THE USE OF METHODS TO REMOVAL OR RECOVERY OF THE Ni^{2+} FROM RAW MATERIALS

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Annotation: Nickel belongs to the class of heavy metals, and the separation and removal of this element from the raw materials used in industry and production requires the use of less specific methods. The following is a description of these special methods, which require application depending on the chemical nature of the raw material used in production and the amount of application.

Key words: Nickel, waste material, removal, recovery, leaching, ion exchange, ion flotation, adsorption, and membrane filtration, electro dialysis, adsorbents

Nickel has been recognized as an important strategic resource because of its optical, electrical, and catalytic performance; toughness; high corrosion resistance; thermal stability; chemical passivity; and ability to make super alloys.

Nickel is extensively used in the stainless steel industry, accounting for two-thirds of the total nickel production. Also, the nickel consumption rate for this industry is increasing at a rate of 5%-6% annually.

Moreover, nickel is one of the most used element for coating of different industrial materials as it provides decorative appearances and improves resistance to corrosion. Watts' baths containing chlorides and sulfates of nickel and boric acid are a widely used industrial method to improve surface finishing and appearance.

Furthermore, nickel is used as a raw material for a wide variety of manufacturing processes such as mineral processing, paint formulation, phosphate fertilizers, electro chromic films, dye-sensitized solar cell, forging, battery manufacturing, magnets, semiconductors, gas sensors, non-ferrous metals, and special alloys as well as for minting of coins and tinting of glasses in green.

Although nickel is one of the main raw materials in industry and production, it is one of the barriers to raw materials that play an important role in industry, in the process of which it is important to purify the raw material from nickel.

Nickel has been considered as a nonbiodegradable toxic trace metal present in different kinds of waste materials. Therefore, removal of nickel from waste has been known as a difficult task and has been considered as a scientific challenge .

Methods mentioned here are subcategorized either for removal or for recovery of the Ni^{2+} ions both from aqueous media and from solid wastes. Most of the extraction techniques revolve around the divalent nature of nickel either from wastewaters or solid wastes. Commercially used methods employed for nickel removal are leaching, ion exchange, ion flotation, adsorption, and membrane filtration. The most prominent commercial methods used to recover Ni^{2+} ions are electro dialysis methods and a combination of electrochemical and ionization processes.

Leaching is the extraction of a soluble component from a solid by means of a solvent. The process is utilized for the extraction of a very valuable solid material like nickel or for the removal of an insoluble solute from a contaminated solvent.

Nickel-based catalysts have been extensively used in oil and gas processes and are disposed as solid waste either in their pure form or as composites. Nickel found in these sources

employs the leaching procedure as explained above through the use of other mineral acids, hydrogen peroxide, and potassium bisulfite.

Ion exchange is a highly selective method and clearly depends on the solution type and the desired contaminant or valuable metal to be extracted. Ion exchangers consist of solid materials that could carry cations or anions interchangeably. The ions are exchanged at a fixed stoichiometric rate with the particles in the solution. The materials with exchangeable cations are called cation exchangers and the materials that could carry anion are called anion exchangers. Ion exchangers are specific to definite metals that have affinity toward that material. Mostly, the ions are exchanged or replaced with the desirable ion or displaced by the undesirable ion from the solution, say, Ni^{2+} from waters. The most commonly utilized exchanger types nowadays are mostly resin based with defined lattices. Some other exchangers are coupled with electric current as in electrolysis for the recovered Ni^{2+} ions from the surfaces of the resins onto a concentrated solution, the details of which can be found in later sections.

The flotation method is a gravity separation method. This method follows the usage of a surfactant that is foamed with an inert gas. The foam is then made to accumulate the trace metal values using the metal-ion complex that is formed. This is usually viable when there is an appropriate surfactant utilized to separate the required cation and the foaming conditions are taken into account as well. This technique utilizes two properties of the material: surface charge and surface energy. These properties need to be controlled by precisely choosing the right surfactants, followed by flotation. After the selective attachment of the cation with the froth or foam, the solids are concentrated and transferred from the body of water to the surface. Thus, unlike settling by gravity only, it is a solidliquid separation technique that has been utilized only after the density of the particles is made lower than that of the liquids. This makes the recovery of Ni^{2+} plausible using separation and by further employing acid treatment and electrolysis.

Adsorption method is especially used for the removal of trace metals in aqueous media. Most of the Ni^{2+} ions are in parts-per-million levels and have several advantages over other processes. Adsorption is the most simplified and the oldest method for nickel recovery. In adsorption, nickel ions are diffused from the bulk solution onto the surface of the solid adsorbent, thereby forming a layer of adsorbed phase. The major drawback of this recovery is that the adsorbate does not hold at a certain level and thus several criteria are made to select the right adsorbents for nickel recovery. Adsorbents that have a large surface area and that are chemically stable with the adsorbate are the basic criteria. Some of the adsorbents are modified through chemical treatments to have an enhanced surface area. Activated carbon (AC), clays, and zeolites are the commonly used adsorbents and have shown promising results for nickel removal from aqueous solutions.

Membrane Filtration is completely driven by pressure and very selective toward the kind of membrane to be used for nickel recovery and its isolation from the aqueous solution. Membrane filtration can be varied in types depending on the sizes of the particles; in nickel, the most prominent techniques used are ultrafiltration, Nano filtration, and reverse osmosis.

Particles in the range of 10-100 nm are separated by ultrafiltration. To enhance the separation process, polymeric agents are used to clog the ions, say, Ni (II) ions. Macromolecules are formed when these polymeric agents combine with the metal ions and are conglomerated, thereby making the separation easier. Electro dialysis and Ion Exchange recovery processes are primarily driven by electric current in the aqueous media. Electro dialysis is a membrane process that is based on the selective migration of Ni^{2+} ions through a suitable membrane using an electric current source. It is most prominent method used to recover the cations from rinse water in electroplating. Low concentrations of trace metals are usually removed by this method, and the effluent water is mostly recycled for use. Electrode ionization is a

combination of techniques for Ni^{2+} recovery. It includes electrolysis, electro dialysis, and ion exchange where the system to be purified is stacked with ion exchange resins, most of which are explained as above, and an external power source is applied as in electro dialysis. Basically, a series of steps were followed to ultimately recover the Ni^{2+} and obtain 100% purity in water. Electrolysiselectrodialysis and ionization combination processes recover both high and low concentrated solutions. Around 94% purity/recovered nickel can be obtained with this method.

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