Institute of Refractories Engineers

Training Day 2022

The Role of Refractories in Achieving Energy Saving

Sam Franklin

Why Save Energy?

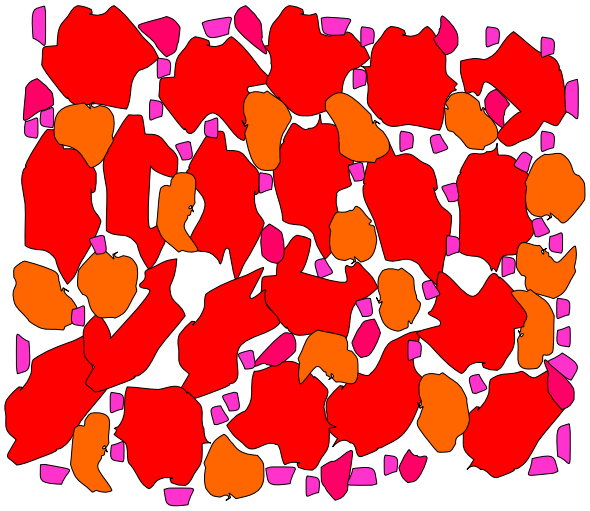
- Reduce Costs
- Reduce CO_2 Emissions

Why NOT Save Energy?

- Capital Cost
- Lining Thickness Constraint
- Need for High Shell Temperature – eg acid gas dewpoint
- Freeze Line – Protective Accretions
- Wear Rate of Lining

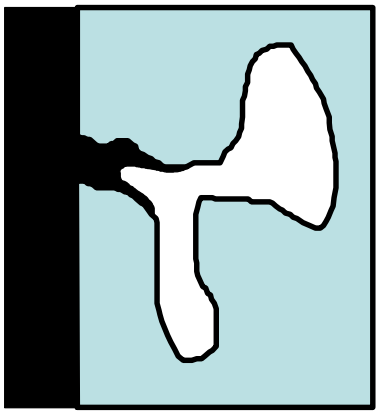
Putting Refractories Together

- Made from irregular grains bonded together
- Space between grains – pores
- Pores are filled with air or gas
- More pores – less solid – more insulation



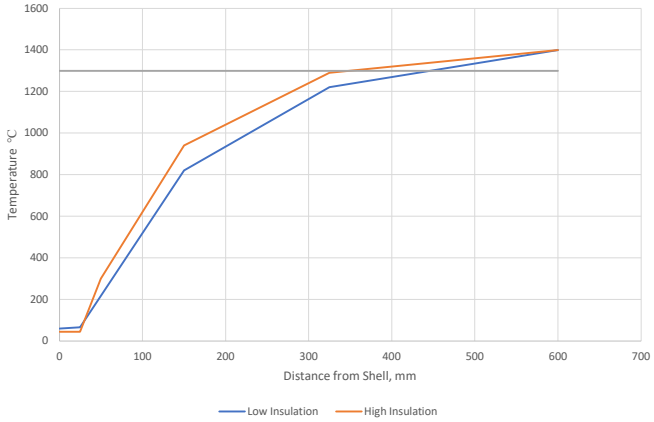
Porosity and Wear

- Pores allow process fluds (gas, slag, liquids) to penetrate into refractory
- More pores allow more attack
- INSULATING MATERIALS are less chemically resistant than dense refractory
- Insulating materials have lower strength than dense refractory



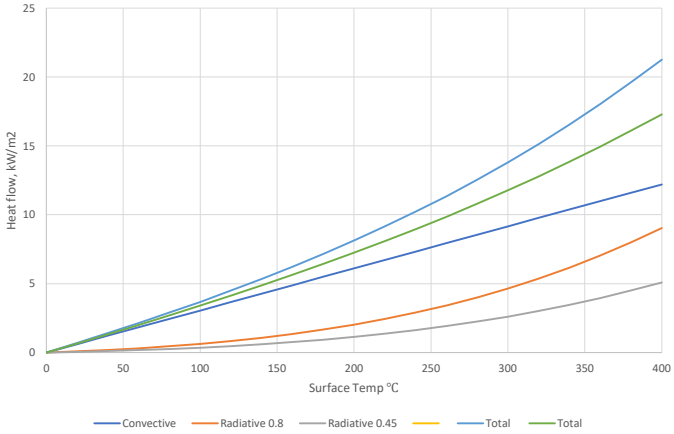
Insulation and Lining Wear

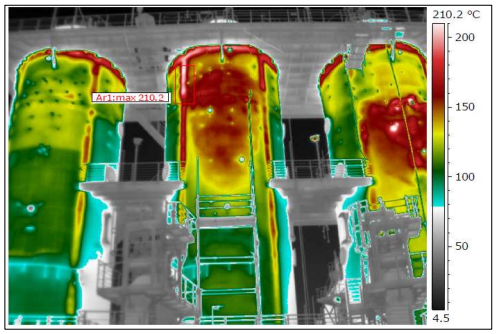
- Lining subject to attack by penetration of fluid
- Limit of attack is freeze line, condensation point etc



Shell Temperature and Heat Flow

- Higher Shell Temp = Higher Heat Loss





New Technologies

- Many process will change as a result of need to achieve zero carbon
  - Need to recover low grade heat
  - Greater focus on energy usage
  - More intermittent processes – avoid energy usage spikes
  - Energy storage

- This will impact on the refractory design

Questions?

https://irengineers.co.uk/

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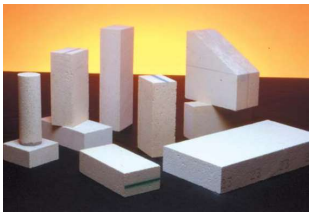
Types of Insulating Materials

Types of Insulation

Insulating Castable/Gunning

Fibre Insulation



Insulating Firebrick

Microporous Insulation

Insulating Castables and Gunmixes

- Aggregate
- Binder – Usually Calcium Aluminate Cement
- Additives – clay in gumixes

- Simple formulations
- High water addition (30-50%) owing to high porosity

Insulating Castables and Gunmixes

- Natural Aggregates
  - Vermiculite and Perlite
  - Expanded Fireclay
- Byproducts from other processes
  - Cenospheres
  - Lytag
- Synthetic Aggregates
  - Bubble Alumina
  - Others, eg Almatis SLA92

Properties of Insulating Castables

Depends on aggregate and binder

- Density 300-1500 kg/m^3
- Cold Crushing Strength <1-20MPa
- Service Temp Limit 800-1700℃
- Thermal Conductivity 0.3-1.2W/mK

Generally lower insulation value than other forms of insulation

Insulating Monolithics

Advantages

- Ease of installation, esp with monolithic hot face
- Better mechanical properties than other finds of insualtion

Disadvantages

- Low insulating value

Comment

- Install without vibration – do not maximise density

Insulating Firebrick

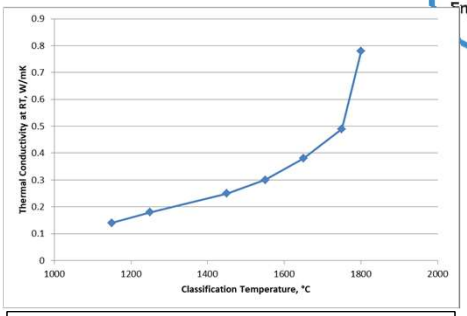
- Composition
  - Refractory Grains eg chamotte
  - Combustible particles eg sawdust, EPS
  - Ceramic Bond
- Properties
  - Density 550-1200kg/ m^3
  - Cold Crushing Strength 0.5-5MPa
  - Insulation Value 0.2-0.8W/mK

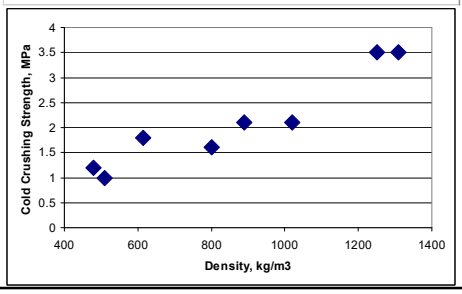
Insulating Firebrick - Properties

An INCREASE in Density ….

- Decrease in Insulation Value
- Increase in Strength
- Increase in Max Temp

- CLASSIFICATION TEMPERATURE
- Defined by Shrinkage.
- **NOT Maximum Service Temperature**





Insulating Firebrick Production

Batch and Mix

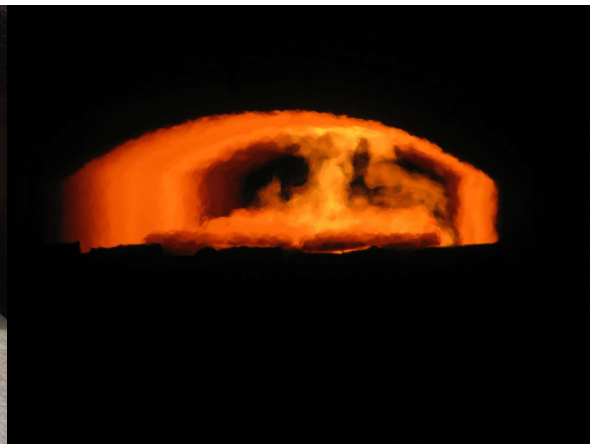
Extrude - Oversize

Dry

Fire

Machine to Size

Insulating Firebrick - Firing



Classification Temperature (IFB)

Definition (ISO 2245)

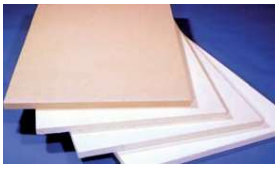
- the temperature at which the permanent change in dimensions, determined in accordance with ISO 2477, is 2 % or less
- Eg a 125 grade IFB will shrink by 2% at a temp higher than 1250℃ over a 12h PLC test

Classification Temperature (IFB)

ISO Grade	Class Temp ℃	ASTM Grade	Class Temp °F	Class Temp ℃
115	1150			
		21	2100	1199
125	1250			
		23	2300	1310
145	1450			
		26	2600	1476
155	1550			
		28	2800	1588
170	1700	30	3000	1699

Fibre Products

Bulk



Board

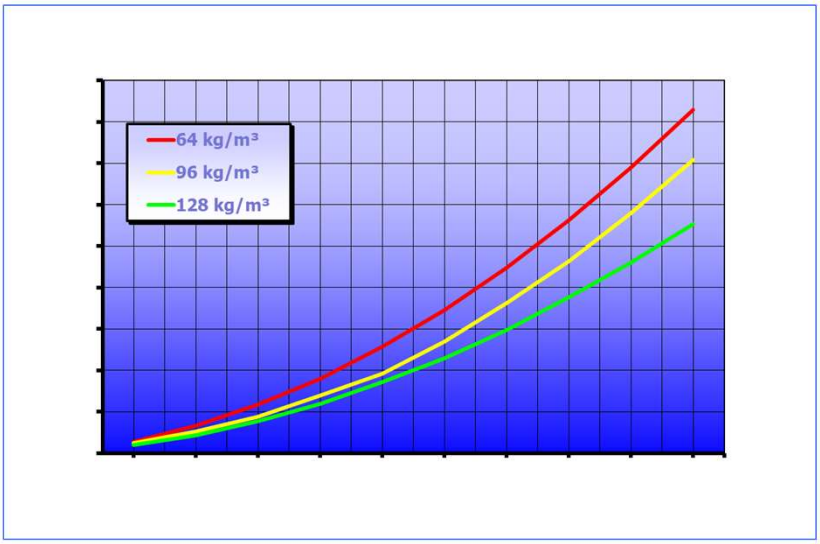
Module

Blanket

Vacuum Formed

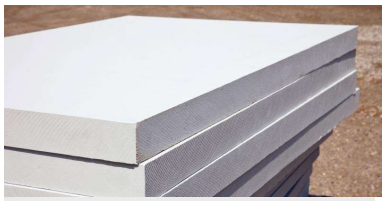
Paper

Fibre Products – Thermal Conductivity



Calcium Silicate

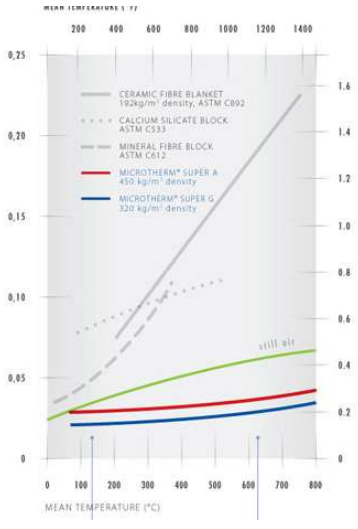
- Rigid Board
- Max Service Temperature of 1000°C
- Easy to cut
- Low cost for insulation value
- Can be machined for complex shapes



Magnesium Silicate

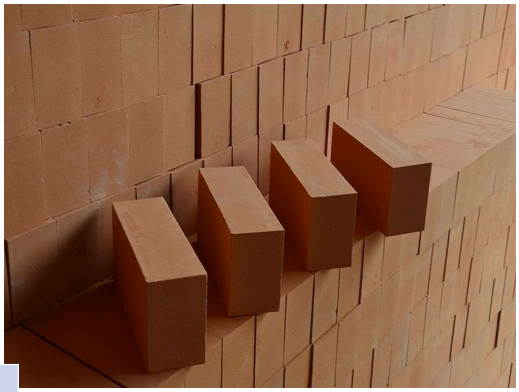
Bulk Density	1.2-1.5 kg/m^3
CCS	15-40 MPa
Thermal Conductivity at RT	0.2 – 0.3 W/mK
Classification Temperature	1050 °C

Microporous Materials



Diatomite Brick

- Diatoms are microscopic sea creatures with a silica shell
- In some areas, the dead shells form layers of rock known as diatomite.
- Each fossil is hollow
- Diatomite is mixed with clay for plasticity and sawdust to add porosity
- Production is same as Insulating Firebrick



Bulk Density	750 kg/m^3
CCS	3-7MPa
Thermal Conductivity at RT	0.15-0.20 W/mK
Classification Temperature	950°C

Cellular Glass

- A glass material with a large volume of CLOSED pores
- Closed pores mean that
- It does not absorb water or other liquids
- Does not allow liquids (esp acids) to pass through
- Protects the steel casing from acid

Bulk Density	100-150 kg/m^3
CCS	0.6-1.0 Mpa
Thermal Conductivity at RT	0.03-0.05 W/mK
Classification Temperature	450-500°C

Relative Insulation Material Cost

Material	Per Tonne	Per Volume	Per R Value
Castable	100-200	300-400	100-150
Brick	200-350	600-1,200	100-500
Fibre	600-2000	300-1,000	60-300
Microporous	20,000-30,000	20,000-50,000	1,000-1,500

Thank you

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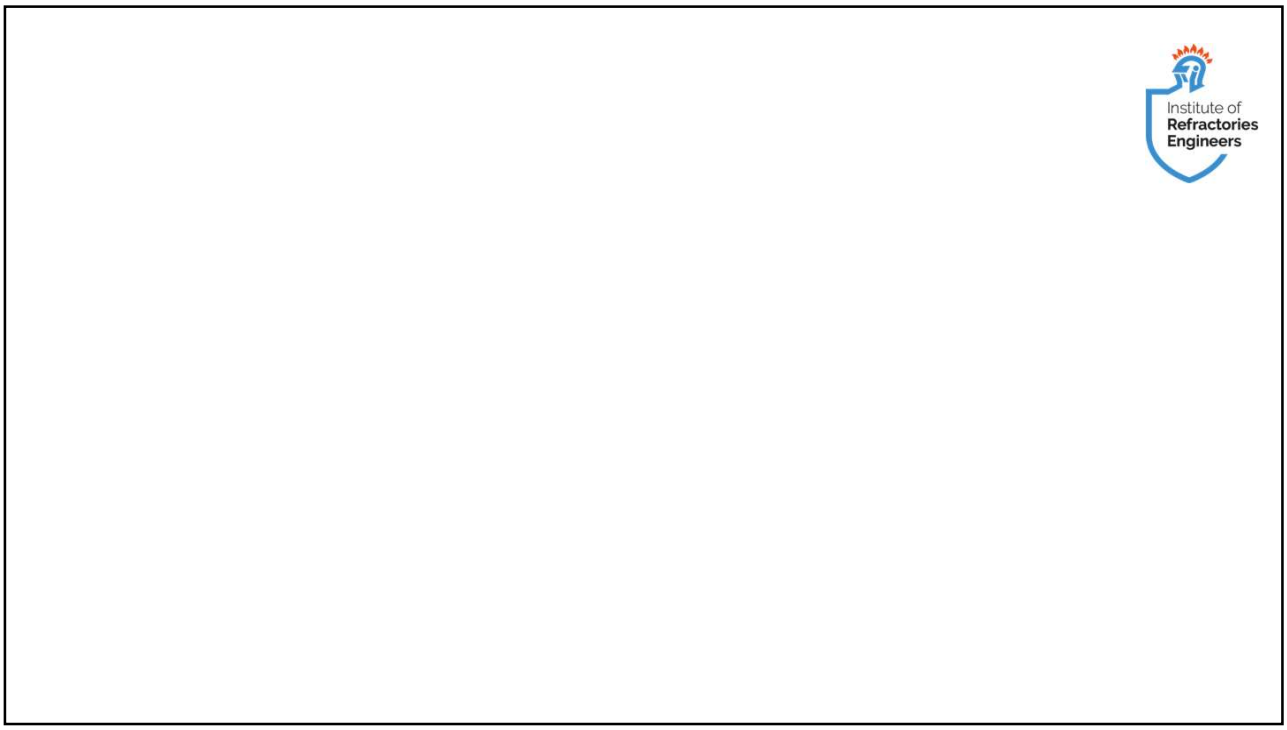
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