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Leaching and recovery of zinc from leaching residue of zinc calcine based on membrane filter press

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Abstract: The feasibility of leaching and recovery of zinc from zinc leaching residue (ZLR) based on a membrane filter press (MFP) was investigated. Experimental results show that zinc calcines with particle sizes of less than 106 μm and chambers of widths of 30 mm are appropriate for establishing uniform filter cakes to obtain acceptable leaching and recovery results. The leaching of zinc from ZLR performed via washing at 90 to 96 °C for 90 min with spent electrolyte using a MFP results in a zinc extraction rate of 97%, and almost all of the zinc leached are recovered after water washing with MFP, thereby avoiding any loss in the ZLR. Compared with the traditional hot concentrated acid leaching process, the process based on MFP as a leaching reactor is able not only to ensure a high extraction rate but also to reduce the leaching time. Moreover, the thickening, pulping, second leaching, washing, filtering and pressing could be integrated and realized using a single MFP.

Key words: zinc; membrane filter press; zinc leaching residue; leaching; recovery

1 Introduction

Zinc sulfide ores are the main source of zinc metal in the world, in which zinc generally exists in forms of sphalerite and marmatite. Currently, more than 80% of the zinc is produced by conventional zinc hydrometallurgical methods, including roasting, leaching and electrowinning processes [1,2]. During the roasting process, ZnS is converted to ZnO, but a significant fraction of ZnO reacts with the iron impurities to form zinc ferrite [3−5]. Zinc ferrite is insoluble in mild acidic conditions. Thus, a considerable amount of leaching residue will be produced in the subsequent leaching process [6,7]. In addition, the leaching reaction rate decreases over time due to the decreasing acid concentration during the traditional leaching process in stirred tank. Consequently, incomplete leaching will occur, thereby further increasing the generation of zinc leaching residue (ZLR), leading to a significant waste of resources and a high environmental risk [8,9].

The high demand for zinc has attracted the interest of industry to utilize the ZLR as a valuable secondary source [1]. Hydrometallurgical processes are widely applied to recycle zinc from ZLR due to their significant advantages of lower capital and operating costs, as well as being less harmful to the environment [1,2]. Currently, the most common hydrometallurgical process is to recover zinc from ZLR in a bath of hot concentrated sulfuric acid [10]. A high extraction rate of zinc can be obtained using this process, but incomplete leaching still occurs due to the leaching in the stirred tank. Moreover, the hot concentrated acid leaching process involves a long reaction time (4−6 h) and consumes an enormous amount of energy and sulfuric acid to process the large amount of ZLRs obtained by thickening. More importantly, in most electrolytic zinc plants, the ZLRs containing water-soluble zinc with a content of less than 5% are directly discharged or heaped, causing a portion of the zinc losses. The water-soluble zinc can cause soil contamination, water pollution and several other serious environmental pollution through the leachate by rainfall [8,9]. Therefore, finding a cost effective and environmental friendly process to recover zinc from ZLR remains a major challenge.

The membrane filter press (MFP), which is a common machine on solid-liquid separation, has advantages of low cost, high solid content and outstanding efficiency that has been widely used in various industries. In recent years, the washing function

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of MFP has also been attracting attention for use in the titanium dioxide, sugar, pigment and electrolytic manganese metal industries [11−14]. LIU et al [14] recovered 50% of water-soluble manganese from an electrolytic manganese residue (EMR) via a MFP using water. This MFP-based water washing technology could be industrially applied because it solves the problem of “water swelling”, which commonly occurs in previous water washing technologies [14,15]. On the basis of the previous work of LIU et al [14], we attempted to wash the EMR via a MFP using anolyte. In 2009, the MFP-based technology on the leaching and recovery of manganese from EMR via a combination of anolyte washing with water washing was realized and resulted in a patent application being submitted (No. CN1024700A) [16]. Note that several demonstrative operations have also been constructed in China based on this technology. However, the possibility of using this technology in the hydrometallurgical zinc process has never been investigated previously. If this technology could be used in electrolytic zinc plants, the thickening, pulping, second leaching, washing, filtering and pressing would be integrated and realized using a single MFP. In addition, the leaching of zinc from ZLR in the form of spent electrolyte washing would be performed under constant acid concentration via a continuous flow of spent electrolyte.

Hence, the feasibility of leaching and recovery of zinc from leaching residue of zinc calcine based on MFP was investigated, combining spent electrolyte washing with fresh water washing. For this work, the uniformity of filter cakes, which is directly related to the leaching result, was examined. Based on this experimental result, the leaching and washing on extracting zinc from ZLR were subsequently studied.

2 Experimental

2.1 Materials

The experimental study was performed using zinc calcine with a composition of 57% zinc, which was purchased from Hunan Province, China. Spent electrolyte containing 160 g/L of H_2SO_4 and 50 g/L of Zn^{2+} was used in all of the leaching experiments. Under all examined conditions, the zinc concentration was determined based on GB/T 14353.3−2010 [17], and the hydrogen ion concentration (H^+) was measured based on GB 6498.2−2001 [18]. The membrane filter press (KM470) was from Beijing ZSC Solid-Liquid Separating Technology Co., Ltd. (China), and the membrane plates (470 mm × 470 mm) were from LENSER Filtration GmbH + Co. (Germany).

2.2 Experimental procedure

The diagram of leaching and recovery of zinc from zinc calcine is presented in Fig. 1. The proper production process is described briefly as follows. 1) leaching in stirred-tank reactor: Spent electrolyte or sulfuric acid was added to the crushed zinc calcine to leach zinc ions from the ores and to obtain the $ZnSO_4$-contained slurry. 2) filtration: the $ZnSO_4$-contained slurry was pumped into MFP through central feeding hole and filter pressed to obtain the filter cakes (i.e., ZLR); next, the filtrate (leaching liquor) entered the subsequent production process. 3) Re-leaching in MFP: Spent electrolyte at the desired temperature was pumped into the MFP and reacted with filter cakes to leach zinc again and simultaneously recover part of $ZnSO_4$. 4) water washing: The filter cakes were washed again with fresh water to further recover $ZnSO_4$. 5) pressing: Water with a pressure

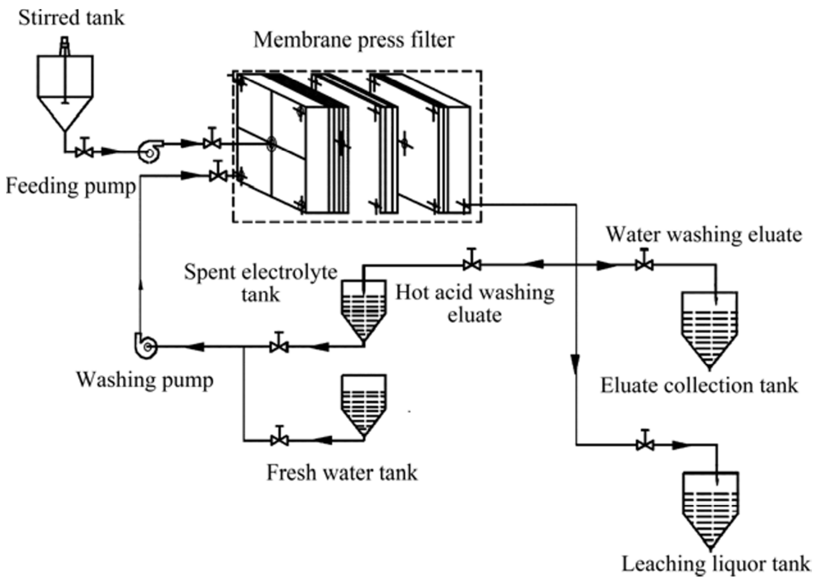

Fig. 1 Schematic diagram of leaching and recovery process using MFP