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Investigation of Adsorption Mechanism of Reagents (Surfactants) System and its Applicability in Iron Ore Flotation – An Overview

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ABSTRACT

The low - grade ores invariably liberate in finer sizes and the fines contain good amount of iron values in it. Flotation is the most established solution, both technologically and economically compared to other alternatives for fines beneficiation. The selection of reagents and their administration system are of critical importance in view of varied mineralogy and size consist of feed material. In this paper, the reagents/surfactants used in direct and reverse flotation process of iron ore has been reviewed with the aim of identifying their usefulness and limitations coupled with adsorption mechanism and surface chemistry. This paper provides a glimpse of study on effect of other parameters like pH, chemistry and composition of pulp, zeta potential and electrostatic potential, temperature. An understanding of the mineral surface-specific adsorption mechanism and proper selection of the reagents system is mandated for successful and effective flotation performance.

1. Introduction

The grade of mined iron ore is depleting steadily and the requirement for steel is increasing expeditiously. Improving the resource base through exploitation of low grade iron ore resources and tailings through upgradation is, therefore mandated. The growth of industrialization with the resultant infrastructure has become a burden on environment and proper utilization of low grade ores and wastes is imperative to create a balanced development, economy and ecology for sustainable industrial growth. As far as tailings management is concerned, reduction of tailing volume is feasible, provided the maximum iron value is recovered by a suitable and improved technology [1].

The conventional ore processing and mining operations generate fines and slimes of huge quantities to the tune of 10–15% of run-off mine, which are generally of poorer grade. These fines and slimes cannot be utilized directly as feed to metallurgical plants, occupy huge space and cause environmental and ecological problems. The cut-off grade is being lowered to 45% as the high grade resources are diminishing, compelling the iron and steel industries to seek upgradation of low grade iron ore fines to meet the demand. Processing of iron ore below 45% grade is imperative to recover the additional mineral values, not only to earn additional revenue but also from the point of view of conservation of mineral wealth.

These low grade fines and slimes, thus, should be considered as a resource rather than a waste. They need to be processed to recover iron values for resource augmentation and to meet environmental stipulation. For the effective utilization of iron ore slimes, research efforts have been oriented towards technology development for beneficiation of fines.

The physical separation techniques are restricted to coarse grained sizes and performed poorly with finer sizes. Iron ores typically consist of iron-bearing minerals intergrown with quartz and kaolinite, making the mineral surface quite complex and the iron minerals are liberated at extremely fine sizes. This nature of particle characteristics compels the use of a technique that relies on surface properties. Froth flotation, being an established method, has been known for its efficiency to eliminate impurities from iron ore in half a century's practice around the world to produce good pellet grade concentrate.

2. Flotation

Froth flotation, which uses the difference in hydrophobicity of minerals, is employed in several industries for fines processing. It is a process for upgrading the mineral by taking advantage of differences in physicochemical surface properties between valuable and gangue minerals.

The technique of selective separation by froth flotation can effectively be applied to the materials in which fine liberated valuable and gangue mineral grains are present. Despite numerous years of research and development work since 1900, flotation is still not fully

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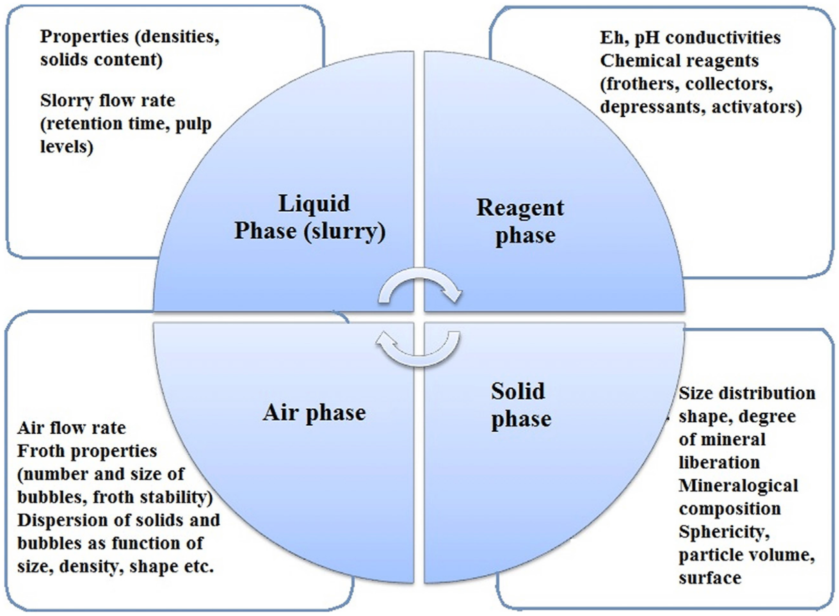

Fig. 1. Process and phases in flotation. Flotation is broadly divided into three main types: (a.) Salt type flotation (b.) Sulphide flotation (c.) Oxide flotation.

understood, fully interpretable and remains a challenge, as it requires a good understanding of the interactions involved between the major phases (macro processes) and the number of inter-related events (micro processes) (Fig. 1.)

Separation and value enhancement of minerals by flotation occurs, when minerals to be separated, have different affinities for air and water. The perfect condition required for flotation of a mineral is when the work of adhesion between the desired mineral particle and an air bubble is high enough to prevent the disruption of the particle–bubble interface. Increased contact angle at the surface–air interface increases the work of adhesion between a particle and an air bubble implying increase in hydrophobicity and improvement of mineral floatability. High polarity and high Gibbs' energy makes most of the minerals hydrophilic.

To make the mineral float, the surface of such minerals has to be modified by adsorption of suitable surfactants in order to reduce the Gibbs' energy. The reagents thus, should be chosen selectively for the achievement of good separation of minerals. Ensuring maximum floatability of desired minerals through maximum selectivity with the aid of reagents are the key elements of flotation research and the driving force of flotation research efforts.

The subsequent part of the paper is focused on an overview of flotation research on iron ores.

2.1. Iron Ore Flotation

Iron is the third most abundant mineral found in earth's crust and is found in varied chemical forms in different ore deposits. The Iron oxides are the most abundantly occurring deposits compared to the sulphides and carbonates.

2.1.1. Mineralogy of iron ore

The floatability behavior of iron ore varies widely, due to the variations in the chemical and physicochemical properties. Chemical and physicochemical properties vary from sample to sample in terms of iron minerals and the nature and association of gangue minerals, which results in the varied flotation behavior [2]. The main impurities associated with iron ore are alumina, silica, phosphorous, sulphur in different forms, which are given below in Table 1.

Most of the iron ores are found in oxide form except pyrite, pyrrhotite and siderite.

Table 1
Gangue minerals associated with iron ores.

Associated gangues	Elemental forms
Alumina	i) gibbsite (hydrated aluminium oxide) ii) kaolinite (a layered aluminosilicate mineral of general chemical formula Al_2 $Si_2O_3(OH)_4$) iii) other gangues like ferruginous clay in minor quantities
Silica	i) quartz, ii) quartzite iii) chert iv) kaolinite Other than these minerals sminnesotaite, greenalite are also silicate minerals which are found associated in very minor quantities with iron ore
Phosphorous	i) apatite ii) hydroxylapatite iii) fluropatite iv) Chloropatite v) Vollophane vi) bromapatite
Sulphur	Found in the form of iron sulphide minerals. iron sulfides minerals are i) Pyrite ii) Marcasite iii) pyrrohotite.

As outlined earlier, the selective modification of mineral surface and the interaction between the minerals and the reagents are the critical factors for effective and efficient flotation. The reagents system used for specific iron mineral flotation by various researchers are outlined in the following:

3. Reagents System for Iron Ore Flotation

The reagent system comprises of collector, frother, depressant, dispersant, activator and pH regulators. The work of the researchers on iron ore flotation is basically focused on achieving selectivity through different collectors and depressants, with other reagents contributing towards an enabling pulp environment.