Acidless Separation: New Technology for Refining Gold and Silver

By Giovanni Faoro, Chief Executive Officer, IKOI Srl

The Acidless Separation® (ALS) project originates from a collaboration between IKOI Srl and Ekaterinburg Non-Ferrous Metals Processing Plant (EZ-OCM). The need for a ‘green’ process for precious metal refiners gave the two companies the idea of developing and patenting a new refining process and a new plant, starting from the process that had been used for many years at EZ-OCM. Over the past two years, IKOI has developed the process and the plant, and now the technology is ready to be used by refiners all over the world.

Background of the refining processes

Refiners currently use several refining processes to refine gold and silver, and in particular to separate these two precious metals. All these processes for separating gold and silver use acids or hazardous chemicals.

The most well-known ‘crude’ process is Metal Chlorination (Miller process), which is applied to a vast range of alloys and is used by many companies. The Miller process has many disadvantages; for example, it requires many structural and regulatory changes to ensure safety, and this entails the need for a major investment to cover the operating costs for the disposal of hazardous materials. The Miller process also entails high operating costs for the treatment of silver chloride. Another disadvantage is the slow recovery of precious metals from the sludge produced by the process.

A second option is to proceed directly with the Electrolysis procedure, but this type of refining process is only advantageous if the input gold alloy contains at least 80% to 85% of gold, otherwise the direct electrolysis procedure can prove very time consuming.

If the gold alloy does not contain the right proportions of gold and silver, then more silver needs to be added to obtain the optimum composition of the gold alloy. Electrolysis, like the Miller process, also incurs high operating costs for the disposal of hazardous materials and involves long precious metal recovery times, in this case, not from the sludge but from the solutions and the anodes.

The final process that we wish to analyse is Dissolution-Precipitation, such as in the process with aqua regia, which has the same disadvantages as the Electrolysis process except that the significant investment in metals is not necessary for this process.

The main advantage of Acidless Separation® (ALS) over the processes discussed above is its ‘green’ philosophy. In fact, ALS requires no chemicals, for example acids, chlorine or other hazardous materials, and it has zero emissions. Another advantage of this technology is its universal application, as the ALS process removes the limitations imposed by the composition of the input alloy.

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The Acidless Separation® machine is also quick and easy to use. It is a fully automatic process and is based on three operations, resulting in a reduction in labour and production costs. This is due to lower energy consumption and also the fact that not only are the precious metal recovery times considerably shorter, but there is also a saving on the costs of managing hazardous materials, which are not required by the ALS process. This process is also safer for staff and the environment.
as well as generating a high yield and a rapid return on investment.

History of the collaboration agreement

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This idea originated from the fact that all the refining methods adopted across the world require the use of hazardous materials. The difference and advantage of the new process over the more established processes is that the process is based on the different degrees of volatility of the materials and therefore requires no chemical additives such as acids or other hazardous materials. Instead the ALS process separates the metals through sublimation of the more volatile metals (e.g. silver, zinc, lead and selenium), and thus allows these metals to be separated from the alloy through distillation and captured in a water-cooled collector.

EZ-OCM has used equipment based on these physical principles since the early 1990s. In 2013, EZ-OCM found the collaborator suitable for developing this technology. IKOI is one of the industry leaders in terms of the research and development of innovative technologies for the heat treatment of precious metals. The collaboration agreement is based on the fact that EZ-OCM manages the raw materials for the tests and analyses the results of the tests, while IKOI undertakes the research and development, design and construction of plants, marketing, sales and after-sales service.

Research & development

Over the past two years, IKOI, with the collaboration of EZ-OCM, has designed and produced some ALS machines. The first step for IKOI was to study and analyse the correlation between the pressure and temperature necessary for the sublimation of the materials. Once IKOI had determined the temperatures and degrees of vacuum that were necessary for the heat treatment of precious metals, EZ-OCM provided its first prototype based in part on the machine already in use in the EZ-OCM plants since the 1990s.

A typical ALS plant consists of:
- A vacuum chamber with a maximum degree of vacuum of ~1x10^{-4} mbar;
- Two condensers (this technology is protected by a global patent): one for the more volatile materials and the other for silver, which is used to collect evaporated metals;
- One melting head.
- An IGBT power generator;
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- One melting head.

The first series of tests was carried out at IKOI with a copper-silver alloy used for the similar vapour tension between copper and gold, as can be seen in Chart 1 above. Other tests were carried out with a three-component alloy using two condensers. This series of tests was carried out to check the movement of the crucible from the first condenser for the more volatile materials (such as zinc, lead and selenium) to the second condenser for the materials with an average degree of volatility (such as silver), while the less volatile materials (such as gold) remained inside the crucible.

When the Research and Development team at IKOI decided that the machine was ready to operate with a real gold alloy, IKOI sent the prototype to EZ-OCM, as stipulated in the collaboration agreement and, at this point, another series of tests began at its plants. These tests, which were followed by the Research and Development team at IKOI, identified the improvements to the machine that were necessary to make the operations performed at a refinery easier for the staff to undertake.

Results of the tests

We shall now explain the results of the first two series of tests. The first series of tests was carried out using one condenser only, while the second series of tests was carried out using two condensers.

The table below (see Table 1) shows the average initial composition of the gold alloys used for the two series of tests. After a few tests with the ALS technology, the results of the first series of tests (average values) only presented ~3% of silver in the block of gold that remained in the crucible, while the sublimated silver contained ~3% of gold.

The second series of tests using the ALS machine on a complex gold alloy gave surprising results:
- All the impurities (zinc, selenium and lead) in the first condenser were sublimated;
- The second condenser contained ~96.5% of silver and only ~2% of gold;
- The block that remained in the crucible had a purity of about 90% of gold, with ~5% of copper and another ~5% of silver.

Table 1: Composition of the two alloys of the first two series of tests

<table>
<thead>
<tr>
<th>Alloy name</th>
<th>Weight g</th>
<th>Composition %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input raw material Au50/Ag35/Zn6/Se3/Pb3/Cu3</td>
<td>24,796.3</td>
<td>59.75, 28.32, 11.93</td>
</tr>
<tr>
<td>Block remained into the crucible (mainly Gold)</td>
<td>17,788.4</td>
<td>82.14, 3.61, 14.26</td>
</tr>
<tr>
<td>Material recovered from the condenser (mainly Silver)</td>
<td>6,980.6</td>
<td>2.91, 91.10, 5.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alloy name</th>
<th>Weight g</th>
<th>Composition %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input raw material Au60/Ag30/Cu10</td>
<td>21,084.6</td>
<td>48.70, 35.60, 6.00, 3.60, 3.40, 2.70</td>
</tr>
<tr>
<td>Block remained into the crucible (mainly Gold)</td>
<td>4,230.4</td>
<td>89.8, 5.3, &lt; 0.1, &lt; 0.1, &lt; 0.1, 4.9</td>
</tr>
<tr>
<td>Material recovered from the condenser 1</td>
<td>1,084.6</td>
<td>0.05, 13.55, 40.6, 23.2, 23.7, 0.03</td>
</tr>
<tr>
<td>Material recovered from the condenser 2 (mainly Silver)</td>
<td>2,424.1</td>
<td>0.23, 99.7, &lt; 0.1, &lt; 0.1, &lt; 0.1, 0.07</td>
</tr>
</tbody>
</table>
The zinc, selenium and lead are made to sublimate at a high pressure simply by increasing the temperature. After the transfer from the first to the second condenser, the pressure decreases in order to make the silver sublimate in the second condenser (purity of about 98%) and figure 5c illustrates the silver which is captured in the second condenser. The silver which is captured in the second condenser is measured using a load cell. The transfer from the first to the second condenser is automatic and is set by the operator at the start of the process. This happens when the more volatile materials have sublimated completely and have been captured in the first condenser. The operator will know when this happens on the basis of the initial composition of the gold alloy and its internal weight.

The Acidless Separation® process and plant can be designed and implemented with the right shape of condensers, the right power and some other special features suited to the refiner’s alloys. By knowing the composition of the gold alloy and on the basis of the results of the tests, the specific OPEX values of each refiner can be calculated.

Marketing programme

For refineries interested in this process, some tests can be carried out using their own gold alloys. On the basis of the results obtained from the tests and the refiner’s alloys, the ALS process and ALS plant can be designed and implemented with the right shape of condensers, the right power and some other special features suited to the refiner’s alloys. The Acidless Separation® process and plant are protected by a global patent.