INSTITUTE OF REFRACTORIES ENGINEERS

TRAINING DAY 2013

ALUMINA REFRACTORIES

EXERCISE 2

APPLICATION OF FIRED ALUMINA REFRACTORIES

For the following applications, consider the service conditions and the properties of the various types of alumina refractories and recommend which materials might be used.

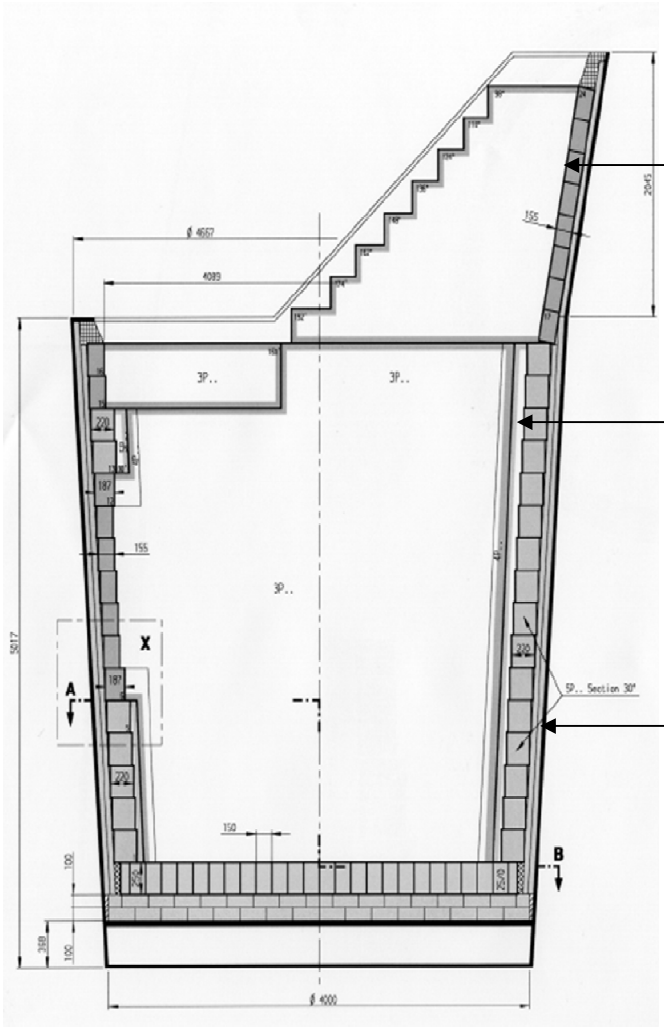
Discuss the reasons for your selection

HOT METAL LADLE

The Hot Metal Ladle, or Charging Ladle, is a refractory lined vessel designed to transport liquid iron from the Torpedo Ladle to the Basic Oxygen Vessel in the Steelplant. In addition to transportation, the Hot Metal Ladle is also commonly used as a process vessel to enable the desulphurisation of the liquid iron prior to discharge into the BOS vessel. This typically employs basic reagents such as CaO, Magnesium and Calcium Carbide which may be singly or co-injected deep into the iron bath using a refractory desulphurisation lance.

The temperature of the liquid iron is generally between 1300 and 1450 degrees C but some hot spots may occur due to the action of the desulphurisation reagents. Though the desulphurisation process is generally short (c. 20-30 minutes), the time in which the liquid iron (and top slags) are in contact with the refractory lining can be a number of hours due to the process flow through the steelplant. Additionally the time during which the ladle is empty can be extensive leading to significant thermal fluctuations in the working lining.

A typical HML design configuration is shown below:



Ladle Lip.
Effectively a liquid iron 'discharge spout'

Working Lining. Lower barrel in contact with liquid iron, upper area in contact with liquid slags/reagents.

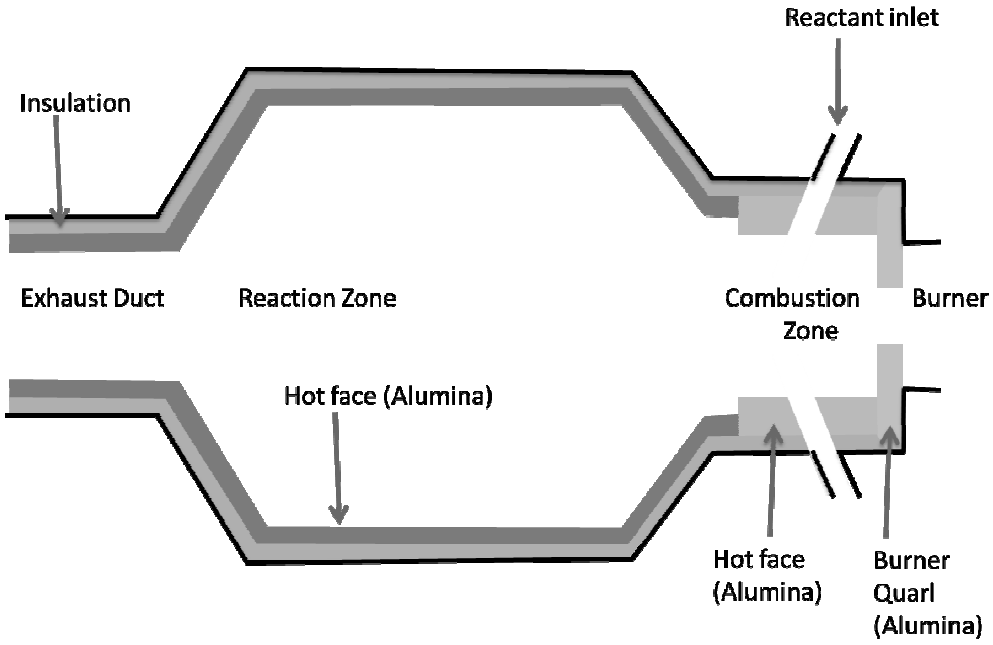
Safety Lining. Used as a backup in case of iron penetration through the working lining or working lining failure. May be single or multi-layer.

THERMAL OXIDISER

A large chemical plant a thermal oxidiser to destroy COS (carbonyl sulphide) which are by products from a process unit. The amount and ratio of the two compounds varies over a short time (10-15mins) from low to high levels. The oxidiser operates for approx. 2 weeks and then has a 2 day stoppage. It is fired with a natural gas burner. Cold COS is injected into the burner zone at high pressures. The heat from the exhaust gases is used to raise steam, and the gases are then passed to a gas cleaning stage and a stack. The combustion products included a high level of SOx.

The operating temperature is 1000-1150°C, with changes over a short time as the input gases vary.

The unit is shown schematically below.



There is a layer of insulating materials and a hot face layer. What materials could be used for the hot face layer in the different zones?.

SULPHUR RECOVERY UNIT

A Sulphur Recovery unit is a process vessel used in oil refineries to recover sulphur from hydrogen sulphide in hydrocarbons. The sulphur is then sold as a valuable product. The thermal process vessel is a cylindrical vessel where hydrocarbons are oxidised with oxygen enriched air at 1000-1200°C. The hot gases leaving the chamber contain gases including

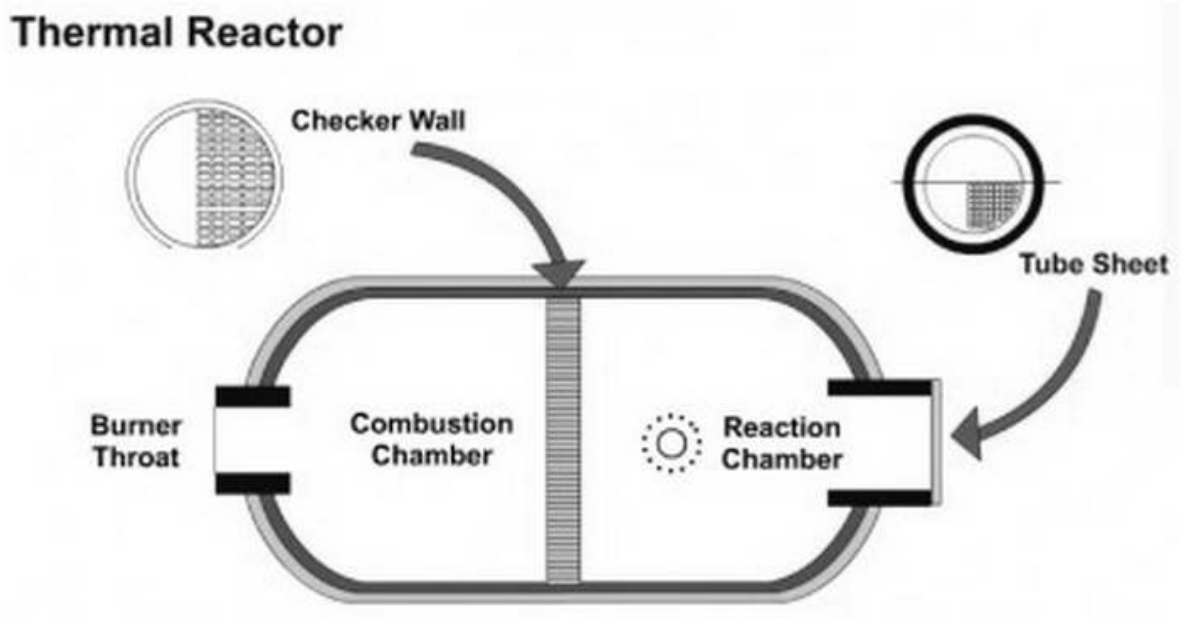
Hydrogen – H_2
Sulphur Dioxide – SO_2
Carbon Monoxide – CO
Carbonyl Sulphide – COS
Hydrogen Sulphide – H_2S
Steam – H_2O

And short chain hydrocarbons.

The process operates continuously for extended periods but temperature fluctuations due to changes in the feed can occur at short notice. Hydrogen gas can react with silica in the refractories to form silicon monoxide gas. Flame impingement in the burner area and chequer wall can lead to localised hotter areas.

What material would you suggest for the working (hot face) lining in the

Burner throat
Combustion chamber
Checker wall

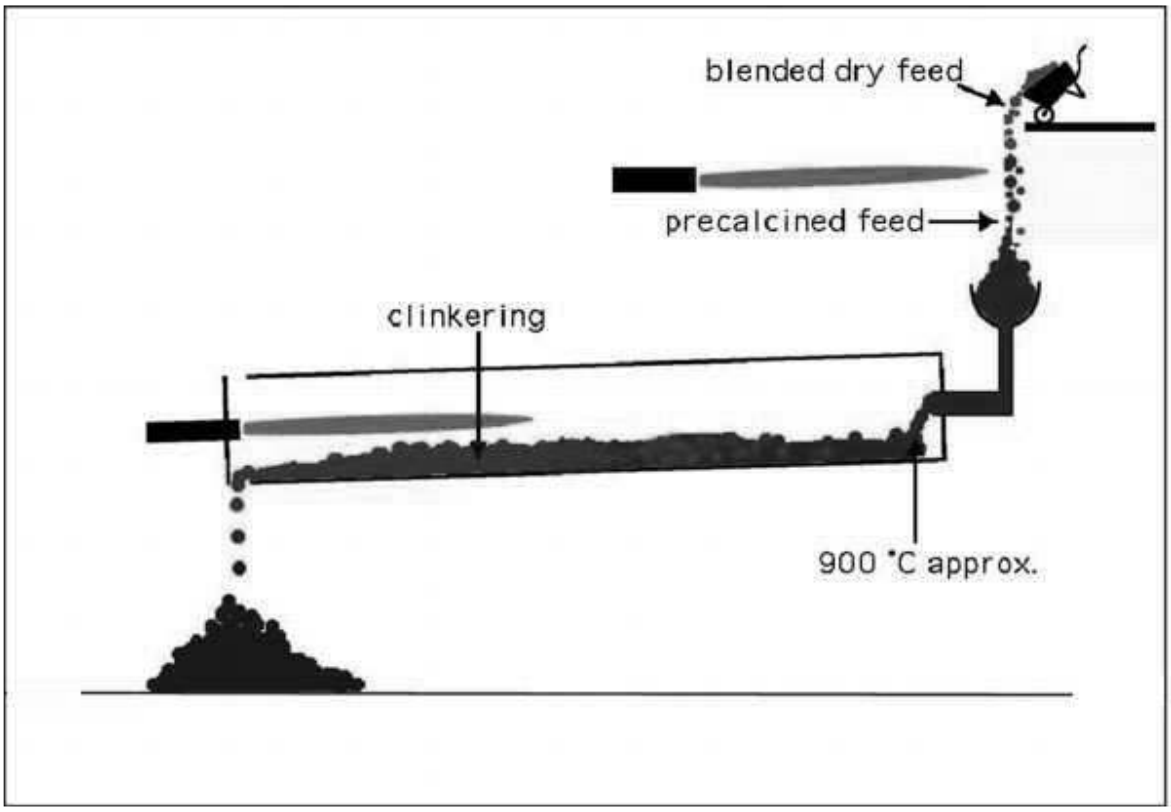


CEMENT PLANT ROTARY KILN

Large parts of a cement kiln are lined with basic materials. The inlet end is commonly lined with alumina materials. These may be bricks or monolithics.

The inlet end is subject to abrasion from the hot feed, and chemical attack from alkali, with alkali vapour in the exhaust gas condensing in this zone as the temperature is lower.

Additionally, there is dynamic loading from the kiln rotation.



Consider a kiln inlet end lined with fired alumina bricks.
What grade would be selected and why?

HML Answer:

60% alumina materials based on Andalusite are generally employed in the lip area and in the slagline area due to their resistance to oxidative attack, good thermal shock resistance and resistance to pull out during deskulling. An alumina boosted Andalusite product may be used to improve slag resistance where desulphurisation processes lead to slags that are very aggressive to alumina based products.

Low Iron 60% alumina products are also employed in the safety lining due to their good thermal stability, relatively low thermal conductivity, high CO resistance (in high fired form).

Oxidiser Answer

Main lining
- Moderate temps, but rapid temp changes
- Flint clay brick has better thermal shock res than fireclay and adequate temp resistance

Combustion chamber
- Rapid temp changes as cold reactant flow rates change
- High mullite content needed for thermal shock resistance
- Alumina boosted andalusite with high firing temp, to give high mullite content

Burner quarl
- Thermal shock and high thermal stress
- Castables unsuitable due to acids formed on combustion
- Complex shape
  - Hand made shape from synthetic fused mullite

SRU

Burner throat – 90% A brick based on WFA – better thermal shcok than 98% due to mullite conente
Com Chamber – 98% Tab A based brick – resists H2 attack
Chequer wall– 90% A brick based on WFA – better thermal shcok than 98% due to mullite conente

Cement Kiln
Fired bauxite brick or fired chem bonded bauxite brick
- Hot strength and hot abrasion res
- Alkali res