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(54) Title: METHOD FOR OPERATING A COUNTER-FLOW ION EXCHANGE SYSTEM

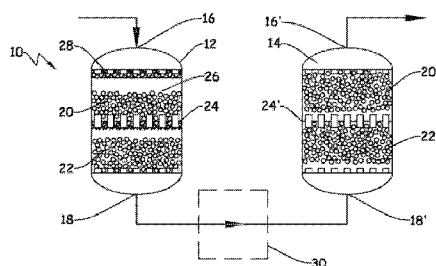


Fig. 1A

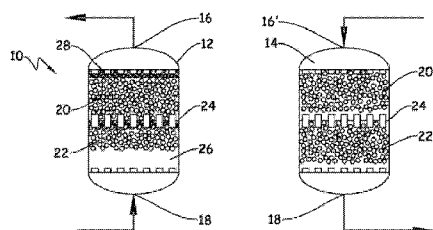


Fig. 1B

(57) **Abstract:** An improved counter-flow ion exchange system and method for operating the same, including a plurality of vertically aligned columns of packed bed ion exchange resin including: an upstream column including a packed bed of cation exchange resin, and a downstream column including a packed bed of anion exchange resin that is in fluid communication with the upstream column, wherein both columns comprises an upper and lower port for ingress and egress of fluid. The subject method of operation includes the steps of: i) introducing a feed liquid into the upper port of the upstream column such that feed liquid flows downward through the column and exits through the lower port, and subsequently flows into the lower port of the downstream column and upward to exit from the upper port, ii) discontinuing the introduction of feed liquid, iii) introducing a first regenerate into the into the upper port of the downstream column such that regenerate flows downward through the column and exits through the lower port and introducing a second regenerate into the into the lower port of the upstream column such that regenerate flows upward through the column and exits through the upper port, and iv) repeating steps i) through iii).

FIELD

The present invention is directed toward ion exchange systems including multiple packed bed columns operating in counter-flow mode.

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INTRODUCTION

Ion exchange systems including multiple packed bed columns are used in a variety of demineralizing and softening applications. For example, hundreds of AMBERPACK™ and DOWEX™ UPCORE™ packed bed systems are in service world-wide. AMBERPACK™ packed bed systems operate in an upflow production and downflow regeneration mode. DOWEX™ UPCORE™ packed bed systems operate in a downflow production and upflow regeneration mode. Both AMBERPACK™ and UPCORE™ systems can be designed as a single or multiple compartment lay-out. For example, two and three compartment columns (so called “layered beds”) can accommodate weak and strong electrolyte resin combinations resulting in highly efficient systems.

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SUMMARY

The invention includes an improved counter-flow ion exchange system and method for operating the same. In one embodiment, the system includes a plurality of vertically aligned columns of packed bed ion exchange resin including: an upstream column including a packed bed of cation exchange resin, and a downstream column including a packed bed of anion exchange resin that is in fluid communication with the upstream column, wherein both columns include an upper and lower port for ingress and egress of fluid. In another embodiment, a method of operating the system includes the steps of:

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i) introducing a feed liquid into the upper port of the upstream column such that feed liquid flows downward through the column and exits through the lower port, and subsequently flows into the lower port of the downstream column and upward to exit from the upper port,

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ii) discontinuing the introduction of feed liquid,

iii) introducing a first regenerate into the upper port of the downstream column such that regenerate flows downward through the column and exits through the lower port and introducing a second regenerate into the lower port of the upstream column such that regenerate flows upward through the column and exits through the upper port, and iv) repeating steps i) through iii).

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is schematic view of a dual compartment embodiment of the invention operating in production mode.

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Figure 1B is schematic view of the embodiment of Fig 1A operating in regeneration mode.

DETAILED DESCRIPTION

In one embodiment, the invention includes a counter-flow ion exchange system generally shown at 10 in Figures 1A and B. The illustrated system includes two vertically aligned columns including an upstream column (12) include a packed bed of cation exchange resin, and a downstream column (14) including a packed bed of anion exchange resin. The downstream column (14) is in fluid communication with the upstream column (12) such that liquid is able to pass from the upstream column (12) to the downstream column (14). Both columns (12, 14) include at least one upper (16, 16') and lower (18, 18') port for ingress and egress of fluid. Both columns (12, 14) are shown including an upper (20, 20') and lower (22, 22') chamber separated by a plate fitted with nozzles (24, 24'). The upper chamber (20) of the upstream column (12) is filled with a weak acid cation exchange resin while the lower chamber (22) is filled with a strong acid cation exchange resin. The upper chamber (20') of the downstream column (14) is filled with a strong base anion exchange resin while the lower chamber (22') is filled with a weak base anion resin. The columns are connected by way of piping with the fluid flow direction during production mode represented by heavy lines with arrows in Figure 1A and in regeneration mode in Figure 1B. The upstream column (12) includes an optional freeboard (26) and floating inert resin (28). An optional degasification tower (30) may be located along the fluid path between the upstream and downstream columns (12, 14).

While shown as including two columns, additional columns may also be used. Similarly, while each column is shown including two chambers, single chambered or multi-chambered arrangements may be used. Each column may include options vents, inlets, jet breakers, reinforcing plates, etc., as is known in the art.

During operation, the system cycles through production and regeneration modes. During the production mode, feed liquid is introducing into the upper port (16) of the upstream column (12) such that feed liquid flows downward through the column (12) and exits through the lower port (18), and subsequently flows into the lower port (18') of the downstream column (14) and upward to exit from the upper port (16). The production mode and corresponding fluid flow direction is illustrated in Figure 1A with reference to schematic arrows. During the regeneration mode, the introduction of feed liquid into the system (10) is discontinued and a first regenerate is introduced into the into the upper port (16') of the downstream column (14) such that regenerate flows downward through the column (14) and exits through the lower port (18') where it is recaptured. Simultaneously, a second regenerate may be introduced into the lower port (18) of the upstream column (12) such that regenerate flows upward through the column (12) and exits through the upper port (16) where it may be recaptured. The regeneration mode and corresponding fluid flow direction is illustrated in Figure 1B with reference to schematic arrows. The operation may additionally include optional backwashing steps.

The subject system and method of operation represents a hybrid of an AMBERPACK™ and UPCORE™ packed bed system where the upstream column (12) operates as an UPCORE™ system

and the downstream column (14) operates as an AMBERPACK™ system. This hybrid system offers unexpected advantages over both AMBERPACK™ and UPCORE™ packed bed systems.

EXAMPLES

The performance of an AMBERPACK™ and DOWEX™ UPCORE™ packed bed system was modeled and compared with a corresponding “hybrid” system using CADIX (Computer Assisted Design for Ion eXchange version 6.2) design software available from The Dow Chemical Company. In each case, flow rates, column configurations, resins and regenerants were the identical. The results of the modeling are summarized in Table 1. A dual compartment hybrid system represented by the Figures is also included. As shown by the data, the hybrid system had greater operational availability and required less service water than a comparable UPCORE™ and AMBERPACK™ packed bed system when operating under increasing TSS loadings.

Table 1:

	TSS load kg/m ²	0	0.5	1
UPCORE™ (single compartment)				
	HCl/m ³	0.204	0.2040	0.2041
	NaOH/m ³	0.1475	0.1475	0.1476
	service water/m ³	0.265	0.0266	0.0269
	operational availability (%)	89.9	89.8	89.7
AMBERPACK™ (single compartment)				
	HCl/m ³	0.203	0.2130	0.2327
	NaOH/m ³	0.147	0.1542	0.1685
	service water/m ³	0.23	0.0252	0.0296
	operational availability (%)	91.1	90.2	88.6
Hybrid System (single compartment)				
	HCl/m ³	0.2035	0.2035	0.2036
	NaOH/m ³	0.147	0.1470	0.1471
	service water/m ³	0.25	0.0251	0.0256
	operational availability (%)	90.7	90.7	90.4
Hybrid System (dual compartment)				
	HCl/m ³	0.2035	0.2035	0.2035
	NaOH/m ³	0.147	0.1470	0.1470
	service water/m ³	0.25	0.0251	0.0250
	operational availability (%)	90.7	90.7	90.7

CLAIMS

1. A method for operating a counter-flow ion exchange system comprising a plurality of vertically aligned columns of packed bed ion exchange resin including:

5 an upstream column comprising a packed bed of cation exchange resin, and
a downstream column comprising a packed bed of anion exchange resin that is in fluid communication with the upstream column, wherein both columns comprises an upper and lower port for ingress and egress of fluid,

wherein the method comprises the steps of:

10 i) introducing a feed liquid into the upper port of the upstream column such that feed liquid flows downward through the column and exits through the lower port, and subsequently flows into the lower port of the downstream column and upward to exit from the upper port,

ii) discontinuing the introduction of feed liquid,

15 iii) introducing a first regenerate into the into the upper port of the downstream column such that regenerate flows downward through the column and exits through the lower port and
introducing a second regenerate into the into the lower port of the upstream column such that regenerate flows upward through the column and exits through the upper port, and

iv) repeating steps i) through iii).

20 2. The method of claim 1 wherein the upstream column comprises an upper chamber including weak acid cation exchange resin and a lower chamber including strong acid cation exchange resin.

3. The method of claim 1 wherein the downstream column comprises an upper chamber including strong base anion exchange resin and a lower chamber including weak base anion exchange resin.

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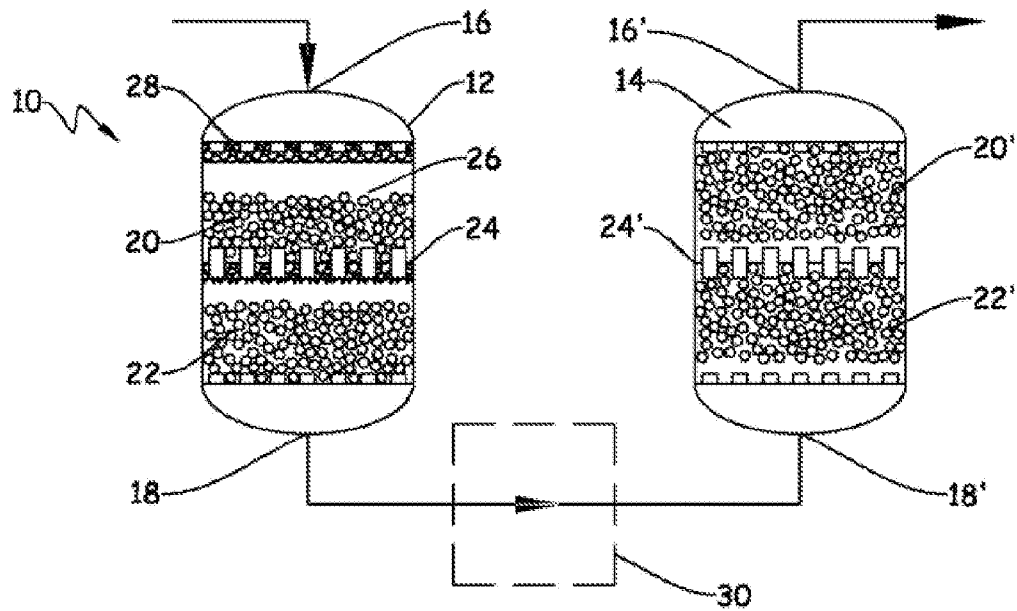


Fig. 1A

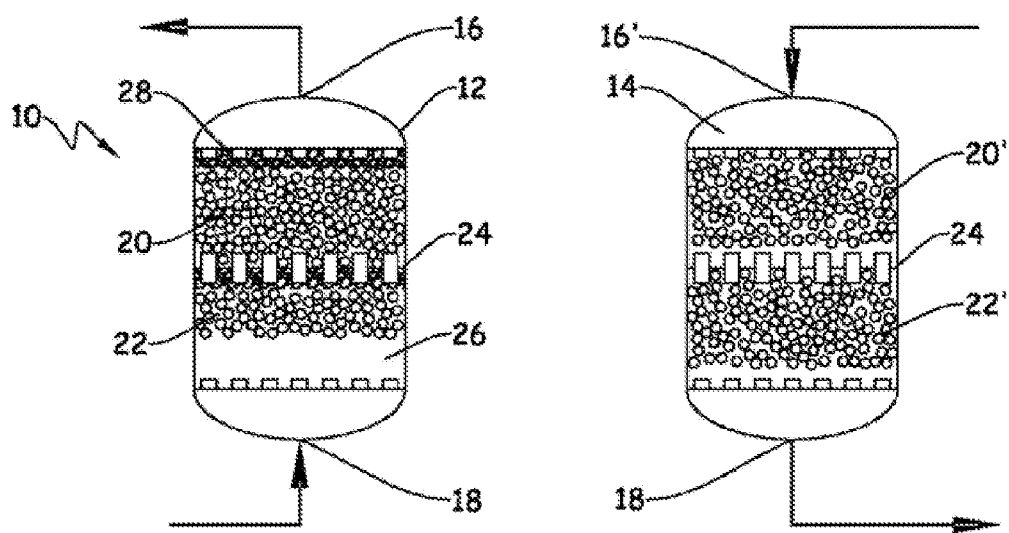


Fig. 1B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/049179

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01J47/02 B01J49/00 B01J49/02
ADD.

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)
B01J

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 214 764 A2 (DOW CHEMICAL BELGIUM [BE]) 18 March 1987 (1987-03-18)	1
Y	column 6, lines 5-10; figure 2 column 9, line 2 - line 7 column 9, line 25 - column 10, line 21; figure 4a column 10, line 61 - line 64 -----	2,3
Y	US 3 617 558 A (JONES GARY D) 2 November 1971 (1971-11-02) column 2, line 68 - column 3, line 33; figure 1 -----	2,3
A	AT 324 962 B (NAGYKANIZSAI FINOMMECHANIKAI V [HU]) 25 September 1975 (1975-09-25) the whole document ----- -/-	1-3



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 001 113 A (SCHOENROCK KARLHEINZ W R ET AL) 4 January 1977 (1977-01-04) the whole document -----	1-3
A	DE 30 14 310 A1 (METALLGESELLSCHAFT AG [DE]) 22 October 1981 (1981-10-22) the whole document -----	1-3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/049179

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 3617558	A	02-11-1971	NONE
AT 324962	B	25-09-1975	NONE
US 4001113	A	04-01-1977	NONE
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