IJSEAS

International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-2, Issue-7,June 2016
ISSN: 2395-3470
www.ijseas.com

Regeneration and Recovery of Nickel- a Review

Sonali Dhokpande[1], Dr.Jayant Kaware[2]
[1]Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai., Maharashtra, India
[2]Bhonsla College of Engineering and Research, Akola, Maharashtra, India

Abstract

Removal of Nickel is carried out by various physical, chemical and biological methods. Nickel is used in catalyst, electroplating, chemical and battery industries. Sorption on various materials is widely investigated method for nickel removal. It is important to recover nickel from these waste material as well as liquid effluents. The nickel in solid waste affects soil quality and contaminates ground water sources , also recovery of nickel renders economical advantage. The reused of sorbent material reduces the cost as well as solid disposal problem. The current review summarizes research and studies on recovery of nickel and regeneration of sorbent material.

Keywords: *Pretreatment, recovery, concentration, eluent, breakthrough curves, recovery, bioleaching.*

1. Introduction

In the era of development and technological advancements, heavy metal removal is widely studied field in environmental engineering. This has to be done by economical and effective method to make it practical and economically feasible. Cost reduction and maximization of profit is the objective of most of the industrial activities. The technological advancement calls for process intensification and cost optimization. The removals of heavy metal by effective method along with proper sorbent material can economies the operations in related industries [1,2,3]. Removal of Nickel is carried out by various physical, chemical and biological methods [4,5, 6]. Nickel is used in catalyst, electroplating, chemical and battery industries[7]. In catalyst industries regeneration of catalyst is major area of investigation. In the chemical and catalyst industries it is always envisaged to regenerate and recover the materials used in processes and unit operations. Sorption on various materials is widely investigated method for nickel removal[8,9,10]. The nickel in solid waste affects soil quality and contaminates ground water sources, also recovery of nickel renders economical advantage. The reused of sorbent material reduces the cost as well as solid disposal problem. The current review summarizes research and studies on recovery of nickel and regeneration of sorbent material.

2. Research for Recovery and Regeneration for Nickel

Acid Leaching, Chelation and Ultrasonication are important methods for nickel recovery in catalyst industries. One such research was carried out by Oza and Patel [11]. Nickel is widely used for hydrogenation, hydro treating, and steam-reforming reaction. The disposal of used catalyst is major problem. It can be solved by reusing the catalyst as many times as possible. So regeneration of spent catalyst by efficient methods makes the process economical feasible. They compared three methods for recovery of nickel salt. The sample requires pretreatment to remove coke. Sulfuric acid can be used for recovery of nickel from a spent catalyst. This is especially used in ammonia plant. The recovery of nickel salt depends on particle size. By using hydrochloric acid 73 percent recovery was possible. In bioleaching microorganisms are used for transforming the solids into extractable organic and inorganic compounds. Caustic soda can be used for alkali leaching and treated residue can be leached off by using sulfuric acid. Heavy metal extraction from contaminated soils can be enhanced by using chelating agents such as Ethylene diamine tetra acetic acid (EDTA). Ultrasound induced recovery of nickel was also found to be effective with recovery percentage of 95. They concluded that ultrasound method has advantages such as better control of process parameters like temperature and pressure over complicated acid leaching and chelation techniques.

Price and Novotny used ion exchange for water recycling and nickel recovery[12].They used three bed ion exchange method. In first column they used strong acid exchange resins. This column removes nickel along with other ion exchange resins. Further the weak Base Exchange is used for removal of anions. Sulfuric acid and sodium hydroxide are used for regeneration of beds. The nickel salt thus obtained is further concentrated by evaporation. The problems like fouling due to salt precipitation, plugging of column need to be resolved for effective operation. Extraction and precipitation are two significant methods for recovery of nickel . These methods were used by Maf et.al. for nickel recovery from spent catalyst[13]. They observed that nickel recovery was maximum with sulfuric acid compared to nitric and hydrochloric acid. Higher acid concentration favors the nickel recovery. Nickel can be precipitated as hydroxides and sulphates. Overall recovery of nickel was observed to be more than 80 percentages in this method. Haavanlammi proposed a novel technique[14]. He studied the methods namely Iron precipitation, solvent extraction and electrowining, ammonia and hydrochloric acid regeneration . He also proposed comprehensive solution for nickel treatment. The proposed method is highly flexible and has advantages such as optimization, high quality product, advanced automation, cost and waste minimization. Biosorption in packed bed using low cost starting material is one of the most explored technique for heavy metal recovery. This method was used for nickel with wheat straw as starting material for biosorbent by Booran[15]. He studied factors affecting column operation such as bed height, initial concentration, particle size and flow rate. He found the optimum values of these affecting parameters. Biosorbent particle size (0.5 inch), highest bed depth (2 m), lowest flow rate (0.1 L.min-1) and smallest initial concentration (10 mg/L) constituted the set of optimum parameters. Increasing bed depth delays saturation time. Increase in flow rate and concentration reduces time. Increase in flow rate and concentration have positive effect on metal uptake. He obtained encouraging results for biomass regeneration using sulfuric acid. Bed depth service time (BDST) model fitted the results of column studies.

Kulkarni and Kaware carried out review on recovery and regeneration in adsorption[16]. According to them, regeneration is very important aspect of the adsorption from economy and environmental point of view. Regeneration reduces need of new adsorbent and hence minimizes solid disposal problem. They found that various methods such solvent washing, thermal, chemical and electrochemical regeneration can be used for regeneration. Devi et.al. discussed various types of acid regeneration methods and recovery of metal from waste sludge[17]. They mentioned Co and Ni separation from HCl with CYANEX 923 from spent catalysts as one of the efficient technique. According to Jadhav and Hocheng industrial wastes can act as artifitial ores[18]. Industrial Solid waste from electronic scraps, medical waste, metal finishing industry waste, spent petroleum catalysts, battery wastes, fly ash etc contains considerable amount of nickel along with other heavy metals. electronic scraps, medical waste, metal finishing industry waste, spent petroleum catalysts, battery wastes, fly ash etc., are some of the major industrially produced wastes. These solid wastes mostly contain considerable amount of nickel along with other heavy metals. Physical, chemical and pyrometallurgical transformations such as calcining, roasting, smelting and refining can be used for metal and hence nickel recovery. In case of hydrometallurgical processes leaching is most often used. In leaching, downstream recovery can be accomplished by precipitation, cementation, solvent extraction and ion exchange. Ismail et. al. carried out the experiment on nickel removal from electroplating waste water using stand-alone and electrically assisted ion exchange processes[19]. They used hydrochloric acid as eluent. They carried out the experiment with and without electric current enhancement. Also they investigated effect of reverse in polarity at different hydrochloric acid concentrations. They observed that the nickel removal increases by 12.7 percentages by Applying the electrical at flow rate 240 ml/h, and 2.5 % at flow rate 500 ml/h. They used hydrochloric acid for as an eluent. They carried out experiments with and without with and without electric current enhancement. Xiong and Yao used micro porous weak acid resin for recovery of nickel[20]. They carried out batch and column studies for nickel removal at constant temperature. They carried out batch experiment for studying elution of nickel by hydrochloric acid from saturated adsorbent. For this they allowed the known amount of adsorbent to equilibrium with the synthetic solution. Then it was brought in contact with eluent with different concentration. 0.5 mol/L hydrochloric acid was found to be best for elution of nickel.

Priya et.al. explored the possibility of nickel recovery from rinse water of electroplating industry[21]. They used ion exchange method for nickel removal from rinse water. This resin was further washed by hydrochloric acid. The chlorides obtained were precipitated as hydroxide by using KOH. They carried out experiments in batch and continuous mode. Also they tested different models for breakthrough curves. They applied The Thomas and the Adams–Bohart models for breakthrough curves. Under batch recirculation mode it was possible to recover nickel to considerable extent. It was also possible to synthesize positive active material to be used in Nickel/Metal hydride cell. Gibas et. Al. Studied recovery of cobalt and nickel by atmospheric leaching of flotation sulfide concentrate from lubin concentrator[22] . They attempted recovery of nickel from Lubin (Poland) sulfide flotation copper concentrate with oxygenated sulphuric acid solution. They carried out experimental removal of nickel in the presence of iron(III) sulfate. In the investigation they studied the effect of temperature, iron(III) concentration, initial sulphuric acid concentration, oxygen flow rate and chloride ions addition on cobalt and nickel leaching. They observed that increase in these parameter increases recovery of nickel by leaching. Aryal studied the biosorption of Ni(II) ions from aqueous solutions by Bacillus sphaericus biomass. His studies indicated that the solution pH, biomass concentration, contact time, temperature and initial Ni(II) concentration affects the nickel biosorption[23]. It was also observed that pseudo-second order kinetic model and the Freundlich isotherm model explains the biosorption of nickel. He was able to recover the Ni(II) ions effectively from Bacillus sphaericus biomass using 0.1 M HNO_3.

4. Conclusions

Nickel recovery in catalyst industries can be carried out by various techniques such as acid leaching, chelation and ultrasonication. The processes can be made economical feasible by regeneration of spent catalyst. Nickel regeneration by using various solvents has been investigated to decide best solvent in terms of removal efficiency and economy. Sulfuric acid was reported one of the best solvents for nickel recovery. Application of ultrasound for the recovery of nickel promises to be better methods than leaching and chelation techniques. Coupling electrical separation with elution increases nickel recovery by approximately 13 percent. Other methods such as precipitation, ion exchange, biosorption etc. have been investigated with satisfactory to excellent results. It can be concluded that the selection of best suited method for the recovery of nickel and regeneration of adsorbent can play vital role in economical and efficient operation of plant and make the process viable.

References

1] Nilanjana Das, R Vimla And Karthika, “Biosorption of Heavy Metal- an Overview”, Indian Journal Of Biotechnology, Vol 7, April 2008, pp. 159-169.

[2] Seshadri, B. Ramesh Naik, N.V. Sandeep Kumar, D.K. Venkata Ramana, K. Seshaiah, “Application of Citric Acid Modified Annona Squamosa (Custard Apple) Bark Powder as Biosorbent to Remove Ni(II) From Waste Water”, Indian Journal Of Advances In Chemical Science, Vol. 3, 2014, pp.1-10.

[3] Zahra Abbasi, Mohammad Alikarami, Eshagh Rezaee Nezhad, Farzaneh Moradi, Vahid Moradi, “Adsorptive Removal of Co^{2+} And Ni^{2+} By Peels of Banana from Aqueous Solution”, Universal Journal Of Chemistry , Vol.1, No.3, 2013, pp.90-95.

[4] Khantong Soontarapa And Nuntachai Srinapawong, “Combined Membrane-Trickling Filter Waste Water Treatment System”, J. Sci. Res. Chula. Univ., Vol. 26, No. 2, 2001, pp. 59-71.

[5] E. Gasparikova, S. Kapusta, I. Bodík, J. Derco, K. Kratochvíl, “Evaluation of Anaerobic-Aerobic Wastewater Treatment Plant Operations”, Polish Journal of Environmental Studies, Vol. 14, No. 1, 2005, pp. 29-34.

[6] Sonali R. Dhokpande, Sunil J. Kulkarni, Dr. Jayant P. Kaware, “A Review on Research on Application of Trickling Filters in Removal of Various Pollutants from Effluent”, International Journal Of Engineering Sciences & Research Technology, Vol.3, No.7, 2014, pp.359-365.

[7] R.S. Dave, G.B. Dave And V.P. Mishra, “Removal of Nickel from Eletroplating Wastewater by Weakly Basic Chelating Anion Exchange Resins: Dowex 50x4, Dowex $50x_2$ and Dowex M-4195”, Journal of Applied Sciences in Environmental Sanitation, Vol.6, 2010, pp.39 - 44.

[8] Gupta VK, Jain CK, Ali I, Sharma M, Saini VK.” Removal of Cadmium and Nickel from Wastewater using Bagasse Flyash--a Sugar Industry Waste” Water Res., Vol.37, 2003, pp 43-44.

[9] Reyad A. Al Dwairi, Aiman E. Al-Rawajfeh “Removal of Cobalt and Nickel from Wastewater by Using Jordan Low-Cost Zeolite and Bentonite” Journal of the University of Chemical Technology and Metallurgy, Vol.47, 2012, pp. 69-76.

[10] Rudre Gowda, A.G.Nataraj And N.Manamohan Rao, “Coconut Leaves as a Low Cost Adsorbent for the Removal of Nickel from Electroplating Effluents” International Journal Of Scientific & Engineering Research, Vol. 2, 2012, pp. 1- 5.

[11] Oza R. And Patel S., “Recovery of Nickel from Spent Ni/Al_2O_3 Catalysts Using Acid Leaching, Chelation and Ultrasonication”, Research Journal of Recent Sciences, Vol.1 , 2012, pp.434-443.

[12] Kenneth Price (Oldsmobile) & Charles Novotny (Industrial), “Water Recycling and Nickel Recovery Using Ion Exchange”, pp85-87.

[13] H.B.Mat, Yuliusman And N.Othman, “ Selective Nickel Recovery from Spent Catalyst”, World Engineering and Congress Exihibition Kuala Lumper, July 1999, pp.19-22.

[14] Kaarlo Haavanlammi, “Nickel Matte Chloride Leaching”, Outotec Seap Customer Enewsletter 2/2014

[15] Shahrad Khodaei Booran, “ Recovery of Zn^{2+} And Ni^{2+} Binary from Wastewater Using Integrated Biosorption and Electro-Deposition’’, A Thesis Presented to Ryerson University, Toronto, Ontario, Canada, 2013, pp. 1-154.

[16] Sunil Kulkarni And Dr. Jayant Kaware, “Regeneration and Recovery in Adsorption- A Review”, International Journal of Innovative Science, Engineering and Technology, Vol. 1 Issue 8, October 2014,pp. 61-64

[17] Anuradha Devi, Anupam Singhal, Rajiv Gupta, “ A Review on Spent Pickling Liquor”, International Journal of Environmental Sciences, Vol. 4, No. 3, 2013, pp.284-295.

[18] U.U. Jadhav, H. Hocheng, “ A Review of Recovery of Metals from Industrial Waste”, Journal of Achievements in Materials and Manufacturing Engineering, Vol. 54, No. 2, October 2012, pp. 159-167.

[19] I. Ismail, A. Soliman, N. Abdel-Monem, H. Salah Ahmed, M. H. Sorour, “Nickel Removal from Electroplating Waste Water Using Stand-Alone and Electrically Assisted Ion Exchange Processes”, Int. J. Environ. Sci. Technol., Vol. 11, 2014, pp. 199–206.

[20] Chunhua Xiong and Caiping Yao , “Ion Exchange Recovery of Nickel (II) on Microporous

Weak Acid Resin (D151resin)", Indian Journal of Chemical Technology, Vol. 18 January 2011, pp. 13-20.

[21] P. Gomathi Priyaa, C. Ahmed Bashab, V. Ramamurthia, S. Nathira Begumb, "Recovery and Reuse of Ni(Ii) from Rinsewater of Electroplating Industries", Journal of Hazardous Materials, Vol.163, 2009, pp. 899–909.

[22] Krzysztof Gibas, Kamil Borowski, Tomasz Chmielewski, Katarzyna Wejman, " Recovery of Cobalt and Nickel by Atmospheric Leaching of Flotation Sulfide Concentrate from Lubin Concentrator", Physicochem Problem of Mineral Processing , Vol.51 , No.1, pp. 191-203.

[23] Aryal M," Removal And Recovery of Nickel Ions Aqueous Solutions Using Bacillus Sphaericus Biomass, Int. J. Environ. Res., Vol 9, No 41, 2015, pp. 1147-1156.

BIOGRAPHIES

Mrs. Sonali R. Dhokpande has completed her Masters in Food Technology from Nagpur University in 2003. She is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Maharashtra, India.She has published and presented five international papers. Her area of interest includes food technology and biological treatment for various pollutants.

Dr. Jayant Prabhakarrao Kaware, male, Chemical Engineer, pursued his education from Laxminarayan Institute of Technology, Rashtra Sant Tukdoji Maharaj Nagpur University. He was Professor-in-charge for the Biodiesel Research Laboratory associated with the department of chemical engineering.He was Member of Board of Studies for Chemical & Polymer Technology at Sant Gadge Baba Amravati University since 2000 and Chairman from 2008 till 2012. He is a Member of Academic Council since 2005 in the University. He has published more than 36 research papers. He is working on various policy making government bodies related to biodiesel.