A Contribution of Research by Chlorination from Nickel silicate and Nickel ferrite in the Presence of Calcium chloride and Coke with Possibilities of their Intensification,

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Abstract:

The previous investigations in the field of the metal compounds chlorination of the refractory nickel minerals: garnierite and nontronite, by the chlorine, Cl_2, HCl, NaCl or $CaCl_2$, were determined directions, confirming the perspective of the mentioned process for the treatment of the low grade and complex minerals-laterites. The existing combined methods for enriching of the oxide-silicate nickel ores are these through which by heating the ore with coke and $CaCl_2$ at high temperature reduced metal from nickel silicate or nickel ferrite is formed on the present coke, or on the silicates which are the component parts of the ore.

INTRODUCTION

For the metallurgical calculation Ni in the oxide - silicate minerals may be shown by means of the general formulas.

The iron in these Ni - bearing minerals and ores is appeared as ferrite $Fe_2O_3.nH_2O$ and as a complex mineral $(Fe,Al)_2(Si_4O_{10})(OH)_2.nH_2O$.

The oxide-laterite ores are with low nickel content. Nickel and iron are as Ni-Fe-limonite $(Fe,Ni)O(OH).nH_2O$ or in the talc form.

The following chemical reactions have explained the scheme and complex segregation high temperature process:

1.) $\mathbf{CaCl_2 + H_2O = CaO + 2HCl}$
2.) $\mathbf{CaCl_2 + H_2O + SiO_2 = CaO.SiO_2 + 2HCl}$
3.) $\mathbf{CaCl_2 + H_2O + Fe_2O_3 = CaO.Fe_2O_3 + 2HCl}$
4.) $\mathbf{NiO + 2HCl = NiCl_2 + H_2O}$
5.) $\mathbf{NiSiO_3 + 2HCl = NiCl_2 + H_2O + SiO_2}$
6.) $\mathbf{Ni_2SiO_4 + 4HCl = 2NiCl_2 + 2H_2O + SiO_2}$
7.) $\mathbf{NiFe_2O_4 + 6HCl = NiCl_2 + 3H_2O + 2FeCl_2}$

The following chemical reactions have explained the scheme and complex segregation high temperature process with additives of BaS or FeS:

8.) $2NiO.SiO_2 + 6HCl + BaS (FeS) = 2NiCl_2 + BaCl_2 (FeCl_2) + 2SiO_2 + 2H_2O + H_2S$

9.) $NiFe_2O_4 + 8HCl + BaS (FeS) = NiCl_2 + BaCl_2 (FeCl_2) + 2FeCl_2 + 3H_2O + H_2S + ½ O_2$

The following chemical reactions have explained the scheme of high temperature process of reduction and segregation (metal obtaining) on coke or other inclusion:

10.) $NiCl_2 + H_2 = Ni + 2HCl$

11.) $NiCl_2 + H_2O + C = Ni + 2HCl + CO$

12.) $NiCl_2 + H_2O + CO = Ni + 2HCl + CO_2$

13.) $NiCl_2 + Fe = Ni + FeCl_2$

The following above mentioned chemical reactions have explained the scheme of high temperature process of reduction and segregation (metal obtaining) on coke or other inclusion. The thermodynamic and kinetic of these reactions are well known, showing appropriate results which prove the thermodynamic possibility of isobaric values (ΔZ^o_{298}), together with kinetic values of reaction velocity, kinetic equation which have showed the rate of above mentioned reactions.

The thermodynamic and kinetic of these reactions are well known and following:

$$\Delta Z^o_{298} = \Delta H^o_{298} - T \text{ x } \Delta S^o_{298}$$

$$\Delta Z^o_{298} = - RT \text{ x } \ln K$$

The Kinetic equations which have showed the rate of above mentioned reactions are well known and following:

$$1 - (1 - \alpha)^{1/3} = k \text{ x } t^m$$

For the values of m = ½ or m = 1 we'll obtain Jander's equation or Spenser – Topley – Kewan's equations:

$$[1 - (1 - \alpha)^{1/3}]^2 = k_J \text{ x } t$$

$$1 - (1 - \alpha)^{1/3} = k_S \text{ x } t$$

Or similar to the last equation named Ginstling – Brousthein's equation:

$$\mathbf{1 - 3\,(\,1 - \alpha\,)^{2/3} + 2\,(\,1 - \alpha\,) = k_{GB}\ x\ t}$$

Table 1. Results obtained from segregation - flotation - magnetic separation - NH_4OH leaching

Ore sample	Addition (%)	Recovery (%) R_{Ni} Flotation	Magnetic separat.	Leaching
$NiO.SiO_2$	2.0% FeS	50.00	49.30	50.30
	3.5% FeS	60.70	60.70	62.75
	2.0% BaS	57.05	54.35	60.10
	3.5% BaS	61.10	63.00	63.25
	2.0% $BaSO_4$	55.20	52.30	57.50
	3.5% $BaSO_4$	60.10	66.00	64.10
$2NiO.SiO_2$	2.0% FeS	53.50	57.20	52.30
	3.5% FeS	63.50	66.35	63.50
	2.0% BaS	56.25	58.10	57.10
	3.5% BaS	65.10	66.00	64.10
	2.0% $BaSO_4$	59.80	58.00	61.40
	3.5% $BaSO_4$	70.50	72.10	74.00
$NiO.Fe_2O_3$	2.0% *F*eS	75.30	76.30	73.85
	3.5% FeS	80.50	79.10	83.10
	2.0 % BaS	80.40	78.25	82.00
	3.5% BaS	86.50	79.45	84.30
	2.0% $BaSO_4$	80.30	80.30	84.50
	3.5% $BaSO_4$	86.50	84.45	86.80

Conclusion

The existing combined methods for enriching of the oxide-silicate nickel ores are these through which by heating the ore with coke and $CaCl_2$ at high temperature reduced metal from nickel silicate or nickel ferrite is formed on the present coke, or on the silicates which are the component parts of the ore. The thermodynamic and kinetic of these reactions are well known, showing appropriate results which prove the thermodynamic possibility of isobaric values (ΔZ^o_{298}), together with kinetic values of reaction velocity, kinetic equation which have showed the rate of above mentioned reactions.

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