Summary of a Situation from Laboratory Investigation of Yugoslav Nickel Bearing Ores by Segregation-Flotation-Magnetic Separation,

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Abstract: A huge list of current laterite operations or laterites processing is following: Fe - ni smelting, Matte smelting, Reduction roasting-ammonia leaching and HPA leaching. Apart from the above mentioned process routes, there have been many attempts to develop processes know as alternative processes, which have included: Sulphuric, Nitric acid leaching, Chlorine leaching, Acid pugging and sulphating roast, especially Segregation Process etc.

Key words: Segregation, roasting, flotation, HPA leaching

1. Introduction

In the meantime none of these progressed past the bench or pilot plant scale because of various technical, economic or environmental factors or problems. Nevertheless, the renewed interest in laterites in nineties has spawned a number of new possibilities and hopefuls, as well as a revival of interest in some older ones. The same is the interest and perspective of the segregation process.

The previous investigations in the field of the metal compounds chlorination of the refractory nickel minerals: garnierite and nontronite, by the chlorine, 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 principal scheme of the segregation process following by the classical concentration methods - flotation or magnetic separation and hydrometallurgical treatment - ammonia leaching. The 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 metal nickel is formed on the present coke, or on the silicates which are the component parts of the ore.

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

$$CaCl_2 + H_2O = CaO + 2HCl$$
$$CaCl_2 + H_2O + SiO_2 = CaO.SiO_2 + 2HCl$$
$$CaCl_2 + ½\ Al_2O_3.2SiO_2.2H_2O = CaO.Al_2O_3.2SiO_2 + 2HCl$$
$$CaCl_2 + H_2O + MgO.SiO_2 = CaO.MgO.SiO_2 + 2HCl$$
$$CaCl_2 + H_2O + Fe_2O_3 = CaO.Fe_2O_3 + 2HCl$$

$$NiO + 2HCl = NiCl_2 + H_2O$$
$$NiSiO_3 + 2HCl = NiCl_2 + H_2O + SiO_2$$
$$Ni_2SiO_4 + 4HCl = 2NiCl_2 + 2H_2O + SiO_2$$

$NiFe_2O_4 + 6HCl = NiCl_2 = 3H_2O + 2FeCl_2$

$2NiO.SiO_2 + 6HCl + BaS (FeS) = 2NiCl_2 + BaCl_2 (FeCl_2) + 2SiO_2 + 2H_2O + H_2S$
$NiFe_2O_4 + 8HCl + BaS (FeS) = NiCl_2 + BaCl_2 (FeCl_2) + 2FeCl_2 + 3H_2O + H_2S + ½ O_2$

$NiCl_2 + H_2 = Ni + 2HCl$
$NiCl_2 + H_2O + C = Ni + 2HCl + CO$
$NiCl_2 + H_2O + CO = Ni + 2HCl + CO_2$
$NiCl_2 + Fe = Ni + FeCl_2$

2. The general behaviour of the nickel bearing minerals

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

$NiSiO_3.mMgSiO_3.nH_2O$ or by possible transformation:

$$(Si_2O_5)^{2-} \Rightarrow (SiO_4)^{2-} \Rightarrow (SiO_3)^{2-}$$

$$NiO.2SiO_2 \Rightarrow 2NiO.SiO_2 \Rightarrow NiO.SiO_2$$

$\Downarrow$ *olivine* $\Downarrow$ *piroxen*

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.

3. The experimental investigations from the nickel natural ores by segregation process

The experimental investigations by the addition-activator 2% (BaS,FeS,S or $BaSO_4$) influence on the metallurgical indicators from combined processes **segregation-flotation-magnetic separation-ammonia leaching** are shown about the ore samples from various deposits.

Table 2. Results obtained from segregation of the ore samples (100% -0.150mm)

Ore sample	**BaS (%)**	**Recovery (%), R_{Ni}**		
		Flotation	**Magnetic separat.**	**Leaching**
Studena Voda	0.0	36.50	34.70	37.20
	2.0	45.45	42.85	46.10
	3.5	60.70	55.60	62.35
Rzanovo	0.0	36.85	35.30	87.60
	2.0	47.10	46.60	48.20
	3.5	62.30	60.70	65.10
Rudinci I/II	0.0	42.50	40.25	43.10
	2.0	48.60	45.30	50.20
	3.5	65.00	63.20	66.75
Goles	0.0	56.00	45.90	55.50
	2.0	70.00	75.30	80.20
	3.5	85.00	86.60	88.30

Table 3. Results obtained from segregation - flotation - magnetic separation - NH_4OH leaching

Ore sample	Addition (%)	Recovery (%) R_{Ni}		
		Flotation	Magnetic separat.	Leaching
Studena Voda	2.0% FeS	47.00	44.35	48.35
	3.5% FeS	60.70	56.70	62.75
	2.0% BaS	47.05	44.35	50.10
	3.5% BaS	61.10	57.00	63.25
	2.0% $BaSO_4$	45.20	42.30	47.05
	3.5% $BaSO_4$	60.10	56.00	64.10
Rzanovo	2.0% FeS	49.50	47.20	52.30
	3.5% FeS	61.50	56.35	63.50
	2.0% BaS	50.25	48.10	53.10
	3.5% BaS	60.10	56.00	64.10
	2.0% $BaSO_4$	49.80	48.00	51.40
	3.5% $BaSO_4$	60.50	56.10	64.00
Goles	2.0% FeS	79.60	76.30	81.85
	3.5% FeS	80.50	79.10	83.10
	2.0 % BaS	82.40	78.25	85.00
	3.5% BaS	76.50	79.45	82.30
	2.0% $BaSO_4$	70.30	75.30	84.50
	3.5% $BaSO_4$	76.50	78.45	88.80

5. Conclusion

The mentioned and carried out combined processes **segregation-flotation-magnetic separation-ammonia leaching** by the synthetic mixtures and appropriate ore samples (various nickel content) have achieved satisfactory results related on the metal recoveries. The existing environmental problems will lead to increased interest in combined processes or hydrometallurgical processes. These include combined processes: **segregation – flotation - ammonia leaching** or some other process as a oxidation in the presence of compounds addition or bio oxidation.

6. References

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