

Recovery of Cu, Ni, Co and Mn from Sea Nodules by Direct Reduction Smelting

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ABSTRACT

Polymetallic nodule contains various metals like copper, nickel, cobalt, manganese, iron, lead, zinc, aluminum, etc. Of these, copper, nickel and cobalt are of much importance and in great demand world over. In fact, due to their extensive technological use these three metals are fast depleting from the earth surface. Hence a world-wide research is progressing on sea nodules as an alternative future source of these metals. India is entirely dependent on imports to meet its requirements of cobalt and nickel both of which are most strategic in nature. In this respect, India has made remarkable progress in recovering these metals from sea nodules. The recovery process so far developed in India is based on either purely hydrometallurgical or pyro-hydrometallurgical routes. The processes generate very dilute leach solution, the downstream processing of which is very difficult. Generation of concentrated leach solution from sea nodule would make the process simpler and economical which may not be possible by direct leaching process. Therefore, it has been planned to explore direct smelting of sea nodules to recover copper, nickel and cobalt along with part of iron in the form of alloy followed by individual metal recovery through matte formation and dissolution. Initial studies on direct reduction smelting of Indian sea nodule were conducted using coke as reductant in lab scale experiments. Various parameters like smelting temperature, reductant concentration, holding time etc. have been optimized to obtain an alloy of suitable composition. At a smelting temperature of 1400 °C, recovery of 90-92% Cu, 92-95% Ni and 80-85% Co is obtained in the form of alloy in a recrystallized alumina crucible which can be further treated to recover these metals in pure form. The iron content in the alloy varies significantly with coke concentration. The slag generated after smelting can be directly treated for production of standard grade Fe-Si-Mn without blending.

Key Words: Sea Nodule; reduction smelting; Cu; Ni; Co; Mn

INTRODUCTION

Polymetallic sea nodules, better known as manganese nodules, contain valuable metals like copper, nickel, cobalt, manganese & others and are available in plenty in the ocean beds. Available estimates show that

nickel and cobalt availability in the manganese nodules is about five and forty times higher, respectively, than that in land-based resources as cited by Das (1989).

Attempts were made to process polymetallic nodule almost forty years back, as an aftermath of the oil crisis. Several oil companies visualized large scale ocean mining, where their expertise on high-sea operations will be useful. This led to formation of several consortiums. Soon, the fluctuating metal prices, the ease of oil crisis, and the lack of a viable mining technology resulted in slowing down, and in most cases, stoppage of metallurgical activities. An excellent review of several processes developed during seventies was prepared by Monhemius (1980) and the similarities and the differences were discussed. The requirement of Cu, Ni and Co by many resource-starved countries like India, Japan, China, and Korea encouraged the research organizations in these countries to develop processes which are economical and environmental friendly. The sea nodules are rock concentrates on the sea bed sediments formed by concentric layers of iron and manganese hydroxide around a core. Metal entities such as Cu, Ni, Co, Mo and Zn are accommodated in the complex cage of iron and manganese hydroxides. Nickel and copper oxides, are distributed and associated with the manganese oxide phase. Cobalt is present as cobaltic oxide, is associated with iron oxide phase. Mineralogical studies of sea nodule have been reported in detail by (Heimendahi, Hubred, Fuerstenau and Thomas 1976). Sea nodules are highly porous due to their inherent morphological structure and, therefore, are associated with high free moisture content. These are often called manganese nodule due to its high Mn content. So far, most of metal recovery processes developed in India for processing sea nodules are hydrometallurgy based, which inherit the associated problem like handling of large volume extractants, dilute leach liquor, very specific downstream processes etc. In this connection, a process to recover Cu, Ni and Co based on reduction smelting is being carried out at NML, Jamshedpur, India. The proposed flow-sheet for this route is shown in figure 1.