULCC and LCC, as well as explosion resistance of microsilica-gel bonded NCC with and without EMSIL-DRY, the following progress in microsilica-gel bonded NCC technology is reported:

- Compared to the silica-sol bond system, microsilica-gel bonded NCCs not only entail easier handling, storage and transportation thanks to the "all-in-the-bag" solution, but also exhibit improved setting behaviour, adequate green strength and slightly improved thermo-mechanical properties.
- Compared to a low cement bond system, microsilica-gel bonded NCCs with SioxX-Zero exhibits excellent hot-properties due to mullite formation.
- Mullite formation is essential to give excellent thermo-mechanical properties of microsilica-gel bonded NCCs. If the microsilica content is too low, or the cement content too high, mullite crystals will not form. Instead of a strong and robust bond, liquid forms which causes dramatic lowering of hot-strength.

√: passed;
x: failed

	Wet (20°C/24hrs)		Dried (110°C/24hrs)	
Temp. (°C)	No EMSIL-DRY	EMSIL-DRY	No EMSIL-DRY	EMSIL-DRY
275	√	√		
300	x	√		
350	x	√		
400		√		
450		√		
500		x		
800			√	√
1200			√	√

Table 2: Explosion resistance of MSZ-7 with and without EMSIL-DRY

- With added EMSIL-DRY, the microsilica-gel bonded NCC exhibit excellent explosion resistance. A perfect 400kgs block was produced with no problems using a fast firing program (20°C to 850°C at a heating rate of 50°C). This confirms that the microsilica-gel bond system contains only small amounts of bound water. Once the free water is removed, the castables can be fired at very high heating rates.

REFERENCES

1. S. Banerjee, C. W. Connors. Composition and method for manufacturing steel-containment equipment. US Patent 5147830. September 15; (1992).

2. B. Myhre and K. Sunde, "Alumina based castables with very low contents of hydraulic compound. Part II." Strength and High-Temperature Reactions of No-cement Castables with Hydraulic Alumina and Microsilica", Proc. UNITECR'95, Kyoto, Japan, Nov. 19-22 (1995), p. II/317-24

3. M. R. Ismael, R. D.Anjos, R .Salomão, V. C. Pandolfelli, Colloidal silica as a nano-structured binder for refractory castables, Refract. Appl. News 11 (4) (2006) 16-20.

4. M. W. Anderson, S. Shah. Pumpable casting composition and method of use. US Patent 5494267. February 27, (1996).

5. C. W. Connors, M. W. Anderson. Colloidal silica refractory system for an electric arc furnace. US Patent 6528011. March 04, (2003).

6. B. Myhre, "Microsilica-gel bond castables for rapid heat-up." *Proc. 48th Symp. On Ref. Am. Ceram. Soc* . (2012), p. 135-145.

7. B. Myhre and Hong Peng, "Microsilica-gel bond castables with potentials." *Proc. 49th Symp. On Ref. Am. Ceram. Soc* 2015, p.112-121.

8. B. Myhre, "Strength development of bauxite-based ultralow-cement castables." *Am. Ceram. Soc. Bull.*, Vol. 73. No. 5, (1994) 68-73.

9. H. Peng and B. Myhre, "Microsilica-gel bonded refractory castable with improved setting behaviour and mechanical properties." Refractories World Forum, vol. 3, (2015) 69-75.

10. H. Peng and B. Myhre, "Further development of microsilica-gel bonded non-cement castables." January 2016, REFRACTORIES ENGINEER, p. 22-25.

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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

MONOLITHIC REFRACTORIES

RHI Magnesita GmbH
8 Clock Court, 1 Campbell Way, Dinnington, South Yorkshire S25 3QD
Tel: +44 (0)1909 552255
Fax: +44 (0)1909 552251
Email: info@rhimagnesita.com
Website: www.rhimagnesita.com

MONOLITHIC REFRACTORIES - CASTABLE

Morgan Thermal Ceramics
Thermal Ceramics UK
Tebay Road, Bromborough, Wirral, Merseyside CH62 3PH
Tel: +44 (0)151 334 4030
Fax: +44 (0)151 334 1684
Website: www.morganthermalceramics.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

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

Unifrax Ltd
Mill Lane, Rainford, St. Helens WA11 8LP
Tel: (01744) 887600
Fax: (01744) 886589
Website: www.unifrax.com

MONOLITHIC REFRACTORIES - GUNNING

Morgan Thermal Ceramics
Thermal Ceramics UK
Tebay Road, Bromborough, Wirral, Merseyside
CH62 3PH
Tel: +44 (0)151 334 4030
Fax: +44 (0)151 334 1684
Website: www.morganthermalceramics.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

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

Unifrax Ltd
Mill Lane, Rainford, St. Helens WA11 8LP
Tel: (01744) 887600
Fax: (01744) 886589
Website: www.unifrax.com

MONOLITHIC REFRACTORIES - MOULDABLE

Morgan Thermal Ceramics
Thermal Ceramics UK
Tebay Road, Bromborough, Wirral, Merseyside
CH62 3PH
Tel: +44 (0)151 334 4030
Fax: +44 (0)151 334 1684
Website: www.morganthermalceramics.com

Unifrax Ltd
Mill Lane, Rainford, St. Helens WA11 8LP
Tel: (01744) 887600
Fax: (01744) 886589
Website: www.unifrax.com

MONOLITHIC REFRACTORIES - PUMPABLE

Morgan Thermal Ceramics
Thermal Ceramics UK
Tebay Road, Bromborough, Wirral, Merseyside
CH62 3PH
Tel: +44 (0)151 334 4030
Fax: +44 (0)151 334 1684
Website: www.morganthermalceramics.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

Unifrax Ltd
Mill Lane, Rainford, St. Helens WA11 8LP
Tel: (01744) 887600
Fax: (01744) 886589
Website: www.unifrax.com

PRE-CAST REFRACTORY SHAPES

Fuel Conservation Services Ltd
Unit 1 Anglesey Business Park, Littleworth
Road, Cannock, Staffordshire WS12 1NR
Tel: 01543 871787
Fax: 01543 425757
Email: info@fcs-ltd.com
Website: www.fcs-ltd.com

Morgan Thermal Ceramics
Thermal Ceramics UK
Tebay Road, Bromborough, Wirral, Merseyside
CH62 3PH
Tel: +44 (0)151 334 4030
Fax: +44 (0)151 334 1684
Website: www.morganthermalceramics.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

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

Unifrax Ltd
Mill Lane, Rainford, St. Helens WA11 8LP
Tel: (01744) 887600
Fax: (01744) 886589
Website: www.unifrax.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 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

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

Fuel Conservation Services Ltd
Unit 1 Anglesey Business Park, Littleworth
Road, Cannock, Staffordshire WS12 1NR
Tel: 01543 871787
Fax: 01543 425757
Email: info@fcs-ltd.com
Website: www.fcs-ltd.com

S.H.L. Refractories (U.K.) Ltd
Celcius House, Lawn Road Industrial Estate,
Carlton in Lindrick, Worksop, Notts. 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

Fuel Conservation Services Ltd
Unit 1 Anglesey Business Park, Littleworth
Road, Cannock, Staffordshire WS12 1NR
Tel: 01543 871787
Fax: 01543 425757
Email: info@fcs-ltd.com
Website: www.fcs-ltd.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, Notts. S81 9LB
Tel: (01909) 731959
Fax: (01909) 731579
Email: sales@shl-refractories.co.uk
Website: www.shl-refractories.co.uk

REFRACTORY LABOUR SUPPLY

Fuel Conservation Services Ltd
Unit 1 Anglesey Business Park, Littleworth
Road, Cannock, Staffordshire WS12 1NR
Tel: 01543 871787
Fax: 01543 425757
Email: info@fcs-ltd.com
Website: www.fcs-ltd.com

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 SAWS

Red Band UK Ltd
Units 41-45 The Warren, East Goscote
Industrial Estate, East Goscote, Leicester
LE7 3XA
Tel: 0116 260 2601
Fax: 0116 260 2603
Email: sales@redbanduk.co.uk
Website: www.redbanduk.co.uk

REFRACTORY SHOTCRETE EQUIPMENT

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

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

ROBOTIC DEMOLITION EQUIPMENT

Red Band UK Ltd
Units 41-45 The Warren, East Goscote Industrial Estate, East Goscote, Leicester LE7 3XA
Tel: 0116 260 2601
Fax: 0116 260 2603
Email: sales@redbanduk.co.uk
Website: www.redbanduk.co.uk

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-SINTERED

Almatis GmbH
Lyoner Str. 9, 60528 Frankfurt, Germany
Tel: +49 69 957341-0
Fax: +49 69 957341-13
Email: info@almatis.com
Website: www.almatis.com

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, Leics. LE11 3GE
Tel: +44 (0)1509 211860
Fax: +44 (0)1509 211862
Website: www.fiberconfiber.com

Fibre Technology Ltd
Brookhill Road, Pinxton, Notts. 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

Morgan Thermal Ceramics
Thermal Ceramics UK
Tebay Road, Bromborough, Wirral, Merseyside CH62 3PH
Tel: +44 (0)151 334 4030
Fax: +44 (0)151 334 1684
Website: www.morganthermalceramics.com

Unifrax Ltd
Mill Lane, Rainford, St. Helens WA11 8LP
Tel: (01744) 887600
Fax: (01744) 886589
Website: www.unifrax.com

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:

Mr J. D. Theron, B.Tech Chem Ing, M.I.Ref.Eng.

Senior Vice-President:

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

Past Presidents:

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1964/65*	H. M. Richardson, B.Sc., F.R.I.C, F.I.Ceram., F.I.Ref.Eng.
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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, M.I.Ref.Eng.

* Deceased

General Secretary & Treasurer:

Mrs J. Woodhead
575 Trentham Road, Blurton, Stoke-on-Trent, Staffs ST3 3BN
Tel/Fax: 0044 (0) 1782 310234
Email: secretary@ireng.org

Branch Secretaries:

M. Walton (Australia)
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Advertisement Sales:
Tel: 0044 (0) 7496 194585, Email: advertising@ireng.org

Editorial Content:
General Secretary & Treasurer
Tel: 0044 (0) 1782 310234, Email: secretary@ireng.org

Design & Artwork:
Advertising Matters Ltd

Website: www.ireng.org