An apparatus and method for removing ammonia from mining and other industrial wastewaters having a nanofiltration membrane separation system (10) to reject most divalent ions but pass most ammonium and other monovalent ions with the permeate (14) to a water softening system (20) with the effluent (21) to one or more strong acid cation NH₃ removal column(s) (30). Alkaline storage tank(s) (40, 50) provide for the regeneration of the NH₃ removal column(s) (30). A stripping tower (61) is provided for ammonia (NH₄OH) removal.

**FIG. 1**
Description

Ammonia Removal Apparatus And Method

5 Technical Field

The present invention relates to an apparatus and method for removing ammonia from wastewaters, and in particular, to removing ammonia from wastewaters associated with mining and other industrial activities.

10 Background Art

Ammonia may be removed from mining and other industrial wastewaters using stripping tower. The pH of the wastewater stream is raised to convert to convert NH₃ in the wastewater to NH₄OH. After stripping, the water is typically neutralized by acid addition. Conventional ammonia stripping also often requires that the water temperature be elevated in order to reduce the effluent ammonia to the required specification.

Disclosure of Invention

The present invention is an apparatus and method for removing ammonia from mining and other industrial wastewaters comprising (1) a membrane separation system with molecular weight cutoff above around 200 (nanofiltration) to reject most of divalent ions but pass most of the ammonium and other monovalent ions with the permeate (filtrate), (2) a water softening system (cation exchange resin in sodium form regenerated with salt brine), (3) one or more strong acid cation NH₃ removal column(s),
(4) an alkaline (5-10% NaOH or other alkaline solution) storage tank for regeneration of the NH₃ removal column(s), and (5) a stripping tower for ammonia (NH₄OH) removal.

The membrane system rejects divalent ions well, such as hardness, but does not reject NH₃ well. The softener adsorbs most of the divalent ions that the membrane passes, but the NH₃ passes through the softener. The NH₃ loads well on the NH₃ removal column because the divalent ions have been mostly eliminated and will not impede NH₃ loading. Also, because of the use of nanofiltration for the bulk of the divalent ion removal, sodium (which would be exchanged for divalent ions during water softening) is minimized. Sodium also impedes NH₃ loading on the cation resin in the NH₃ columns. If hardness (Ca + Mg) plus sodium is reasonably low (less than approximately 500), the membrane system is not necessary.

Conventional ammonia strippers treat the water stream, requiring a large stripping tower. The present invention system only strips the alkaline regenerant solution from the NH₃ removal media, which is roughly 1% of the volume of the treated water, requiring a much smaller stripper, which operates only about 5% of the time that the water is being treated.

It is necessary to raise the pH of the stream to approximately 11.5 to convert NH₃ to NH₄OH with conventional ammonia strippers. After stripping, the water is typically neutralized by acid addition. Therefore, chemical feed systems and pH controls are necessary as well as the chemical costs associated with the continuous pH adjustments. The present invention reuses the alkaline regenerant solution after the ammonia has been stripped from it with only about 5% loss of regenerant per
regeneration cycle.

Conventional ammonia stripping often requires that the water temperature be elevated, with inherent energy cost, in order to reduce the effluent ammonia to the required specification. The alkaline regenerant solution of the present invention is maintained at a pH near 14 for the most expedient conversion of NH₃ to NH₄OH at relatively low temperature.

Calcium and other divalent ions which contribute to scaling and impede ammonia stripping are diverted around the NH₃ removal column so that the scaling potential of the stripping tower is greatly minimized or eliminated and stripping efficiency is enhanced.

These and other features, objects and advantages of the present invention will become better understood from a consideration of the following detailed description of the preferred embodiments and appended claims in conjunction with the drawings as described following:

Brief Description Of Drawings

Fig. 1 is a block diagram of an embodiment of the present invention.

Best Mode for Carrying Out the Invention

With reference to Fig. 1, the preferred embodiment of the present invention may be described as follows.

The present invention is an apparatus and method for removing ammonia from mining and other industrial wastewaters. The wastewater 11 is pumped by pump 12 to
Membrane separation system 10 is preferably a nanofiltration system with molecular weight cutoff above around 200. Most of the divalent ions in the wastewater are rejected in reject line but most of the ammonium and other monovalent ions are passed in permeate line 14. The permeate is fed to water softening system 20. Water softening system 20 is preferably a cation exchange resin in sodium form. The resin is regenerated with salt brine 15. The effluent from water softening system 20 is passed to a strong acid cation NH₃ removal column 30. If hardness (Ca + Mg) plus sodium in the wastewater is reasonably low (less than approximately 500), the membrane system 10 is not necessary.

The NH₃ removal column 30 may actually comprise one or more columns. The removal column 30 is regenerated with an alkaline solution stored in one or more storage tanks 40, 50. The alkaline solution is preferably 5-10% NaOH or other alkaline solution. The alkaline solution is maintained at a pH near 14 for the most expedient conversion of NH₃ to NH₄OH at relatively low temperature. The alkaline solution is stripped of ammonium hydroxide in stripping tower 61 using air blown by blower 60.

As noted above, the present invention only strips NH₃ from the relatively small volume of alkaline regenerant solution from the NH₃ removal media rather than stripping the NH₃ from a large volume of water. Although one embodiment of the invention is described above with respect to stripping the NH₃ using a stripping tower, other strippers for stripping the NH₃ may be used with the present invention. For example, the Liqui-Cel® membrane contactors (Celgard LLC, Charlotte NC) may be used for stripping NH₃ from the alkaline regenerant solution. Any type of apparatus or method capable of stripping NH₃ from an alkaline solution may also be used at the stripper in
the practice of the present invention.

The present invention has been described with reference to certain preferred and alternative embodiments that are intended to be exemplary only and not limiting to the full scope of the present invention as set forth in the appended claims.
Claims

1. An apparatus for removing ammonia from wastewaters containing divalent ions and monovalent ions including ammonium ions, comprising:
   a nanofiltration membrane separation system for passing in a permeate a substantial portion of the monovalent ions including ammonium ions in the wastewaters while rejecting a substantial portion of the divalent ions in the wastewaters;
   a water softening system for receiving the permeate from the membrane separation system and absorbing a substantial portion of divalent ions remaining in the permeate;
   a strong acid cation ion exchange column for receiving the permeate from the water softening system and for removing a substantial portion of the ammonium ions in the permeate;
   a storage tank containing an alkaline solution for regeneration of the strong acid cation ion exchange column removal column and producing an ammonium hydroxide brine; and
   a stripper for stripping ammonium hydroxide from the brine.

2. An apparatus for removing ammonia from wastewaters containing divalent ions and monovalent ions including ammonium ions, comprising:
   a water softening system for passing a substantial portion of the monovalent ions including ammonium ions in the wastewater while absorbing a substantial portion of divalent ions in the wastewaters;
   a strong acid cation ion exchange column for receiving the effluent from the
water softening system and for removing a substantial portion of the ammonium ions in the effluent;

- a storage tank containing an alkaline solution for regeneration of the strong acid cation ion exchange column removal column and producing an ammonium hydroxide brine; and

- a stripper for stripping ammonium hydroxide from the brine.
A  CLASSIFICATION OF SUBJECT MATTER
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USPC - 423/352
According to International Patent Classification (IPC) or to both national classification and IPC

B  FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
USPC, 423/352
Pub WEST, Google Scholar (see the key words below)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Pub WEST (USPT, PGPB, EPAB, JPAB) Google search Search Terms apparatus removing ammonia, wastewater, ions, nanofiltration, nanofiltration membrane separation, acid cation, alkali, storage tank

C  DOCUMENT S CONSIDERED TO BE RELEVANT

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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
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Authorized officer

Lee W Young

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