NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF Metallurgical & Materials Engineering

REPORT

TITLE Sintering of iron ore fines in laboratory sintering machines

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Date of Experiment 30/8/2023

Title:

Sintering of iron ore fines in laboratory sintering machines

Aim:

To perform sintering of iron ore fines of size and microstructural evolution of synthesized sinter

Theory:

Sintering: Sintering of iron ore is a process where fine iron ore particles are used and mixed with additives like water, limestone and cokebreeze.

The mixture is made into granules, ignited and heated

During heating, the additives form a liquid phase that helps the particles stick together, creating a porous material called sinter

The sinter is then cooled, broken into pieces, and used in iron and steel production.

The process involves:

(a) Granual formation

(b) Mineral decomposition

(c) Sintering bond formation

(d) Mineral transformation

In agglomoration iron ore fines are mixed with additives such as limestone, coke breeze and return fines.

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The mixture is carefully proportioned to achieve a specific composition that facilitates sintering
The additive serves various purposes such as providing flux to aid in forming a liquid phase during sintering, promoting bonding between particles and controlling physical and chemical properties of final sinter
Ignition and combustion involves the heating of granulated feedstock
The heat generated during ignition causes the combustion of coke breeze, releasing heat and forming a localized high temperature zone
In mineral decomposition, limestone undergoes thermal decomposition to release CO_2 and form CaO
These oxides then react with other components in feedstock to form silicate and aluminate, which contribute to the formation of a liquid phase that promotes agglomeration
At higher temperature, the iron-ore particle soften and the liquid phase generated from decomposition of fluxes facilitates the bonding between particles
This results in formation of a porous and coherent sinter structure

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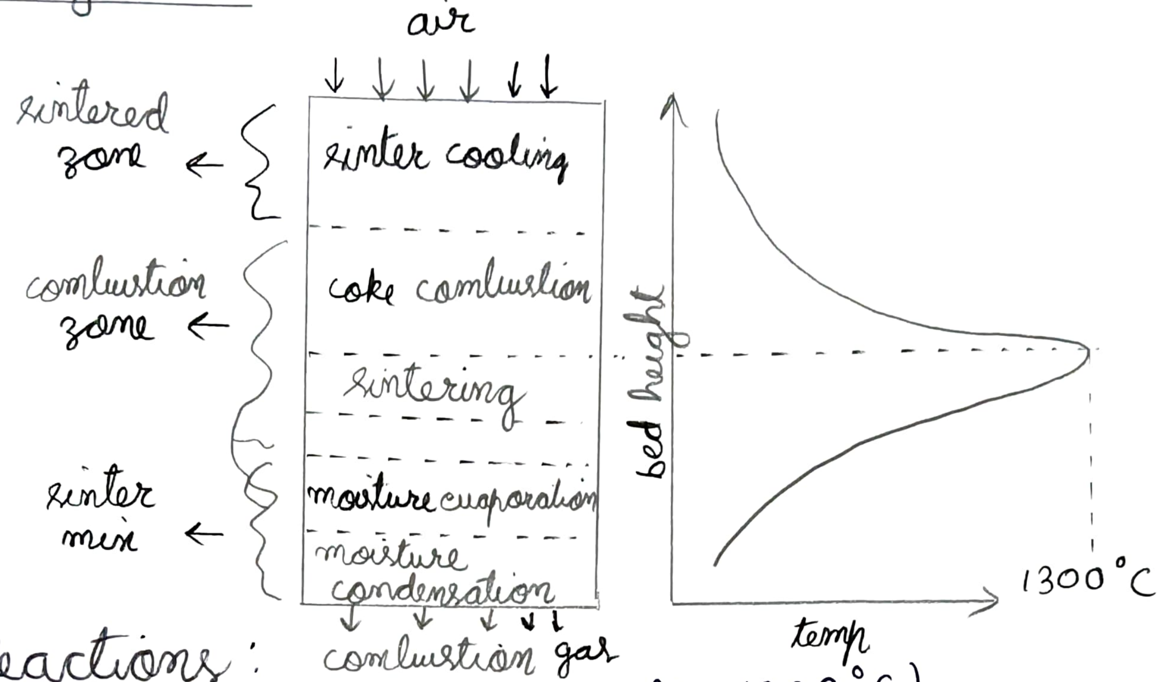
Diagram :



Reactions :

Solid - solid reactions (750°C - 1200°C)

$Fe_2O_3 + 2CaO \rightarrow 2CaO.Fe_2O_3$ at 750°c to 780°C

$2CaO.Fe_2O_3 + Fe_2O_3 \rightarrow 2[CaO.Fe_2O_3]$ at 920°c to 1000°C

$CaO.Fe_2O_3 + Fe_2O_3 \rightarrow CaO.2Fe_2O_3$ at 1050°c to 1150°C

Above 1200°C: solid liquid reaction predominates, with the presence of a molten phase which reinforces the assimilation of material to form ferrite

$CaO.Fe_2O_3 + Al_2O_3 + SiO_2 = CaO\text{-}SiO_2.(Fe\ Al)_2O_3$

Throughout the process, the Fe-oxide can simultaneously get reduced by co gas produced during coke partial combustion

$Fe_2O_3 + CO \rightarrow Fe_3O_4 + FeO + CO_2$

Fe_3O_4 can oxidize to Fe_2O_3. FeO can oxidize to Fe_3O_4 or Fe_2O_3 and can initiate with outside energy, low melting point following these slag formation reactions:

$$FeO + CaO \rightarrow CaO.FeO \text{ at } 1120^\circ C$$

$$FeO + SiO_2 \rightarrow SiO_2.FeO \text{ at } 1180^\circ C$$

$$FeO + SiO_2 + CaO \rightarrow CaO, SiO_2.FeO \text{ at } 1228^\circ C$$

Silica from the iron ore reacts with the molten ferrite as per the following equation to form calcium silicates and precipitated magnetite/hematite

$$CaO.Fe_2O_3 + SiO_2 \rightarrow CaO.SiO_2 + Fe_2O_3$$

Materials Required

- Iron ore fines
- Return fines
- Return sinter
- Coke dust
- Flux (limestone, dolomite)
- Binder (water)
- Ignition source
- Sieves

Experimental Procedure:

1) Preparation of feedstock:

Weigh 6 kg of iron ore fines. Mix the iron ore fines with additives (limestone) and water throughly to ensure a homogeneous blend

b) Granulation

Prepare the binder (water) mix with iron ore fines. Gradually add water to mixture while continously mixing until material reaches desired moisture content. Then this granulated mixture is fed to ignition strand. At the bottom of strand, return sinter is placed carefully to block the way for granulated sinter going out.

c) Ignition and sintering

The prepared sinter bed in strand is then ignited. The combustion of coke breeze generates the necessary heat for sintering. At temperature (1300-1470°c) the flux melts and forms a liquid slag. This liquid slag helps in binding the particle together

d) Sinter cooling:

After the completion of sintering process, sintered material is ~~cooked~~ to room temperature. The cooled sinter is then broken into small pieces for the analysis and sent for microstructural evaluation

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Observations and Result:

The microstructural difference between originally recieved sample and heat treated sample can be significant and are often influenced by specific heat treatment applied.

Various heat treatments were:

(a) annealing
(b) compressed air
(c) normalization
(d) water quenching

- sample 1: weight = 34.35g (air + water)
- sample 2: weight = 56.06g (originally recieved)
- initial mass of sinter = 2100g

Heat treatment resulted in grain growth of crystals. There are coarser grains in heat treated sample compared to originally recieved sample

Heat treatment affects porosity inside sinter (increases black patch meaning increase in porosity).

Bonding between particles occur enhancing the strength and integrity of sinter

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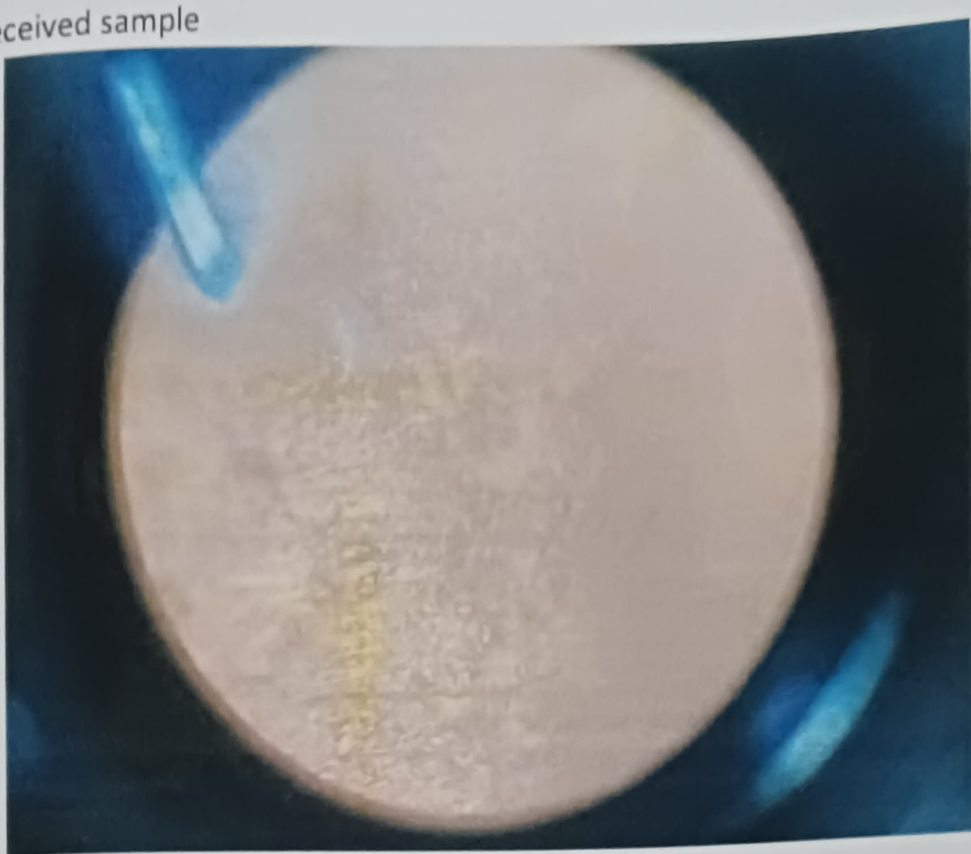
As Received sample



Heat treated (Air+Water)