PRESENT ECONOMIC CRISIS AND SOME NEW THOUGHTS ON THE RESEARCH, DEVELOPMENT AND APPLICATIONS FOR THE REFRACTORIES IN THE NEXT DECADE

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Introduction:

The current world economic environment is turbulent and frightening. This has come from a consequential irrational exuberance, a dash of greed and failure to acknowledge the complexities of over-clever financial instruments. To understand this crisis and also to face the challenges of this uncertain world let me start with the story of "BLACK SWAN". Before Australia was discovered it was believed that all Swans are white as there was no evidence of any other kinds of Swan in our Hemisphere. The Dutch explorer 'Willem De Vlamingh first discovered in the area which is now Perth in the western Australia in the 17th century the Black Swan. First they did not believe their eyes as Swans were by definition white. The Black Swan phenomena is principally concerned with the problems of uncertainty and knowledge. The Black Swan phenomena has three attributes:

(1) It is outside the realm of normal expectation
(2) It must make a huge impact
(3) It must be seen to be logical and explainable after the fact.

The present global financial crisis is exactly the same and we can expect in next 12 months

(a) The global economy is likely to enter a period of negative growth
(b) Equity markets are expected to be weak in the near to medium term
(c) Lower demand trends
(d) Lower prices
(e) Lower credit availability
(f) High cost of capital &
(g) Currency volatility.

We are certainly living in a "VUCA" world (Volatile, Uncertain, Complex and Ambiguous).

This is not a time to berate globalisation and build a fortress around our economy. Rather it is a time to sally forth and look for opportunities to make our presence felt on the global financial stage. 20 years ago we could never imagine the impact of inter-net and the true emergence of China. The winds of change continue and moving relentlessly faster and assuming strong proportions. In the next 10 years we may also see such significant developments as widespread cheap solar power, wearable computers, targeted drug delivery or green manufacturing. Looking further ahead we may see world changing breakthroughs which could allow us to build computers that learn like human or we can rebuild living organisms to fight disease, make bio-fuels and solve industrial problems. These are not dreams but innovations that scientists and engineers across world are actively working on making reality. These changes have the potential to profoundly impact how we live and work, what business model should be followed, what social net works we pursue, what products and services we use. More than ever we have the power to create and set our destiny.

The forces that are impacting our world:
(a) Shifting economic power
(b) Changing labour landscape
(c) Growing pressure on natural resources
(d) Changing technology landscape
(e) Changing industrial landscape
(f) Changing consumer landscape.

In a country like India we are going to gain into two important ways from the present crisis. First like many other emerging markets we may go through some pain but it will be minimal. We may not grow at the rate of 8% but still we will be one of the world's fastest growing economies. Thanks to our Reserve Bank for relative insulation.

Secondly this crisis could hold the seeds of a great opportunity. Wall street Giants have fallen and there is a vacuum, the Indian financial sector with its newfound confidence must be among these. Globally there is still a lot of liquidity outside the western world, particularly in west Asia and thus it is expected that focusing on the following parameters such as:

(a) Financial conservation
(b) More focus of risk adjusted valuation of asset classes
(c) Focusing more on balance sheet and
(d) With the elimination of risk of regulatory clamp up, we are sure to manage the present crisis.

Refractories though poised for a big growth have always remained squeezed between the raw material suppliers and steel makers. The negotiating power of the refractories makers is poor mainly due to their size as it cater to the industries which are far bigger in sizes like steel, aluminium, cement etc,. To add to this, the industry is facing countless difficulties both in terms of increasing raw material and other input costs as well as the availability. The industry in its pursuit of sustenance have to get a better realization, make more profit for providing long term service and develop newer products though research and development and also through newer application technologies. Let us now dwell on the subject of some future research, development and application methodologies in the refractories horizon.

Iron Making Area:

1. *Torpedo Ladle:*

- For effective dephospherisation the most suitable lining is Al_2O_3-SiC–C brick and the performance of these bricks can be improved by any one of the following methods.
  (a) Reduce oxidation by adding ß Al_2O_3
  (b) Minimise joint corrosion by adding MgO thereby causing spinel formation.
  (c) Lowering the thermal conductivity by suitable selection of amorphous carbon material.
  (d) Addition of metallic aluminium and borosilicate glasses.
- FEM analysis has been developed to determine the accurate temperature loss resulting to occurrence of mechanical stress.
- Possible opening of the joints at the hot face.
- Designing of the mouth castable should consider
  a) Shear thinning characteristics
  b) Should flow like Bingham plastics.

2. *Trough:*

Anhydrous mass – A specially developed aluminium power is added to the composition of the ramming mixes Al_2O_3-SiC–C and it acts both as a sintering agent and antioxidant. After melting Aluminium react with CO and CO_2 to get a newly formed Al_2O_3 that are helpful to improve strength density and structure.

Castable – Normally lined with low cement Al_2O_3–SiC–C castable and generally the wear is characterized by two locally generated corrosion one between Metal–Slag interface (ML-metal line) and the other Slag – Air interface (SL – slag line).

- Studies required to evaluate the SiO_2 content and its influence on the corrosion resistance arising out of the SiC oxidation.
- Some studies have also been done on the influence of the spinel addition but no quantitative data are available. Microstructure study of the spinel

addition and the corresponding behaviour towards corrosion resistance improvement will be an interesting area for further development.
- Another important study should be grain size distribution of the components as very often it has been seen that inhomogenity causes lowering of mechanical strength, increase of apparent porosity and thus non uniform chemical composition and phase distribution.

Steel Making Area:

Both for ladle and converter MgO-C bricks are still the widest choice and several work at different laboratories are being carried out to improve the properties of MgO-C bricks starting from improving the purity and crystalinity of MgO and finally to density increase.

- Recent studies are on the on the C- side i.e. specially processed pitch or changing the morphology of the C being used.
- Another area of development being the change in the metal additive and here specially developed Boron alloy powder i.e. the best additive showing improved oxidation resistance.
- A possible study can be to use MgO-CaO clinker as CaO is more stable than MgO at high temperature in contact with carbon.
- However, break through improvement in converter have been achieved by flame gunning repair. This is primarily a technique that involves simultaneous melting of a refractory powder and gunning it on the hot surface. Since the gunned repair material is dense and fused directly on the worn out surface excellent results are achieved.
- Study of the factors that control the secondary spinel formation in direct bonded Mag-Chrome refractories being used in RH degasser. It improves the necessary hot strength and corrosion resistance.

Monolithcs:

- To develop cements which will enable castables to be adjusted to a normal setting behaviour and will avoid the variability and uncertainty of setting specially during winter time.
- To develop defloculants which will provide castables with prolonged working time and improved flowability compared to polyacrylates and polyphosphates being commonly used now – a - days.
- Matrix interaction study to understand fully the mechanism of flow delay and initial stiffening arising out of the interactions of phosphates, fume silica and calcium aluminate phases.
- Study of the total amount of alumina and the ratio of line to ultra line alumina powder to interpret the strength of different castables.
- In magnesia based castable with Al_20_3 in the matrix the rate of spinel formation and the temperature range will determine the densification of the continuous spinel matrix which will determine two important characteristics of the spinel castable:

a) Corrosion resistance
b) Thermal shock resistance.

- Binders are the harmful component of the refractory castable. While no cement castables have been developed they suffer regularly from a distorted rheological behaviour.
- One possible developmental area may be to obtain binding properly by a mechanical and chemical processing combined (mechanical dispersion and chemical interaction processes combined).

Shotcreting:

It is the process by which castables are pneumatically projected at high velocity onto a surface. One aims to get the benefit of both the castable and gunning technique in one go. The main essence of the process is suitable judgement of the accelerator as it is normally added at the nozzle. Refractory mixes for shotcreting are often designed to be self flow,

transportable or sprayable. Accurate accelerator dosing is essential.

The most important aspect of obtaining a quality lining through shotcreting route are:

a) Proper self flow castable consistency
b) Use of high air pressure.
c) Suitable dose and as minimum as possible quantity of accelerator.
d) Proper anchoring
e) Proper scaffolding
f) Proper nozzle adjustments

Today suitable mixes have been developed to shotcrete cement rotary kilns, Aluminium melting furnaces, waste incinerators etc, etc. Lastly on the monolithics one last word and probably that is the dream of all unshaped refractory producers to have a Mag– Carbon castable to replace Mag-C brick in ladles, converters etc. There are activities all around across the globe but real progress have not been met yet. The increase in carbon content normally reduces the strength of the castable. Development work should possibly be a complete new type of carbon and i.e. why we need to work with the carbon producers and on some chemical defloculent as well. All developments of refractory technology should aim towards environment protection and points to consider for that are reducing the refractory emissions for which it requires an improvement of service life of the furnace and reduction in refractory consumption. For this it is required to focus on the development of:

1. Technologies to repair effectively partial worn areas prior to complete replacement of the lining using monolithic refractories with an extremely good durability.
2. Progress on sequential repairs that will allow continuous relining to be done without discarding the remaining lining.

Other Industries:

Cement: Main concern area is the burning zone and here we all know a variety of influence contribute to the wear of the refractories and cause either a chemical, mechanical and thermal loading of the kiln. While mostly bricks have been developed to take care of the mechanical and thermal loading chemical aspect, are still bothering the operators and most probably the decisive factor is DS index (degree of sulfatisation).

$$DS = \frac{SO_3 + Cl}{Na_2O + K_2O.}$$

and the developmental efforts need to be to optimise the lime content of the binder phase and the alkali chromate of the magnesia chrome refractories.

- Three other new types of refractories are being developed.

(1)Magnesium orthotitanate (Mg_2TiO_4) which is a spinel and after reaction with cement clinker $CaTiO_3$ is formed which provide good coating formation and $CaTiO_3$ is also a stable phase in contact with Portland Cement.

(2)Magnesia orthostannate refractories by incorporating 90% SnO_2 powder in M.A. spinel. Here MgO decreases the volatility of SnO_2 due to formation of **Mg_2SnO_4** and also the resultant material shows higher corrosion resistance compared to magnesia chrome refractories.

(3)For developing flexible structure i.e. to absorb the stress developmental work is required to produce bricks with MgO-CaO-ZrO_2. This will not only improve the corrosion resistance and will provide good coating adherence but will also eliminate the problem of hazardous hexavalent chrome compounds.

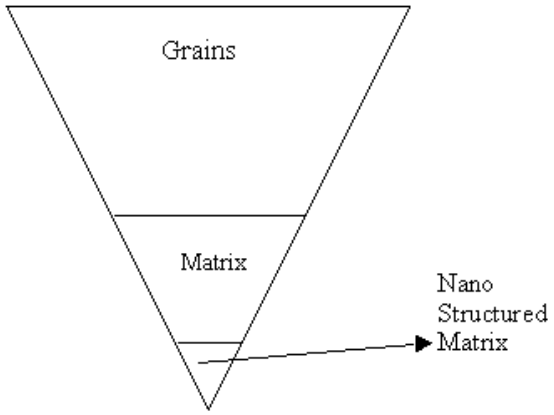
Aluminium: Anode baking: The main mechanism of deterioration of refractories has to be identified. Early works have shown that the deterioration occurs in the matrix and the XRD studies have shown that this is due to an increase of Na-rich liquid phase. How to reduce the liquid during the corrosion of sodium gas is actually the challenge of the refractory researcher.

Aluminium Cast house (Melting and holding furnace): There are plenty of commercially available castables (both conventional and low cement) having non wetting characteristic combined with excellent chemical / mechanical properties with good thermal shock resistance is available and are in use. Further research required to improve the properties like:

a) Abrasion resistance
b) Superior aluminum resistance even at high temperature.
c) Better and improved thermal shock resistance.

Nano Tech Refractories:

Thermal shock resistance and corrosion resistance conventionally require opposite characteristics and nano tech refractories essentially satisfy both these characteristic.



The whole idea is to control the microstructure. A whole host of research is going on and addition of nano particles will revolutionalize the refractory technology altogether. Grossly saying it acts in two ways:

1. The nano particle – They are consisted of mono spheres and improve the properties like elasticity and strength.
2. The control of molecular structure as the particles have many small pores of about several hundred nanometers.

Refractory research, development and application methodology have to concentrate on the following aspects:

1. High temperature tensile and compressive behavior of the lining.
2. Characterization and modeling of the thermo-chemical bahaviour of lining through FEM
3. Creep and plasticity at high temperature.
4. During heating always refractory linings are exerting important pressure on the metallic part of the structure and leading to lining cracks. Study of the structural designs are thus important by adopting multiscale approach
5. Thermal stress studies of the lining are important again with FEM.
6. Interaction between refractory material and the steel heat as for the cleanliness of the steel total oxygen content should be extremely low.
7. Low nitrogen content, low hydrogen content and low C- pick up – these studies are essential as this will impact the steel heats.

Finally we must protect our Environment and hence Recycle and Reuse is a must. In conclusion I may add that refractories cost is about 8% of the total cost of steel production and there is good possibility of further reduction of the specific consumption of refractories in Steel industry, Cement industry, Aluminium industry etc, etc and it would be through monolithics and special products. The leadership team has to decide which products and services it feels passionate about and then formulate the vision of R&D.

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