Paper ID: A377

Sensitivity Analysis Of Leaching Process On Rare Earth Elements by Using Metsim Software

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EXTENDED ABSTRACT

Leaching is part of the hydrometallurgical treatment in the separation of rare earth elements (REEs). The increase of demand for REEs in the world but its limited supply caused by the separation process that has negative environmental impact, as well as high costs of laboratory work, the alternative method to study on the extraction of these resources are urgently needed. This can be done through simulation study that eliminates the number of experiment that needs to be carried out. In this work, a sensitivity analysis of the leaching process for light rare earth elements (LREEs); Lanthanum (La) and Neodymium (Nd) from monazite concentrate was carried out by employing a software called METSIM which is able to model metallurgical processes. METSIM software is also able to calculate mass and heat balance of complicated hydrometallurgy processes and furthermore, its function has been expanded to involved chemical reactions, process control and equipment sizing. The simulation of the digestion and the leaching process was run and compared with experimental work from the literature, which aimed to optimize the leaching process. Leaching is an extraction process of a substance from a solid material that is dissolved in a liquid. In this study, the leaching process is modelled as a two-steps process, in which the first step is the digestion process, followed by the actual leaching process. The monazite concentrate is made strong bonds as REEs oxide, therefore, they are not soluble in water before leaching process. For the digestion process, the monazite concentrate was mixed with sulfuric acid (H_2SO_4) in the digestion reactor. The precipitates which contain leachate was then mixed with deionised water in the leaching reactor to increase the solubility of La and Nd. The reaction equations for the digestion reactor are as shown in Equations (1) and (2), while for the leaching reactor are shown by Equations (3) and (4) as follows:

$$2LaPO_4(s) + 3H_2SO_4(aq) \rightarrow (La)_2(SO_4)_3(aq) + 2H_3PO_4(aq) \quad (1)$$
$$2NdPO_4(s) + 3H_2SO_4(aq) \rightarrow (Nd)_2(SO_4)_3(s) + 2H_3PO_4(aq) \quad (2)$$
$$(La)_2(SO_4)_3.9H_2O(s) \rightarrow (La)_2(SO_4)_3(aq) + 3H_2O(l) \quad (3)$$
$$(Nd)_2(SO_4)_3.9H_2O(s) \rightarrow (Nd)_2(SO_4)_3(aq) + 3H_2O(l) \quad (4)$$

In this study, optimum parameters have been applied, in which the digestion process was carried out at temperature 225oC, retention time at 3.5 hour and the liquid solid ratio is at 2.5 [3]. For the leaching process, the temperature is 75oC, retention time is 15 hour and liquid solid ratio is 7.5 [3]. Figure 1 shows the process model simulated in METSIM. The digestion reactor, denoted as Digestion Tac (Tank Agitated with Coil) is the main reactor to allow for the reactions between monazite concentrate phosphate and H2SO4 (Equations (1) and (2)), while the leaching reactor denoted as Leaching Tac is where the precipitated monazite leachate and deionised water produce monazite leachate (Equations (3) and (4)). Other equipment modelled in this study includes mixer reactor, phase splitter, heat exchanger and controller as shown in Figure 1.

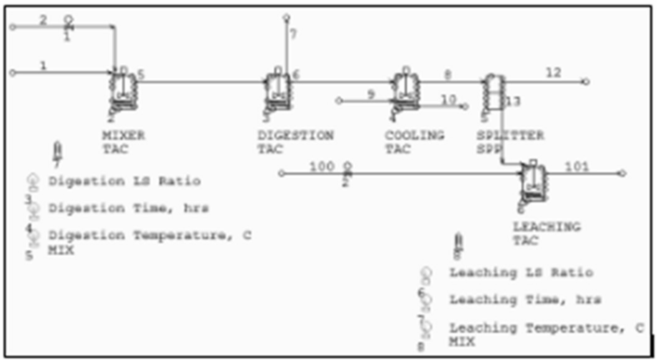

Figure 1: Digestion and leaching process in METSIM software.

Table 1 shows the case studies run in this work with parameter range: temperature (200-250)oC, time (1.0-6.0) hr and liquid solid ratio (1.00-1.75).

Table 1: Case study followed by different parameter temperature, time and liquid per solid (L/S) for digestion.

Case	Parameter			Case	Parameter		
	Temperature (^{o}C)	Time (hr)	L/S (mL/g)		Temperature (^{o}C)	Time (hr)	L/S (mL/g)
Case 1	200	1	1	Case 6	225	6	1
Case 2	200	3.5	1.75	Case 7	250	1	2.5
Case 3	200	6	2.5	Case 8	250	3.5	1
Case 4	225	1	1.75	Case 9	250	6	1.75
Case 5	225	3.5	2.5				

The results for the sensitivity analysis for Case 1 to 9 are shown in Figure 2. The results show that the possibilities of digestion recovery of monazite concentrates ores have high recovery between 80%-90%. In addition, the model results show excellent agreement with the literature [3], whereby <5% errors of differences were determined. This shows that the developed model is able to represent the leaching process of the REEs.

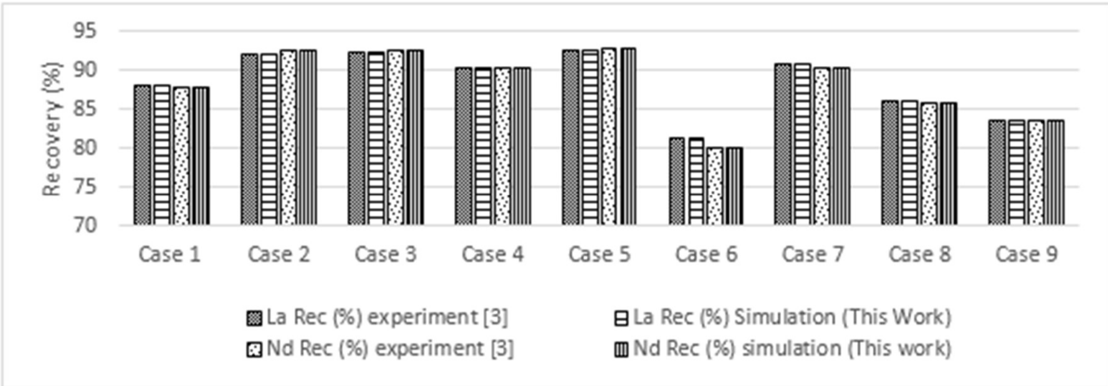

Figure 2: Effect of cases in digestion on recovery of $LaPO_4$ and $NdPO_4$.

Keywords: Leaching, temperature, retention time, liquid solid ratio, METSIM software

Acknowledgement

This study was support by RDU160123 (Modelling Rare Earth Element Leaching and Residual Separation Systems).

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