The
Refractory BEAT

Dalmia OCL

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Severe Coating Conditions

When does a desirable coating become undesirable, and how does one prevent such situations

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The India Advantage Basically

Cement manufacturers are increasingly opting for Basic refractory bricks because of the clear advantages they offer. The new & improved Magnel 85 takes it even further.

Basics of Basic

Criticality of operating conditions sometimes force cement manufacturers to opt for Basic bricks to avoid unplanned and unwanted stoppages. E.g. if thermal load in the kiln is higher than 5.5 GCal/m^2 and the kiln is being fired with high amount of petcoke or alternative fuel, it is safer to use a Basic brick lining.

Basic bricks offer a clear advantage over Alumina brick linings: while good quality Alumina bricks can withstand temperatures of up to 1600°C, good quality Basic bricks can extend this tolerance up to 1750°C. Another advantage Basic bricks offer is higher thermal conductivity, around 3 W/mK in comparison to Alumina which has thermal conductivity of 2 W/mK or thereabouts. Burner flame temperatures at the tip vary between 2000°C and 2200°C, depending on the type of fuel being used. For some reason, if the burner flame touches the refractory lining, an Alumina lining cannot dissipate heat fast enough and will melt. Basic bricks on the other hand can not only withstand higher temperatures if exposed to flame, but can pass on the heat at a faster rate towards the kiln surface too. Thereby reducing flame-related failure rates. Basic bricks also generally give better life than Alumina bricks under higher thermal load and continuous operation of the kiln. For larger kilns, producing more than 6000 TPD, a Basic brick lining often promises a more economical lining option since it eliminates unforeseen shutdowns. It should be reiterated here that Basic bricks offer good performance under continuous operation only. For intermittent operations, they deteriorate faster than Alumina due to their higher expansion and contraction on every startup and shutdown.

Current Scenario

For top-quality, high-performance Basic refractory bricks for kilns, manufacturers have no option but to turn to imports. Aside from foreign currency related challenges, plants have to maintain unusually high inventories to protect against unforeseen delays or disruptions in the midst of long delivery cycles. Another challenge is the perishable nature of these bricks, with shelf-lives of about one year. So if the plant is in a humid area, the bricks hydrate and are unusable at the time of lining. Moreover in case of urgent requirements, imported bricks are not available at short notice. In a nutshell, reliance on imports means higher-than-necessary investments and poor cost-benefit scenarios.

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Severe Coating Conditions & Remedies Thereof

Coatings Are Desirable

It is a well-known fact that coatings in cement kilns protect refractory linings from thermal shocks, abrasion by kiln charge and chemical infiltration of gases. The uneven surface of a coating assists in transfer of heat to the kiln charge by causing the charge to climb-and-tumble as the kiln rotates. Coatings also thicken the effective refractory lining of the kiln, increases insulation of the kiln shell from high process temperatures and reduces radiation losses and thus overall thermal energy consumption.

Formation of a 'good' coating depends on the kiln feed, clinker properties, refractory lining material and operating conditions of the kiln.

Increasing the Alumina to Iron ratio restricts coating build-up. A similar effect is observed when Silica to Iron ratio is increased.

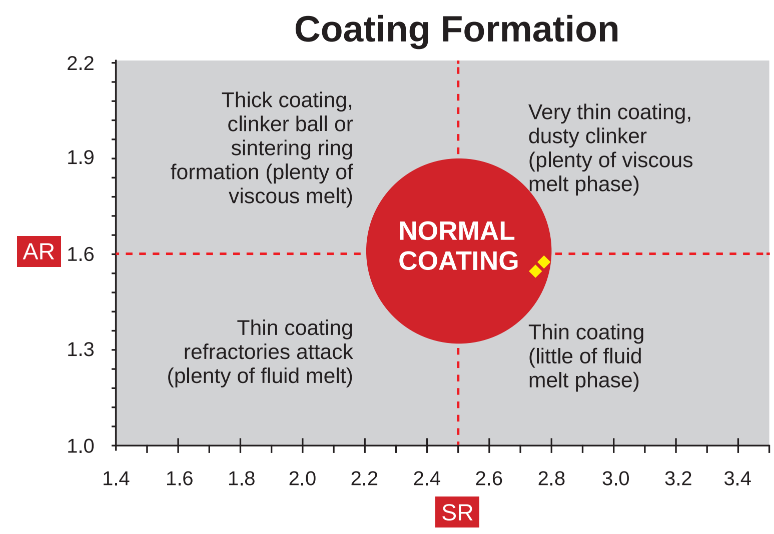
A stable operation is critical for maintaining stable coating in the kiln. Any changes in kiln feed or combustion of fuel in the main burner affect the temperature profile, amount and properties of the flux in different areas of the kiln.

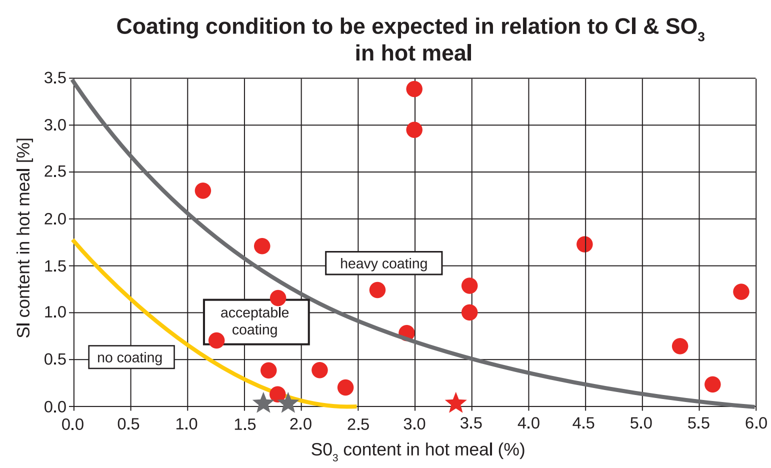
The Tipping Point

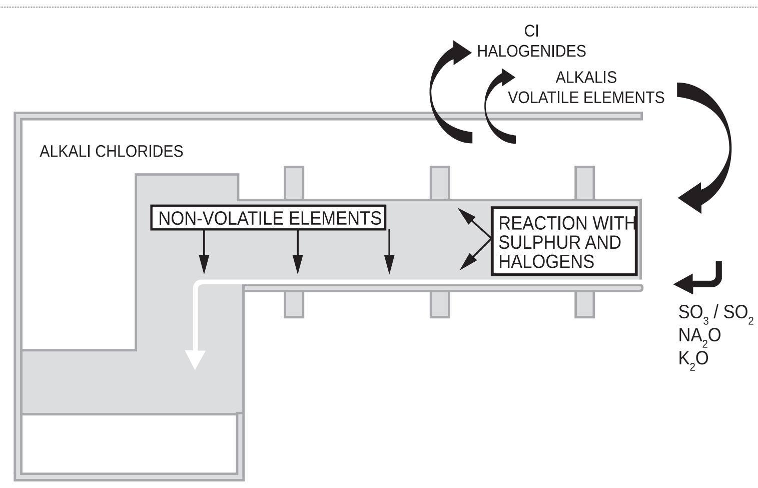
When coating grows beyond a thickness of half a meter, becomes a ring, it poses a problem. It suddenly becomes undesirable! And this happens when the accretion tendency of the coating outweighs its erosion tendency. Before we get into the reasons as to why such a phenomenon occurs, let's look at what are the different types of undesirable coatings that form in different parts of the kiln.

Type 1

The most common type of coating is Sulphate spurrite $2C2SCaSO_4$, its most common cause being the presence of sulphur in petcoke. These rings create a sort of dam that impedes free flow of material from the inlet. Which is problematic as they are too far in from the outlet in the calcining zone. The only way to deal with these formations is to use refractories containing Silicon Carbide, since they help create a glass-like surface of Silica that disallows coating formation. Sulphate spurrite rings are either unable to form or get dislodged very easily due to movement of the kiln and abrasion with charge.







Cl	< 0.02%	Usually no problems
	> 0.05%	Heavy coating problems depending on the Sulphur cycle
SO_3	< 0.5%	Usually no problems
	> 1.25%	Heavy clogging problems
K_2O	< 1.0%	Usually no problems
	> 1.5%	Problems with encrustation depending on degree of sulphurisation (molar alkali/sulphur ratio)
Na_2O	Little volatile, thus no problem due to circulation of Na_2O	

Type 2

At the beginning of burning zone, coatings or rings are formed by sintered material. Here all the CO_2 has been driven out of Calcium Carbonate and the liberated lime has begun to combine with acidic SiO_2, Al_2O_3 and Fe_2O_3. Coating begins to form as soon as the temperature is high enough for significant flux formation. And any local cooling can cause this flux to freeze turning good coating into bad. Flux softens when exposed to kiln atmosphere and stiffens when it turns into the charge. Solid particles from charge stick into flux and a ring might form.

Rings so formed have a tendency to grow rapidly and are usually tackled by adjustments to the main burner. Slight shift in temperatures affects the point where flux is first formed, and very often the rings break to form at a different point.

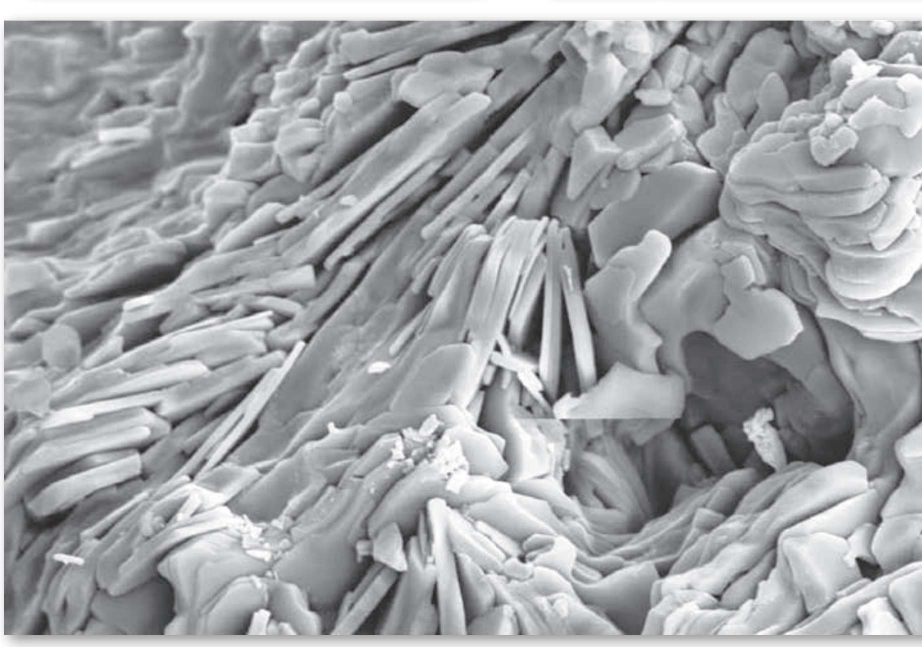
Type 3

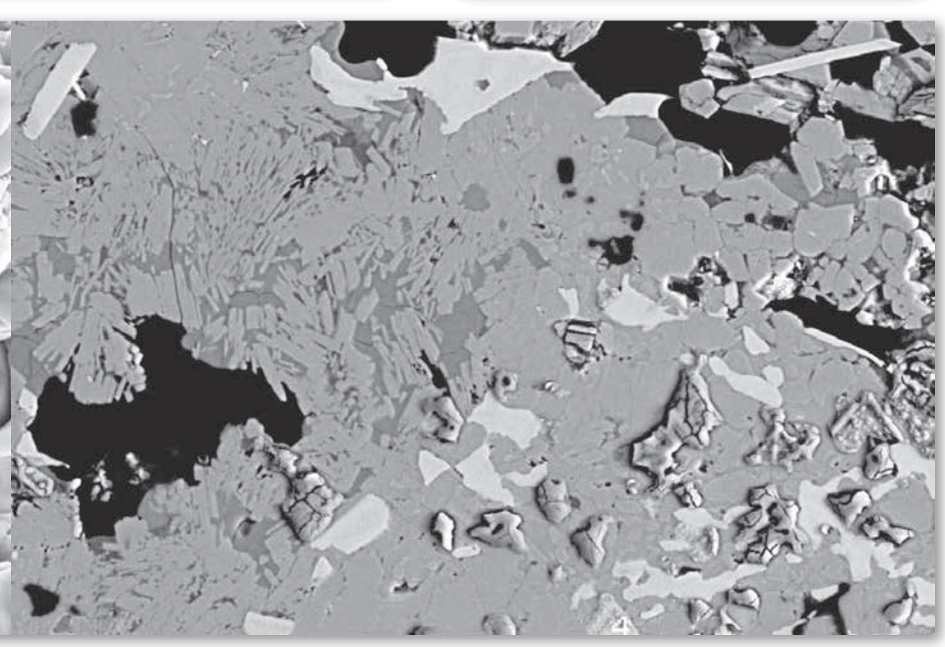
More problematic are longer middle rings caused by recirculation of clinker dust from cooler through secondary air. Dusty clinker leads to heavy dust burden on secondary air drawn into kiln from the cooler. The flux in clinker particles remelts and due to burner momentum, clinker droplets get carried back towards inlet, up to a point where the flux stiffens again and sticks to the refractory lining. An elongated ring builds up in layers with a fine structure showing curvature of the kiln. The solution here is to eliminate recirculating dust from the cooler which is generally triggered by long, lazy flames that lead to higher sulphate recirculation with slow heating and cooling of the clinker.

Type 4

When secondary combustion air drawn into the kiln leads to cooling of the clinker falling over the nose ring, it sometimes causes stiffening of flux in the clinker and its adhesion to the refractory lining. This tends to dam the combined clinker in the kiln at high temperatures and might lead to clinker quality problems. A common solution for such outlet rings is to push the burner into the kiln creating a clinker cooling zone within the kiln itself.

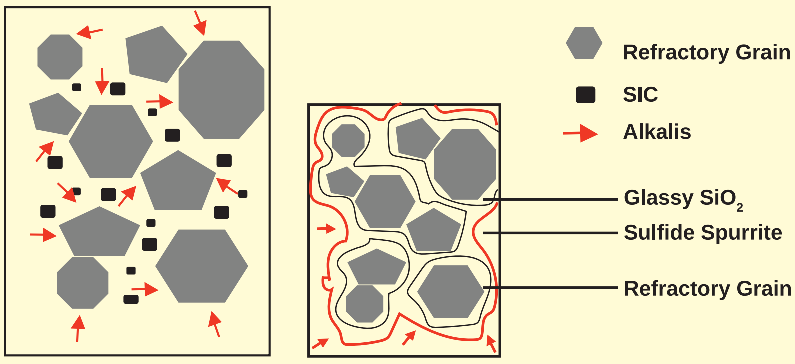
Bottom Left: SEM photo showing plate-like crystals of sulphospurrite
*Bottom right: C_2S (1), C_4AF (2), CaO (3), K_2SO_4*2CaSO_4 (4), $2C_2S$*CaSO_4 (5)*

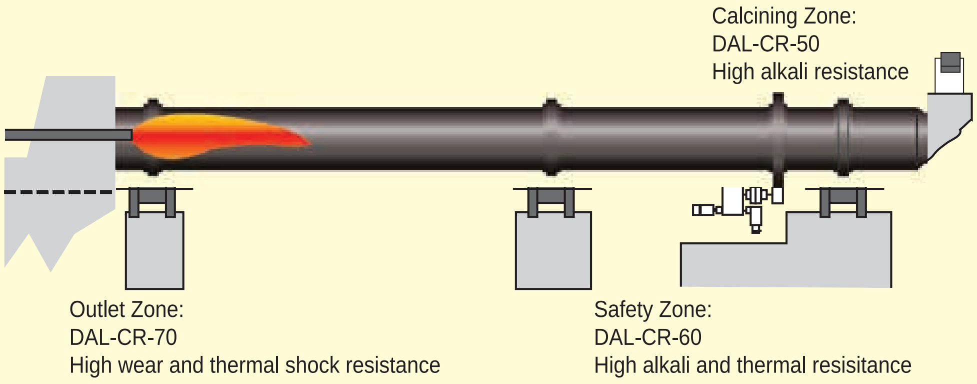




DAL-CR to the rescue

While Type 2, 3 & 4 type of rings can be tackled with process alone, for Type 1 rings, the only solution is to use specialised refractory bricks containing Silicon Carbide (SiC). Dalmia-OCL's specially developed DAL-CR range of bricks containing SiC offer very high Alkali and Sulphur resistance with anti-coating properties that inhibit ring formation. Used in all kinds of kilns, fired with or without alternate fuels, these bricks are a proven option with long service life.





DalmiaSeven
ADVANCED MONOLITHICS

RECENT INSTALLATIONS

DS CAST 30 NC SIC
ACC - Kymore Cement Works

Challenge

Dalmia Seven was asked to submit a recommendation for smoke chamber area, bearing the following operating conditions in mind:

1. Coating formation
2. High temperatures
3. Chemical attacks from alkalies
4. High abrasion

Solution

Dalmia Seven's technical team concluded that the ideal recommendation would have to ensure properties and features such as:

- Low Cement castable with Silicon Carbide content
- Main raw material: Adalusite + SiC + some selected additive
- Al2O3 - 37.4%, SiC - 30.7%
- Good thermal shock resistance
- Good alkali resistance
- Good mechanical abrasion resistance
- CCS 1000 kg/cm^2 at 800°C - 1200°C
- Good coating repellent properties

Dalmia Seven's DS CAST 30 NC SIC was therefore recommended. A trial installation in the smoke chamber area of 5 MT of castable was carried out in Kiln #1 in Nov 2018. Water requirement was approx. 4.5%. Just 2 days after installation, the kiln was lit up. Dalmia Seven & ACC Kymore teams are jointly monitoring performance of the installed castable and are awaiting any upcoming shutdown for inspection.

DS CAST 50 RD 01 W
Dalmia Cement (Bharat) - Ariyalur Cement Works

Challenge

Dalmia Seven was asked to submit a recommendation for burner pipe, bearing the following operating conditions in mind:

1. High temperatures
2. High thermal shocks
3. High chemical attacks
4. High abrasion due to clinker dust

Solution

Dalmia Seven's technical team concluded that the ideal recommendation would have to ensure properties and features such as:

- Andalusite-based low cement castable with Silicon Carbide
- Main raw material: Andalusite (Al_2O_3 51%) + SiC (9.6%) + special additive
- Good thermal shock resistance / good thermal stability at all temperatures
- Good alkali resistance
- Good mechanical abrasion resistance
- CCS 1050 kg/cm^2 at 800°C - 1200°C

Dalmia Seven's DS CAST 50 RD 01 W was recommended. A trial installation in the burner pipe of 5 MT of castable was carried out. Water requirement was approx. 4.5%. The burner pipe was put into operation in Dec 2018. Dalmia Seven & DCBL Ariyalur teams are jointly monitoring performance of the installed castable and are awaiting any upcoming shutdown for inspection.

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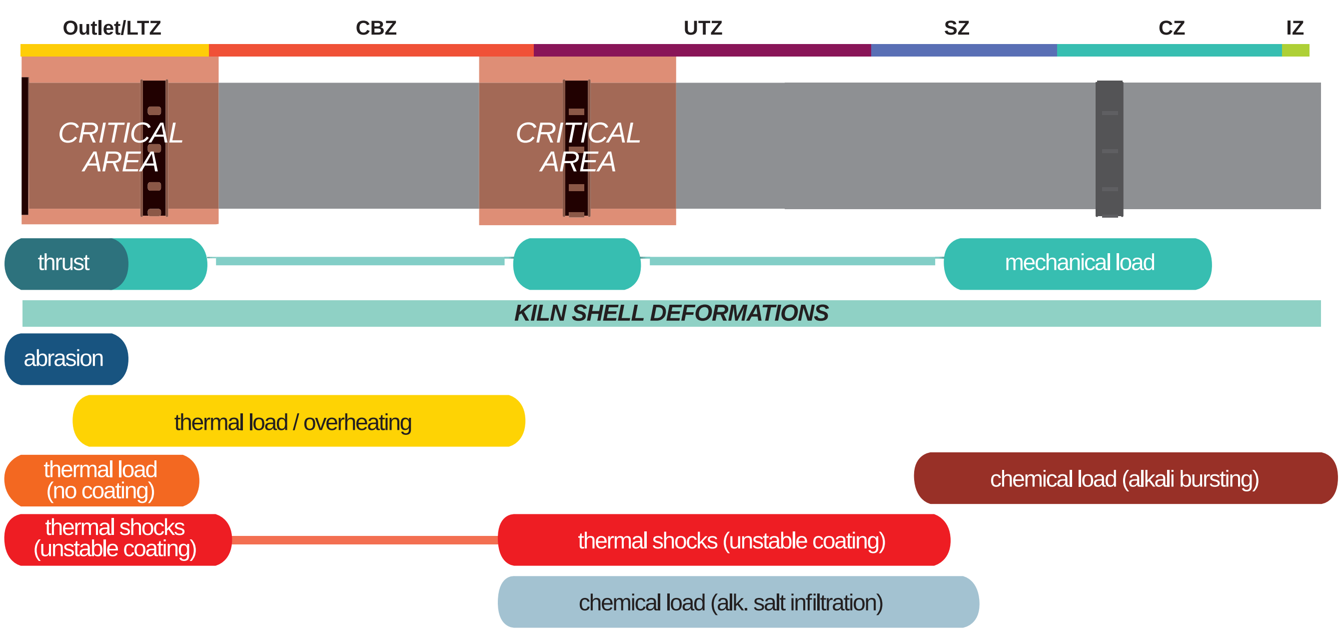
Advantage of maintaining the CaO/SiO_2 ratio in the Basic brick matrix at 2:1 ratio or higher

It is important that the Basic brick matrix has Silica and Lime in proper proportions so that refractoriness of the matrix is well above clinkerisation temperature. Keeping Silica and Lime in 1:2 or higher proportions helps in formation of DiCalcium Silicate (C_2S) or TriCalcium Silicate (C_3S) in brick structure. DiCalcium or TriCalcium Silicates can withstand temperatures above 2000°C giving bricks the ability to easily withstand clinkerisation temperatures ranging from 1280°C to 1350°C without any softening of the matrix.

When Silica and Lime are in almost equal proportions, there are possibilities of formation of low temperature melting phases like MontiCellite, Merwinite etc. These phases start melting near clinkerisation temperature. Brick matrix therefore becomes soft and performance of brick is adversely affected.

Name	Formula	Melting Point (°C)	CaO/SiO_2 ratio		
			<1	> 1 & < 2	>2
Periclase	MgO	2840	X	X	X
MagnesiaFerrite	$MgFe_2O_4$	1715	X	X	X
Spinel	$MgAl_2O_4$	2135	X	X	-
Forsterite	Mg_2SiO_4	1890	X	-	-
MontiCellite	$CaMgSiO_4$	1492	X	X	-
Merwinite	$Ca_3Mg(SiO4)_2$	1575	-	X	-
DiCalciumSilicate	Ca_2SiO_4	2130	-	X	X
TriCalciumSilicate	Ca_3SiO_4	2150	-	X	X
DiCalciumFerrite	$Ca_2Fe_2O_5$	1449	-	-	X

Predominant Wear Mechanisms in Rotary Kilns



The India Advantage Explained
Made from imported raw material at Dalmia-OCL's state-of-the-art manufacturing facility in Rajgangpur, Odisha, Magnel 85 is at par with the best in the world in terms of quality, finish and performance. Importantly, Magnel 85 finally gives Indian cement producers a better option. They can now choose to lower and unlock their investments, pay in local currency, manage inventories smartly thanks to incredibly shorter delivery cycles. And last but not the least, get faster service support in view of the geographical convenience. That's the India advantage.

Evolution of Magnel 85
Cement manufacturing is a 'basic' process due to presence of lime. Refractories need to be 'basic' therefore to withstand clinker corrosion. Of all commonly used refractory materials, MgO has so far been the obvious choice for manufacturing basic bricks since they offer maximum resistance to cement clinker corrosion. There's one problem though. MgO behaves poorly when it comes to thermal shock resistance. An MgO lining will crumble and fall down in its entirety as soon as the cement kiln is stopped and cooled. To address this, some other material has to be mixed with MgO grains, to act as a modifier and to impart thermal shock resistance to refractory. Advanced basic bricks are thus made up of two components: one is resistor which provides resistance against thermochemical attacks by cement clinker, and the other is modifier which helps increase resistance to thermal shocks. Not only that, the modifier also provides greater structural flexibility. It creates a crack-network inside the brick's microstructure for fracture toughness, which is essential to cope with mechanical stresses coming from thermal expansion, kiln shell ovality and shell deformation.

Magnel 85 Development
For the new and improved Magnel 85, Dalmia-OCL put greater emphasis on modifier since this is the component which is put to test as soon as the kiln is fired. It is also vulnerable to clinker corrosion than MgO grains which are resistant to clinker corrosion. It is possible that the modifier will react with cement clinker at higher temperatures to form low melting secondary Calcium-Alumina compounds which will increase brick density to make the lining lose its elasticity and result in wear. Keeping this in mind, Magnel 85 uses Zirconia compounds in modifier as these form compounds with high refractoriness with cement clinker. Therefore bricks can be used in thermally highly loaded transition zones to achieve a satisfactory life.

Since fused Spinel reduces wear rate of kiln linings considerably, Magnel 85 employs synthetic Magnesia with a higher primary crystal size, along with fused Spinel or modifier with Zirconia additives. In Magnel 85, it has also been ensured that Fe_2O_3 content is <1% so that volume change due to redox reaction is nominal and bricks are resistant to redox attacks.

Magnel 85, the Super Brick
While on one hand, due to its high hot strength, Magnel 85 bricks with addition of Zirconia can be used under severe thermal and thermochemical loads, this also makes them suitable for different parts of the kiln.

Magnel 85 is characterised by high abrasion and thermal shock resistance making it suitable for outlet and lower transition zones where main stresses come from lining thrust on retainer, abrasion from cement clinker, thermal load due to burner flame and thermal shock.

In central burning zone, bricks are mostly covered by a stable coating. Bricks are therefore expected to be coating-friendly. Magnel 85 has optimum levels of coatability making them suitable for central burning zone also.

Stresses in upper transition zone come from thermal shocks due to rapidly changing coating conditions, thermochemical attacks from alkali and Sulphur, and clinker melt infiltration. This is also the area where the second tyre is located which causes mechanical loads in case of ovality. Excellent thermomechanical and thermochemical properties of Magnel 85 make them suitable for this area too.

Magnel 85, the Super Brick, is suitable for all basic zones in a cement kiln. With its unique combination of synthetic Magnesia, fused Spinel, Zirconia additives to match different types of loads in different parts of the cement kiln, it is just the solution Indian manufacturers need to take care of severe operating conditions at best possible value. The best part, it is made right here in your neighbourhood. Made in India.

Magnel 85 Recent Performance Data

Plant/Works	Kiln Diameter	Production (TPD)	Basic Lining Length	Life
JAYPEE ANDHRA	4.35	4500	X	1 Year
JK GOTAN	3.6	3000	0.0-6.0	1 Year
CALCOM CEMENT, UMRANGSU (RUNNING)	3.8	3400	2.0-16.0	1 Year
OCL RAJGANGPUR LINE 1 (RUNNING)	3.8	3000	0.8-2.6 & 24.0-26.0	9 Months
OCL RAJGANGPUR LINE 2 (RUNNING)	4.2	4700	0.8-2.8	10 Months
DCBL ARIYALUR (RUNNING)	4.35	6000	3.0-6.0	> 1 Year

Did you catch the beat?

Find out by simply answering a couple of questions. And should you want, email your answers to Comms@DalmiaOCL.com for a FREE Beat t-shirt! But hurry, only 20 t-shirts are up for grabs and will be given away on first-come-first-served basis to those who get their answers right. Here goes...

Q1. What advantage do Basic bricks offer over Alumina bricks?
a) Ability to withstand higher temperatures
b) Higher thermal conductivity
c) Both

Q2. Special refractory bricks containing SiC can be used to address all types of severe coating condition
a) True
b) False

How do you like The Refractory Beat? Bouquets, brickbats, suggestions & feedback - email us all at Comms@DalmiaOCL.com. We'd love to hear from you.