Magnetic Properties of Fe-Bearing Spinel($MgAl_2Fe_{(2-X)}O_4$) in EAF Refining Process

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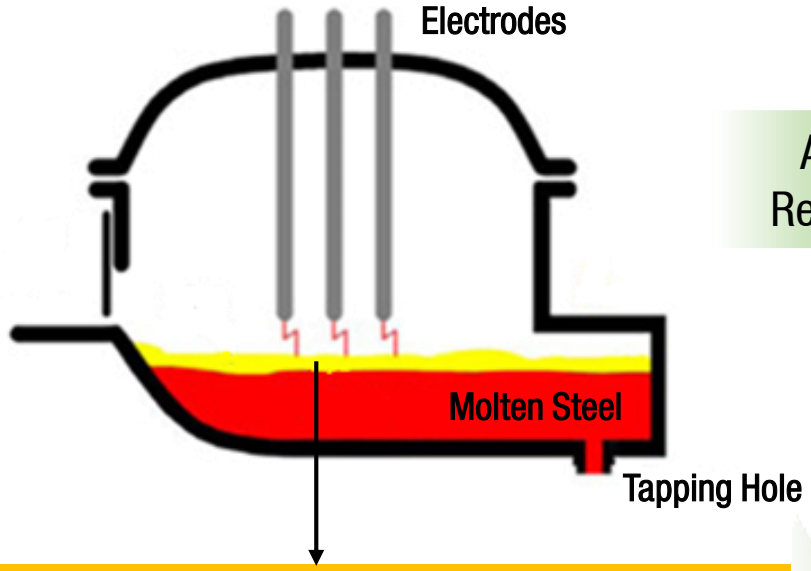
Paper Seminar

INDEX

History of Refining of EAF

Electronic Arch Furnace



Slag(CaO-SiO_2-FeO-Al_2O_3-MgO system)

During Refining

$$2Al + 3FeO = 3Fe + Al_2O_3$$

Reaction Occur in Slag-Metal Interface

After Refining

Higher Alumina Composition

(0wt% ☞ 15wt%)

Lower FeO Composition

(40wt% ☞ 20wt%)

After Refining

Tapping

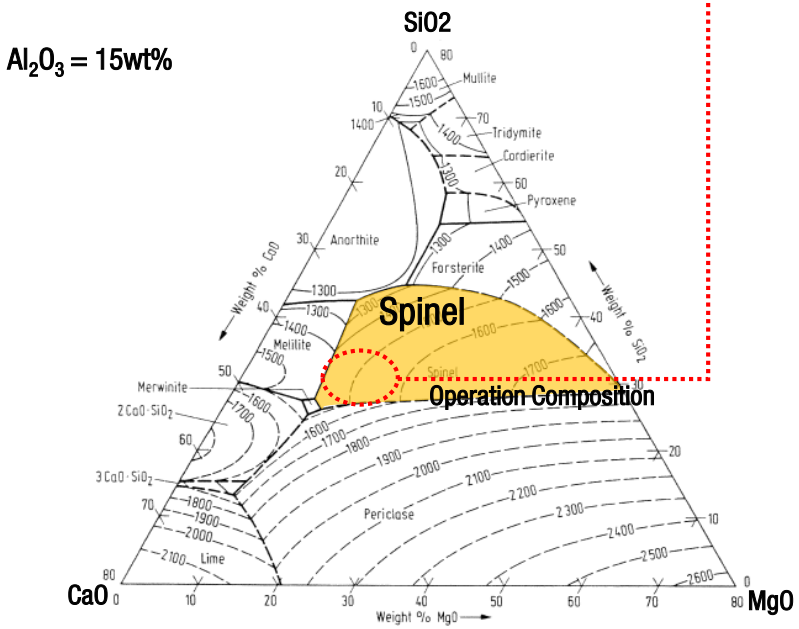
Use Steel after 2nd Refining

Recycling of FeO in Slag By Magnetic Separation

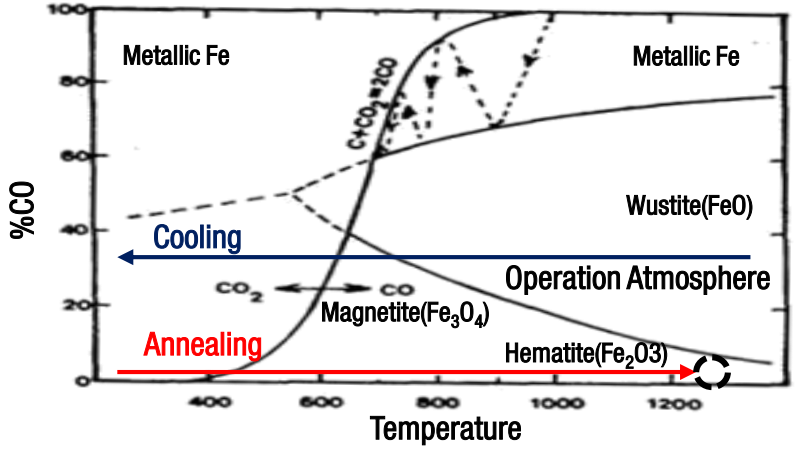
Magnetic Properties of Fe-Bearing Spinel

$CaO-SiO_2-Al_2O_3-MgO$ System

①Composition Consideration(Phase diagram)



②Atmosphere Consideration(Boudouard Reaction)



Slag Composition(After Refining)

Primary Solid Phase : Spinel

Cooling to room temperature

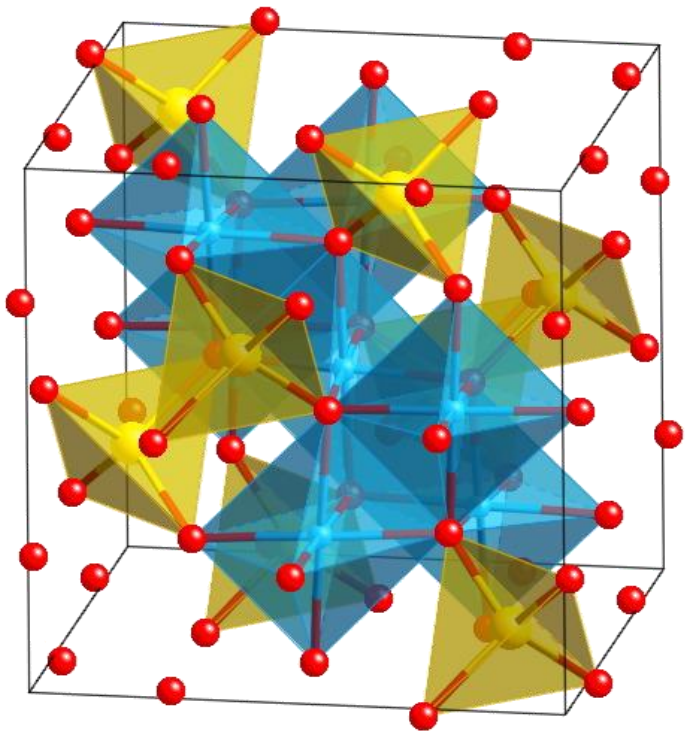
Spinel + Amorphous Oxides Glass

Annealing to Fe_3O_4 Equilibrium Region

Hematite(Fe_2O_3)
Fe^{3+} ionic states present in spinel

Magnetic Properties of Fe-Bearing Spinel

Spinel Crystal Structure



AB_2O_4 crystal structure

- A site : Tetrahedral site, +2 Charge
- B site : Octahedral site, +3 Charge
- O site : Oxygen(O^{2-})

Cations (A & B sites)

Diamagnetic or Magnetic Cation
Randomly Substituted in Both Sites

① Frustration

Inter-Sublattice (J_{AB}) ⟷ Intra-Sublattice (J_{AA} & J_{BB})

Interaction

Determine Antiferro- or Ferrimagnetic Properties

If, $J_{AB} >> J_{AA}, J_{BB}$ ☞ Ferrimagnetic Ordering in Spinel

② Non-Collinearity

When magnetic Cations are
Substituted by Dia(Para)magnetic Cations.

∵Diamagnetic Cation are in A or B site non-equivalently

Inter-sublattice Interaction Decrease

Broken Antiparallel Between A & B site

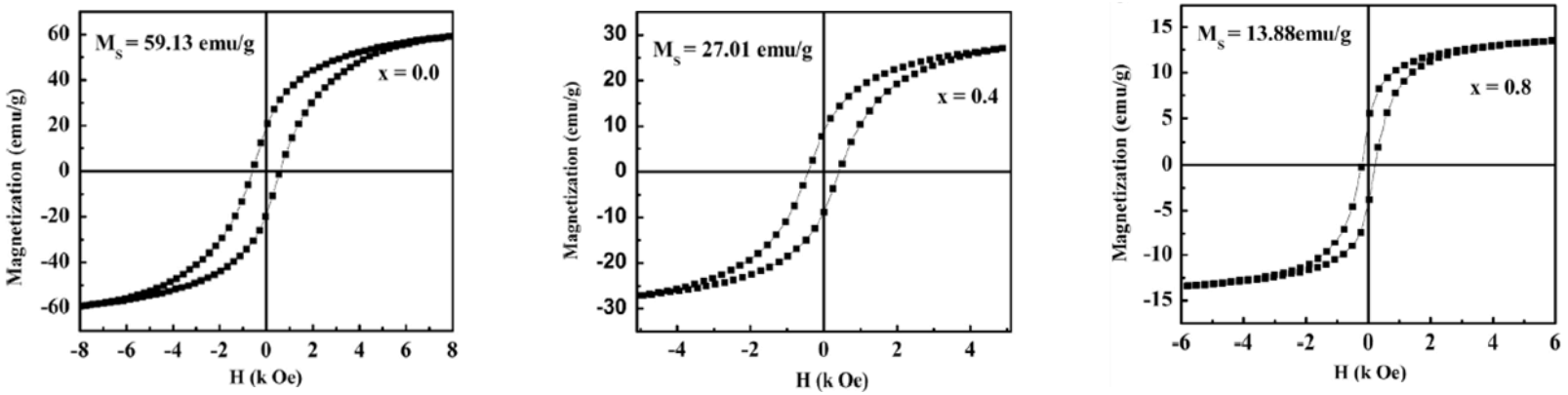
Paramagnetic

Magnetic Properties of Fe-Bearing Spinel

$CoAl_xFe_{(2-x)}O_4$

A Site	Co^{2+} **(Ferromagnetic)**
B Site	Fe^{3+} **(Ferromagnetic)**

Substitution → Al^{3+} **(Paramagnetic)**



Magnetic Field Dependence of Magnetization at Room Temperature for $CoAl_xFe_{(2-x)}O_4$ Spinel

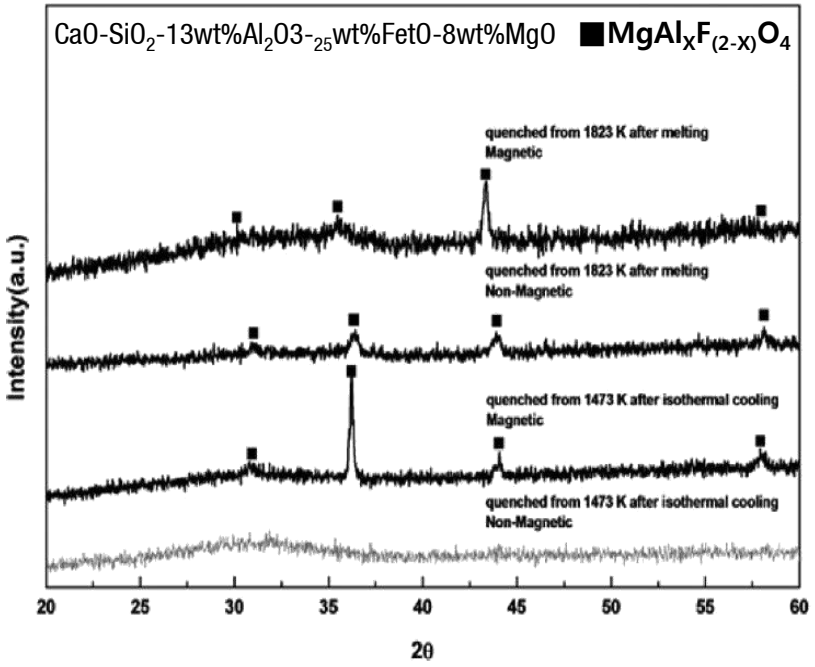
Al^{3+}(Paramagnetic) Fraction Increase

- ✓ M_S Decrease
- ✓ Lower Ferrimagnetic Properties

When Cations are Substituted by Al in Spinel's B site,
Ferrimagnetic alignment is broken & Magnetic properties weakened gradually

Application

Magnetic separation of Fe-Bearing Spinel



XRD patterns of the magnetic and nonmagnetic(paramagnetic) part of solid under different cooling condition

holding temp. (K)	magnetism	composition (mass%) Ca	Si	Al	Mg	Fe
1823	mag	20.64	11.7	6.37	4.49	18.81
	nonmag	20.65	11.7	6.76	4.46	18.76
1473	mag	20.09	11.1	6.91	4.65	19.68
	nonmag	25.92	14.5	5.95	2.88	11.53

Slag

Magnetic Separation

Magnetic	Nonmagnetic
Ferrimagnetic (Fe-Bearing Spinel)	Paramagnetic (Amorphous Glass)

Annealing at 1473K

Grinding at R.T

Magnetic Separation

By Thermodynamic Equilibrium, Fe contents in Spinel increase and Spinel's Magnetic properties increase(Larger M_S & Hysteresis loop). As a result, Spinel which charged with Ferrimagnetic properties could be classified by Magnetic separation and We can have possibility to recycling Fe in spinel (High Fe content)

Thank you
Any Question?