Introduction

- What is a Refractory ?
  - What are Refractory Materials?
  - What is Refractory Technology?

What is Refractory Technology?

Refractory Technology is fundamentally:

•Physical Chemistry

mixed with

•Inorganic Chemistry

with a splash of

•Organic Chemistry

So before we even start it is clear that Refractories Technology is a little abstract, it is not something that can be easily pinned down, it is hybrid, it is mongrel.

What is Refractory Technology?

Refractories Technologists are REAL APPLIED SCIENTISTS;

they take science and use it practically to actually Do something that needs Doing.

Refractory Technology is not science just for the sake of science.

For this reason Refractory Technology is often described as an Art not a Science,
a Black Art

What is Refractory Technology?

Wikipedia on Refractory

A Refractory is:

•a material that retains its strength at high temperatures.

•"non-metallic materials having those chemical and physical properties that made them applicable for structures, or as components of systems, that are exposed to environments above 1000 °F (538 °C)".

•Refractory materials must be chemically and physically stable at high temperatures.

•Depending on the operating environment, they need to be resistant to thermal shock, be chemically inert, and/or have specific values of thermal conductivity and of the coefficient of thermal expansion

What is Refractory Technology?

- So in summary at this stage:

- ‘Refractories are Non Metallic Materials that can withstand High Temperatures and Chemically Challenging Environments’

What is Refractory Technology?

However, Wikipedia continues

Refractory materials are used in linings for furnaces, kilns, incinerators and reactors. They are also used to make crucibles.

And finally identifies the main building blocks

The oxides of aluminium (alumina), silicon (silica) and magnesium (magnesia) are the most important materials used in the manufacturing of Refractories.

What is Refractory Technology?

- **G.B. Rothenberg expands on this slightly in his book that is enticingly entitled, ‘Refractory Materials’.**
  - ‘Most industrially used Refractories are composed of metal oxides’.
  - ‘Their usefulness depends on their ability to maintain their mechanical functions at high temperatures, quite often in contact with corrosive liquids and gases’
  - ‘Refractories are comprised of ceramic materials used to line furnaces and high temperature vessels. Also, they are needed to line passages or chambers remote from the combustion region, but which contain high temperature gases. When Refractories are used to line a vessel in which fluid such as molten steel or glass is to be contained, the chemical reaction of the refractory is important’

What is Refractory Technology?

- So as a final definition we could say that:
- ‘Refractories are High Melting Point, Chemically Inert Metal Oxides’
- Or
- Materials that can withstand high temperatures and chemically challenging environments such as the Oxides of Aluminium, Silicon and Magnesium

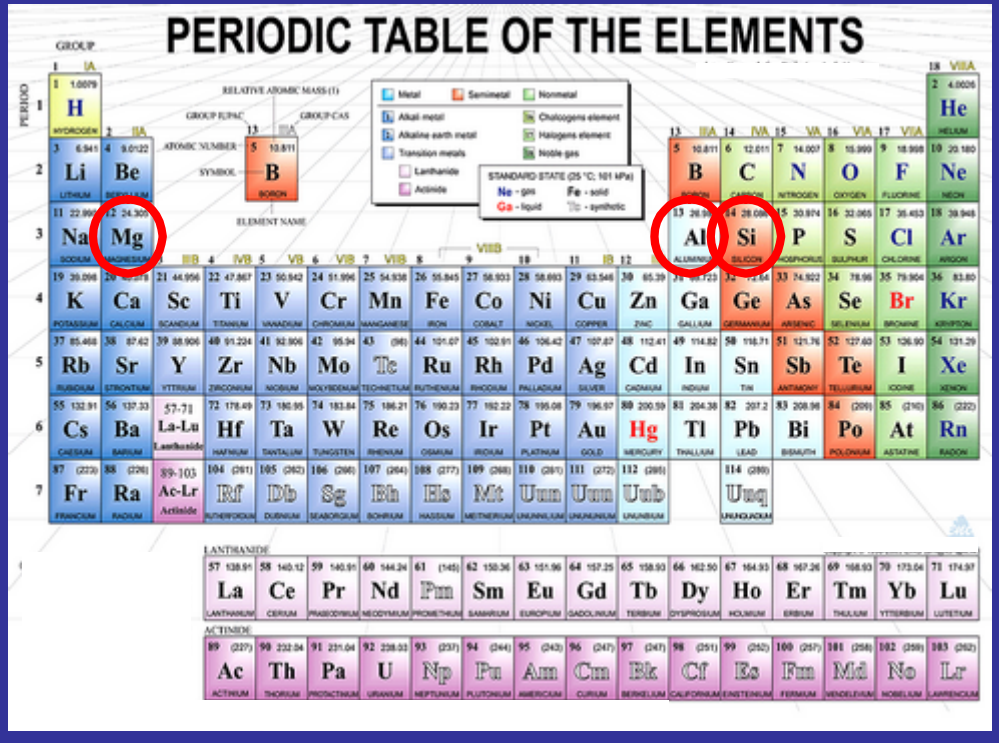
What is Refractory Technology?

- So why are these Metallic Oxides so useful, why do they survive in high temperature and chemically challenging environments?

- The answer is simple,
  - ’ because they are so stable’

What is Refractory Technology?

- Why are the Oxides of Aluminium, Silicon and Magnesium so stable



- As of 2007 117 Elements have been ‘observed’
- These are pure Chemical Substances composed of Atoms with the same number of Protons
- 94 of these Elements occur naturally on Earth
- However, most Metals are not found in their pure state but as Oxides or Sulphide Mineral Ore Deposits
- In the case of Aluminium, Silicon and even Iron this attraction to / for Oxygen is so strong that it can take a significant effort to Reduce the Oxide to pure metal
- And once you have formed the Pure Metal it will immediately try to revert to combine with Oxygen once again

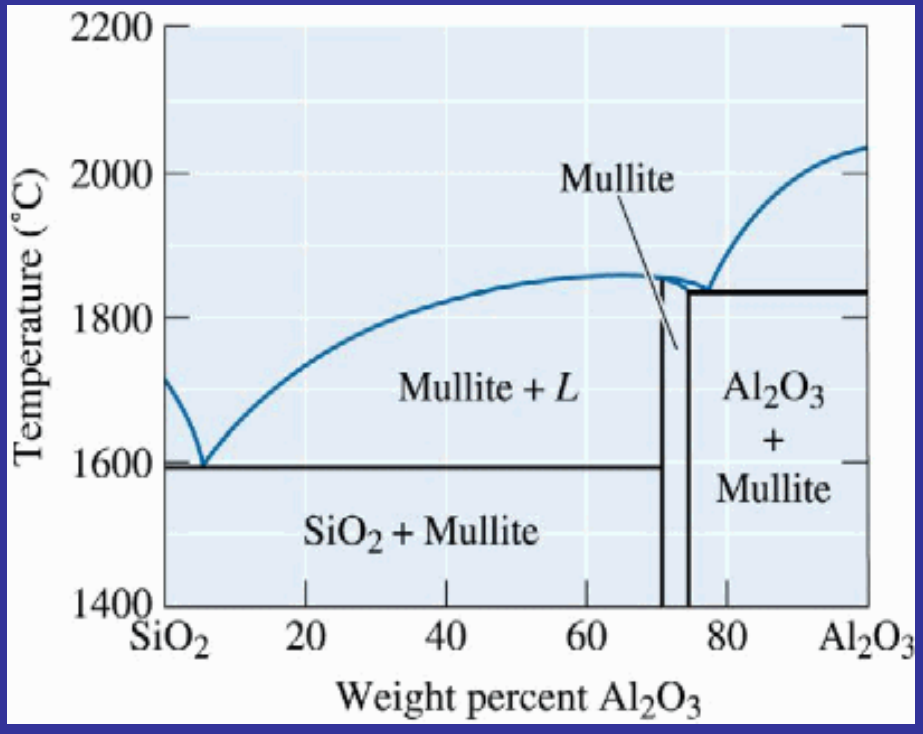
- It is this level of stability that makes Alumina, for example, such an ideal Refractory Material
- These Elements feel more comfortable, feel more Stable when combined with Oxygen and they hang on to that state tenaciously.

What is Refractory Technology?

- Of course the fact that these Metals are found naturally as Oxides does make it things potentially rather convenient for the Refractories Producer
- These Key Raw Materials can be quarried / mined and following relatively simple processing they are suitable for manufacturing Refractory Products

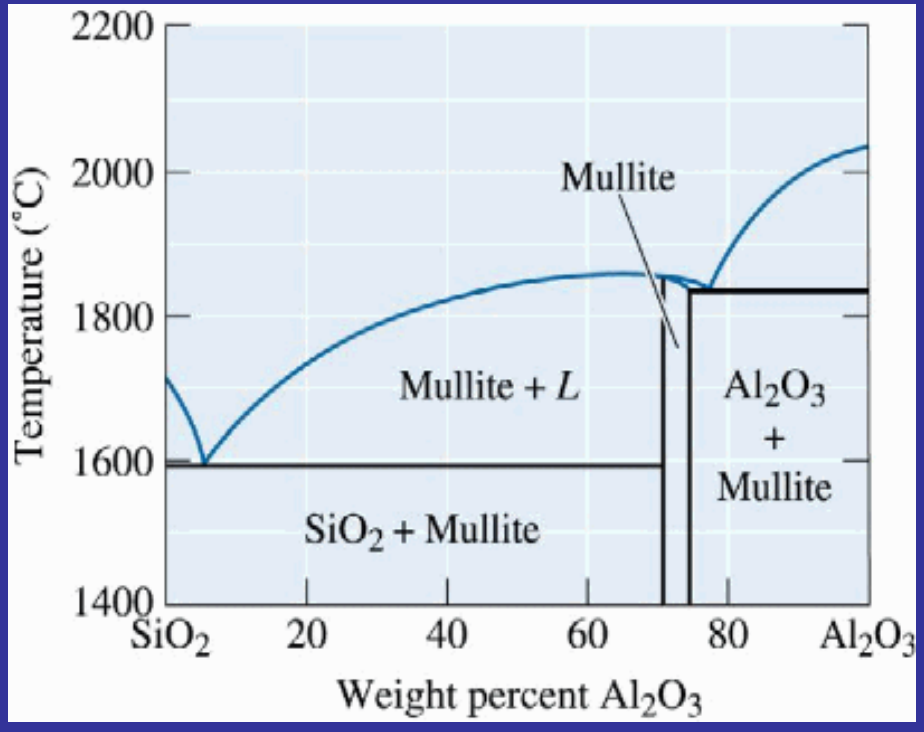
- However, there is a slight catch

Silica – Alumina Binary Phase Diagram



- Unfortunately, naturally occurring deposits of these Metal Oxides tend to be found combined with each other along with further components in what is a bit of a soup of potentially useful items
- Some naturally occurring deposits are refined to produce very pure forms of Alumina, Silica and Magnesia but this can be expensive
- Whilst with others we tend to work with what we have got and just compromise
  - Of course sometimes the mix of properties from the Hybrid materials are actually beneficial
- One of the most common combinations that you find is that between Alumina and Silica, The **ALUMINO SILICATES**

Silica – Alumina Binary Phase Diagram



- Here we have the Silica - Alumina Binary Phase Diagram
- This shows:
  - The melting point of Pure Silica is between 1600 c and 1800c
  - The Melting Point of Pure Alumina is over 2000 c
  - However, the melting point of a mixture of Silica and Alumina will change as the proportion of the 2 components varies
- However, it is not just the Melting Point that varies other physical properties can also be affected by the relative proportions of these components
- The Refractory Technologist has to be aware of these factors as he determines which deposits are acceptable for use in different products for different applications

- The Alumino Silicates
- Examples of Alumino Silicates, (naturally occurring and synthetic):
  - Bauxite, Kyanite, Andalusite, Chamotte, Flint Clay, Kaolin, Mulcoa

What is Refractory Technology?

- The situation with Magnesia is slightly different
- Magnesia is actually produced from naturally occurring Magnesite, which is Magnesium Carbonate
- When this Magnesite is fired to 900c it converts to Magnesium Oxide, (Magnesia).
- If it is then fired further to 1600c it produces a more stable Dead Burned Magnesite
  - This is just to confuse people.
    - Magnesite is Magnesium Carbonate which when fired becomes Magnesia but when it is fired to 1600c we refer to it back by the Carbonate name but with a prefix to note that we have fired it to form the Oxide
- Of course naturally occurring Magnesite is not pure Magnesium Carbonate but generally contains Calcium Carbonate, (Lime) and Iron Carbonate, ($FeCO_3$).

Classification of Refractories

- **Classification**

- Refractories are no different from most things in that there is an obsession with attempting to classifying the different Refractory Materials

- Refractories can be classified in a number of ways none of them is really very satisfactory

Classification from a Chemical Standpoint

- From a Chemical Standpoint, refractory substances, in common with matter in general, can be classified into 3 groups
  - » Acid
  - » Basic
  - » Neutral

- In theory Acid Refractories should not be used in contact with Basic Slags, Gases or Fumes
- And Basic Refractories should only be used in contact with basic Slags, Gases and Fumes

- However, for various reasons these rules are continually broken and the existence of a truly Neutral Refractory is doubtful.

- Therefore this type of classification is a little academic, it doesn't really provide any guidance to which refractory can be used where and it is confusing

Classification by Application

- Refractories can also be classified by application, such as Blast Furnace Refractories or Steel Making Refractories
- However, these classification groups are too wide and diverse to be of any real use

Classification in Terms of the Raw Material that are Used

- So, pretty much by default we generally end up classifying Refractories in terms of the Raw Materials used in their manufacture and in terms of the main minerals that exist after they have been processed.
    - Silica Refractories
    - Alumino Silicate Refractories
    - High Alumina Refractories
    - Magnesia – Lime Refractories – (Basic Refractories)
    - Special Refractories

- The majority of Refractory products that are used today will fall into the middle 3 categories

Classification – Product Type

- Unfortunately classification, in its purest sense, doesn't quite end here. However, we shouldn't dwell too much on the next tiers of classification because these will become clearer when you have heard presentations that will follow shortly.

- Suffice to say, there are:
  - Shaped and Unshaped Refractories which in crude terms can be described as Bricks and Monolithics

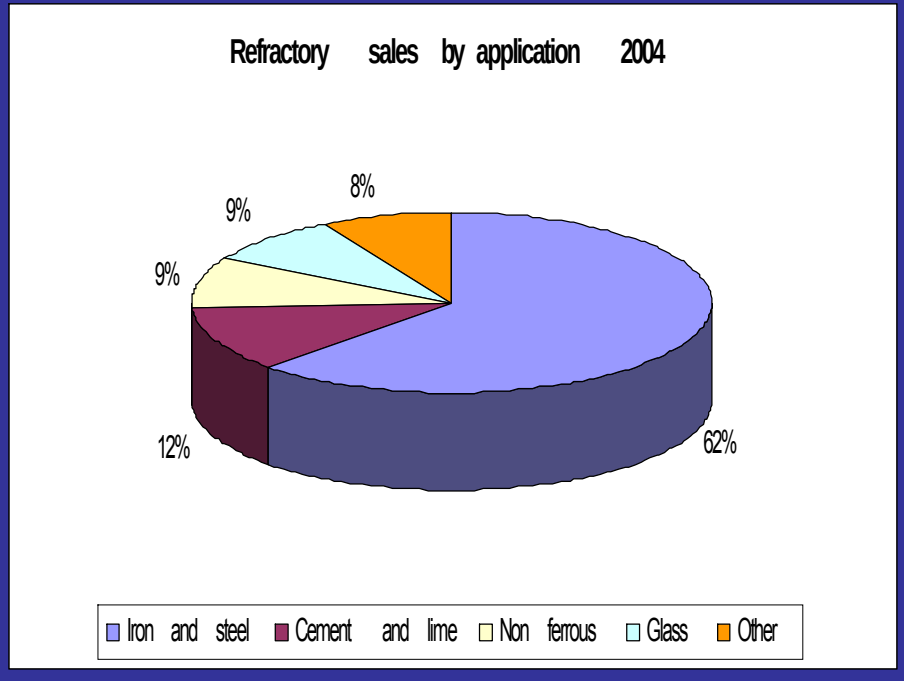
  - There are Dense Refractories that are designed for their strength and resistance to penetration by liquids and gases.

  and

  - There are Insulating Refractories which are light weight, low density materials designed primarily to prevent heat loss

Refractory Applications

- The steel industry is the largest consumer of refractories both in this country and worldwide.
- Approximately 2/3 of all refractories are used in the steel industry.
- However, without doubt Refractory Materials play an extremely important role in a wide range of vitally important Industries



- **Steel**
- **Cement**
- **Non Ferrous Metals**
- **Glass**
- **Power Generation**
- **Incineration**
- **Boilers**
- **Minerals Processing**
- **Foundry**
- **Chemical**

What is Refractory Technology?

- So in Summary
- If anyone asks, ‘what are Refractories’ tell them:

- **‘Refractories are High Melting Point, Chemically Inert Metal Oxides’**

- **Or**

- **Materials that can withstand high temperatures and chemically challenging environments such as the Oxides of Aluminium, Silicon and Magnesium**

- **And don’t be embarrassed because these products are extremely useful and have a vitally important role to play in a wide range of Industries**