GEKKO SYSTEMS

RESIN ION EXCHANGE COLUMN (G-REX)

By

M O Braaksma¹, T R Hughes² and M Trenorden³

¹ Senior Process Engineer, Gekko Systems Ballarat Australia
² R&D Manager, Gekko Systems Ballarat Australia
³ Senior Mechanical Engineer, Gekko Systems Ballarat Australia

CONTENTS

1. INTRODUCTION ................................................................. 2
2. DEVELOPMENT .............................................................. 2
3. COLUMN SPECIFICATIONS ............................................ 10
4. APPLICATIONS ............................................................. 10
5. REFERENCES ................................................................. 10
1. INTRODUCTION

Gekko Systems in the late 1990’s developed an innovative gold concentrate leaching systems, the batch and continuous InLine Leach Reactors (ILR), which revolutionised gravity gold handling in particular. Due to the increasing complexity of some concentrates treated in the ILR (float, high Antimony, Arsenic, Copper), the pregnant solution wasn’t always optimally treated by the typical direct electrowinning method. After an extensive literature survey, resin which offered high loadings and selectivity was investigated.

A resin (AuRIX®100) was found that was developed specifically for the gold market by the Cognis group. AuRIX®100 resin is a weak base resin, which is highly selective for gold over many metals, and is stripped by a strong caustic solution, from which the gold can easily be electrowon using conventional cells.

Gekko Systems’ desire to offer a complete processing solution with their ILR, resulted in a close relationship with Cognis, who licensed the exclusive marketing rights for the resin to Gekko Systems. As a result, the Gekko Resin Exchange Column (G-REX) was developed to utilise the resin. G-REX is a multistaged, counter current, pulsed, resin ion exchange contactor, which is not only effective for AuRIX®100 resin, but possibly suitable for other broader resin applications.

This paper describes the development, mechanical aspects and an operating description of the G-REX ion exchange column.

2. DEVELOPMENT

2.1. RESIN

AuRIX®100 is a cross linked polystyrene alkaline resin functionalized with an active guanidine group. The resin beads are off-white in colour, spherical in shape, with a nominal size of 100% + 600µm. AuRIX®100 beads suffer minimal osmotic shock as they are always in an alkaline media during extraction and stripping. The maximum recommended temperature for stripping is 60°C to avoid the possibility of thermally induced failure.

The resin extracts precious metal cyanide complexes from leach solutions with a pH less than 11.5 however as the pH falls the selectivity of precious metals over base metals drops. At the higher pH the selectivity improves and the order of preference is Au>Ag>Hg ~Ni>Cu>Co>Fe.

As with most resins, periodic (weekly/monthly) washing with, in this case, a dilute acid is required to unblock resin pores.

2.2. INITIAL TRIALS

Cognis’ initial trials with the resin concentrated on resin in solution (RIS) circuits, consisting of fixed bed contactors, in both upflow and downflow configurations.

During the upflow trials, it was found that the low bulk density of the resin results in a low specific fluidization velocity limiting the upflow flowrate that can be passed through a resin contactor. Initial bed fluidization occurred at an approximate specific upflow velocity of 3.5 m3/m2/hr. Specific upflow flowrates up to 20 m3/m2/hr could be used if sufficient provision is made in the contactor design to allow for the resulting bed expansion to prevent resin carryover.

In the downflow configuration, the trials indicated that the pressure drop across the resin bed was 10 kPa/m at a superficial velocity of 20 m/h, which gave a high specific downflow flowrate with minimal bed compaction. A carousel setup was followed to progressively move fully loaded beds from the extraction to the stripping stage.

\[ \text{Patent Pending} \]
Based on these results, the preliminary RIS circuit design incorporated downflow for extraction and upflow for elution. The downflow configuration for extraction allows the RIS circuit to operate over a wide range of flowrates without the concern over bed expansion limitations. The upflow configuration for elution would permit the flushing of any trapped particulate material from the resin column and partially expand the bed to prevent compaction and potential short-circuiting.

2.3. RESIN CONTACTER CONCEPT

Gekko Systems’ initial concept for a contactor, was to pump clarified pregnant leach solution (PLS) to fixed bed resin contactors that would be cycled between absorption and stripping duties. However this was eventually dropped in favour of a contactor that would be a hybrid between a resin in pulp (RIP) contactor and a multistage column. It was recognized that this would simplify the solid liquid separation and reduce solution gold losses.

The specific goals of the contactor were:

- To treat dilute leached slurries without the need for clarification
- Multistaged contactor
- Low wear on resin
- Low footprint
- Simple to operate

Figure 1 displays the flowsheet that was chosen to meet these goals. The contactor/absorption column consists of four stages that are separated by a screen, each filled with a bed of resin. A pulse is applied by a hydraulically driven diaphragm at the base of the column, which momentarily fluidises each bed of resin at quick intervals.

Figure 1: Pilot Resin Column Circuit
Presized leached slurry is added to the top of column, and this passes down the column, through each bed of resin before exiting at the base. The regular fluidisation of the resin beds, allows solids to gently work their way down through each bed and then out of the column. The resin is moved countercurrently to the feed flow, starting with the transfer of loaded resin from the top stage (stage 1) to a dewatering screen, before entering a stripping column. The resin beds in the stages below, are progressively transferred up the column (2 to 1, 3 to 2 etc). The empty bottom stage is then filled with barren resin from the stripping circuit. This cycle would be repeated every 8 hours.

At the stripping column, strip solution is pumped into the bottom of a conical bottomed tank, which effectively fluidises the resin and ensures good mass transfer is occurring. The stripped solution exits through a screen at the top of the column, and passes through a recovery unit (in this case an electrowinning cell) before returning to the column. At the end of the stripping step (up to 8 hrs in total), stripped resin is passed into a holding tank before being returned to the column.

2.4. PILOT RESIN COLUMN

Figure 2 displays a photo of the pilot resin column which was designed and built at the Ballarat factory to prove the concept. The circuit starts with the pumping of reacted slurry from a small ILR to a safety screen that removed + 200µm material, before being passed down a pulsed resin column (30cm diameter) consisting of four stages, each separated by a 400 µm wedge wire screen. The pulse allowed the resin to be fluidised thus enabling solids to pass through the resin bed and out of the column. The barren slurry was withdrawn from the bottom of the column and dewatered in a thickener, where the bulk of the solution was recycled to the ILR.
Each stage of the contactor held 10 Litres of resin, and this was advanced up the column counter currently to the slurry, via eductors driven by motive solution sourced from a pump connected to the bottom of the column. The loaded resin at the top of the column is then transferred to the stripping circuit where it is stripped at a temperature of 60°C, with 4% w/w caustic, with the gold being simultaneously recovered by electrowinning. The stripped resin is returned to the base of the column for reuse.

The column is pulsed using a hydraulic ram acting on a diaphragm, to ensure that there is no binding of screens, and that the solids are kept fluidized so that they aren’t held-up within the column. The screens which are horse-shoe in shape, are sealed within the column with linatex gaskets fitted to both sides of the screen. The screen can be removed by using jacking bolts, that open up the gap between column segments, allowing the screen to be pulled free.

The results of extensive pilot testing proved that particles less then 200 µm could be passed through the column.

2.5. MARK I - COMMERCIAL COLUMN

The first commercial column was located at the Bong Mieu plant in Central Vietnam. The feed flowrate capacity of the column (8 m³/hr), was twenty times the capacity of the pilot column. A single change was made to the design from the pilot plant, and that was the ability to stir up the larger bed of resin in each stage, by injecting barren solution via the eductor pump. Figure 3 displays the original process.

Figure 3: Bong Mieu Resin Flowsheet

The column consisted of four compartments (see Figure 4) loaded with approximately 200 L of resin each, separated by 400 µm aperture wedge-wire screens which held the resin in each stage. A motive solution pump (Warman 1.5/1), which sourced fluid from the base of the column, supplied pressure to eductors situated on the column which allowed resin to be moved up to the next stage.
Figure 4: Mark I - Gekko Resin Column

Figure 5: Mark I - Gekko Resin Circuit as used at Bong Mieu
The first application while successful, raised various problems which were overcome by site personnel and Gekko engineers. The main issues were:

- Difficulty in prescreening and removing +200µm particles and trash efficiently.
- Inability of the column to handle large quantities of fine solids.
- Premature screen failure.
- Difficult screen removal process.
- Eductor motive solution source and pressure control.
- Additional extraction stage required (primarily due to poor eductor control extending the time resin was out of the column).

The pre-screening issue and excessive solids entering the column, were eliminated by adding a solid-liquid separating cone to the circuit (See figure 6 below). This reduced the pulse required to keep the solids fluidised, which helped to improve the screen reliability. The screen reliability was further improved by replacing the 400 µm wedge wire with woven wire stainless steel, supported by 20 mm woven wire mesh. The difficulty of removing the screens remained an issue that could only be solved by a major column redesign.

The eductor pump inlet was changed from the bottom of the column to a separate tank, as the pump was creating suction forces within the column, that restricted smooth resin fluidisation by the pulse mechanism. Erratic eductor motive pressure control also resulted in unreliable resin transfers by the automated system, which resulted in uneven distribution of resin in the stages after several cycles.

The eductors were also slow in moving resin between stages (up to 30 minutes/stage) which resulted in significant periods when only three stages were available for absorption of gold. New eductors were installed which significantly increased transfer times.

Figure 6: Mark I – Modified Resin Column Circuit
2.6. TESTING AND REDESIGN PHASE

After the experience gained in running the first full scale resin contactor, extensive testing was continued in the factory on other prototypes. This mainly concentrated on improving the reliability of interstage screens and the efficiency of eductors.

Following this the product development team revisited the design and goals of the contactor. The revised design is shown in Figure 7.

**Figure 7: Mark II – G-REX Resin IX Column**

The main changes made to the design were:

- The goal of treating leached slurries was dropped and a solid-liquid separation unit was incorporated in the process. The column has been proven to process unclarified solution containing up to 1% solids (< 200 µm) for over two years.
- As solids were no longer passing through the column in large quantities, the cone bottom was dropped, and the diaphragm pulse mechanism was relocated from the side to the base of the column. The relocation of the pulse from the significantly reduced vibration in the column structure.
- Screens were changed from a heavy machined 7 mm stainless steel rim, to a circular rim holding polyester woven screens supported by grid mesh. Stainless steel woven screens were dropped after failing before the requisite 1,000,000 cycle fatigue limit.
- The circular screen design allowed them to be removed from two different locations around the column. This improved the maintenance access issues associated with the Mark I design.
- The column supports were improved and jacking bolts increased in size to improve the ergonomics of screen removal.
- Eductor design and motive solution supply were modified to significantly improve the resin transfer rate.
• The dedicated eductor pump was dropped, the discharge sump capacity increased and the discharge pump used for both pressurising the eductor motive solution and removing barren solution.

• A motive solution pressure control loop was incorporated along with other significant improvements to the process control system. This increased reliability and simplified operation.

• The number of absorption stages were increased from 4 to 5. This ensured that 4 contact stages were in contact with feed solution, even during transfer periods.

2.7. MARK II – G-REX

The newer Mark II version of the G-REX column was incorporated into Hoschild’s San Jose project in Southern Argentina and Lihir’s Ballarat Goldfields project in Australia. The photo of the San Jose plant is shown in Figure 8.

Figure 8: Mark II – G-REX Resin Column Circuit – San Jose

The solution feed to both columns are sourced from unclarified thickener overflows containing up to 2% solids. Both applications have proven that the column is robust in handling the feed solutions and reliable in the transfer of resin around the circuit.
3. COLUMN SPECIFICATIONS

The specifications for the G-REX column are listed in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Mark I</th>
<th>Mark II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>5.43</td>
<td>5.02</td>
</tr>
<tr>
<td>Working Height (m)</td>
<td>5.07</td>
<td>4.24</td>
</tr>
<tr>
<td>Volume of each stage (L)</td>
<td>450</td>
<td>385</td>
</tr>
<tr>
<td>Volume of resin in each stage (L)</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Number of stages</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Volume of resin in column (L)</td>
<td>1000</td>
<td>1250</td>
</tr>
<tr>
<td>Au Equivalent Capacity (oz/yr)*</td>
<td>45,000</td>
<td>55,000</td>
</tr>
<tr>
<td>Resin Transfer Time (mins)</td>
<td>150</td>
<td>75</td>
</tr>
<tr>
<td>Strip Cycle Time (hrs)</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Column Flowrate (m3/hr)</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>“             ” (BV/hr)</td>
<td>8.0</td>
<td>10.4</td>
</tr>
<tr>
<td>Downflow velocity (m/hr)</td>
<td>13</td>
<td>20</td>
</tr>
</tbody>
</table>

*Cycle time 8 hrs and 8000 g Au/m³ maximum loading

4. APPLICATIONS

Whilst the G-REX column has been designed principally with AuRIX®100 resin and gold/silver extraction in mind, the column can be used in any ion-exchange application utilising an ion-exchange resin and “dirty” solutions. The column’s design also readily lends itself to other materials of construction such as stainless steel for use in acid environments.

The successful scale-up of the column from the original pilot column has led to provisional designs for a column treating significantly larger volumes of solution and metal loadings. The maximum design to date is a 3.6m diameter column capable of treating 250 m³/h of PLS containing 7m³ or resin.

5. REFERENCES


2. Sandy, A.H., Katsikaros, N. and Fallon, P. 2001“Gold Recovery from Gold Copper Concentrates using the InLine Leach Reactor and AuRixIX®100 Resin”