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Optimization of Acid Wash Process on Activated Carbon with Variation of HCL Concentration at PT XYZ

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Abstract

The acid wash process is used as a unit operation in the gold adsorption route with the primary objective of removing calcium carbonate, magnesium, and sodium salts from gold-rich carbon surfaces. In general, the use of HCl with an initial concentration of 3% (w/v) and immersion for 1 hour with 1 bed volume of acid can achieve calcium removal of more than 95% from the carbon surface. This research involved reducing the HCl concentration from 3% to varying concentrations between 1%, 1.25%, 1.5%, 1.75%, 2%, 2.25%, 2.5%, and 2.75% with the aim is to optimize the use of HCl and increase economic efficiency in the acid wash process. Analysis of carbon activity data shows that the acid wash process does not have a significant effect on carbon reactivation. The research method involves collecting activated carbon samples in three types, namely Loaded Carbon (LC), Carbon After Wash (CAW), and Barren Carbon (BC). The samples were then analyzed using the Carbon hardness test to evaluate the level of impurities on the carbon surface, as well as the Carbon activity test to measure carbon absorption activity. Data on gold and silver recovery results was also collected from the elution process. The research results show that an HCl concentration of 2% provides optimal effectiveness in acid wash. At this concentration, desorption results were achieved that met the ADR KPI, confirming that acid wash did not significantly affect the gold desorption process. In addition, the acid wash efficiency at a concentration of 2% is close to the baseline value, indicating a good ability to clean carbon from impurities. In the context of this study, acid washing has been proven to be an effective method for cleaning activated carbon for gold adsorption. These findings provide an important contribution to improving the efficiency and quality of the gold absorption process.

Keywords: acid wash; HCl; calcium carbonat; carbon hardness test; carbon activity test

Introduction

Gold is a precious metal that is widely used and has an important role in human life. Gold is included in the class of precious metals because it is rare on earth and has

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certain specific properties (Aminah, Suparno, dan Haeruddin 2022). Nowadays, we could recover gold from various ores or industrial waste, for example waste electrical and electronic equipment (WEEE, also called e-waste) containing highly valuable materials (Cui dan Zhang 2008). To meet the needs of gold, various methodologies were used in the leaching of gold from some concentrates, such as physical and mechanical separation technology, pyrometallurgical method, hydrometallurgical processing, bio-technology, microwave treatment and supercritical fluid technology (Ma, Li, dan Liu 2015).

The method used for processing in the Seven Hills Project PT XYZ is Hydrometallurgy via Heap Leach, was chosen because it has advantages in terms of economic efficiency because it is able to extract various types of low grade ore (Ghorbani, Franzidis, dan Petersen 2016). A heap is a constructed pile of crushed, and in most cases agglomerated, rock material built on an impermeable under-liner fitted with a solution collection system (Petersen 2016).

The metal-rich pregnant leach solution (often termed PLS or simply the preg) is then collected by gravity and sent to a process facility for recovery of the metal values (Pyper et al. 2019). Activated carbon is the most widely used adsorbent available today(De Gisi et al. 2016). The adsorption process is carried out using the Carbon in Column (CIC) method which is one off common Activated Carbon (AC)-based technologies for the gold cyanide recovery (Salehi, Yarali, dan Ebadi Amooghin 2020). Activated carbon is a highly promising adsorbent material characterized by a large specific surface area, high porosity, high pore volume, and adjustable surface properties in morphology and functional groups (Mariana et al. 2021).

Activated carbon can be made from various materials such as palm shells, sugar cane bagasse (Suliestyah, Tuheteru, dan Hartami 2018), almond skins, hazelnuts, olive kernels, apricots, peaches, and coal (Cuhadaroglu dan Uygun 2008). The most common sources of activated carbon on a commercial scale are wood, anthracite and bitumen charcoal, lignite, peat shells and coconut. The carbon content of these materials ranges from 40 to 90% (wt.), with a density s several factors that influence this adsorption ability. One of them is the inappropriate absorption of organic or inorganic substances by activated carbon during the process. The organic substances in question include Flotation Reagents, Oils, Humic and Fulvic Acids originating from plant materials, and so on. Meanwhile, the inorganic substances absorbed by activated carbon fall into two categories; basic metal cyanide which is also adsorbed (such as: $Cu(CN)^{-}_{2}$, $Hg(CN)^{-}_{2}$, $Ni(CN)^{-}_{2}$) and the formation of scale on activated carbon. The adsorption process using Activated Carbon (AC) based technology provides conditions that encourage the formation of calcium scale, the most common of which is $CaCO_3$ (calcium carbonate). Calcium is present due to the addition of lime to control pH (lime concentration is generally around 200 g/t). Such inappropriate absorption can harm carbon adsorption activity by reducing its activity. Impurities precipitate or adsorb carbon, filling pores that would otherwise be available for gold adsorption, and can block the flow of solution

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through the carbon during adsorption and desorption processes. Impurities can also affect the composition of the eluate if they are absorbed during the elution stage (Rogans 2012).

The acid wash process is used as an operating unit in the gold adsorption route, mainly to remove calcium carbonate, magnesium, and sodium salts from the carbon-rich gold surfaces. Generally, the use of 3% HCl (b/v) and immersion for 1 hour with 1 bed acid volume can more than 95% calcium removal from the carbon surface. In the acid wash process, HCl was used with an initial concentration of 3%. In this study, reductions in HCl concentrations were made to 1%, 1,25%, 1,5%, 1,75%, 2%, 2,25%, 2,5% and 2,75% with the aim of optimizing HCl usage and improving economic efficiency in acid wash.

Research Methods

The sampling process is done by dividing it into three different types of carbon. The first sample was Loaded carbon (LC), which is carbon that has been adsorbed with gold. The second sample is Carbon after wash (CAW), a carbon rich in gold that has undergone a washing process. The final carbon sample is Barren carbon (BC), which is carbon that has gone through an elution process or re-release of gold.

In the analysis of samples, two different methods are used. The first method is the Carbon activity test, which is used for a BC carbon sample to determine the level of activity or absorption of the carbon. The second method is a Carbon hardness test, used for LC and CAW samples to find the concentration of residues stagnant on the surface and the pores of carbon. Through this method, it can be known to what extent the adsorber affects the quality of carbon in the gold adsorption process. Flow diagram on this research can be seen on Figure 1 below.

As for the data observed in the carbon test, together with the data of the emission results and the cost will be described in detail as follows;

a. Carbon hardness test

It is an inorganic detector data that is absorbed into the pores of active carbon and forms a scale that can affect the adsorption process, there are two samples used for this method first loaded carbon which is active carbon which will be carried out acid wash process to remove the detector that is being absorbed, second is carbon after wash which is carbon that has passed the acid Wash process before going to the elution process.

b. Carbon activity test

Data showing the ability of activated carbon to bind the gold ions that will then be released back to gold in the elusion process, the sample used here is a barren carbon (BC) sample BC is a carbon after elusion.

c. Desorption Result

Data that shows the desorption results of the elusion process where samples are taken before entering the elution process (LC) and after passing through elusion (BC) to

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determine the recovery of gold that can be taken and removed from carbon. The carbon used is loaded carbon and barren carbon. According to KPI for all ADR sections

d. Cost

The cost is required for one intermediate bulk container (IBC) of HCl with a concentration of 32% and weighing 1100kg.

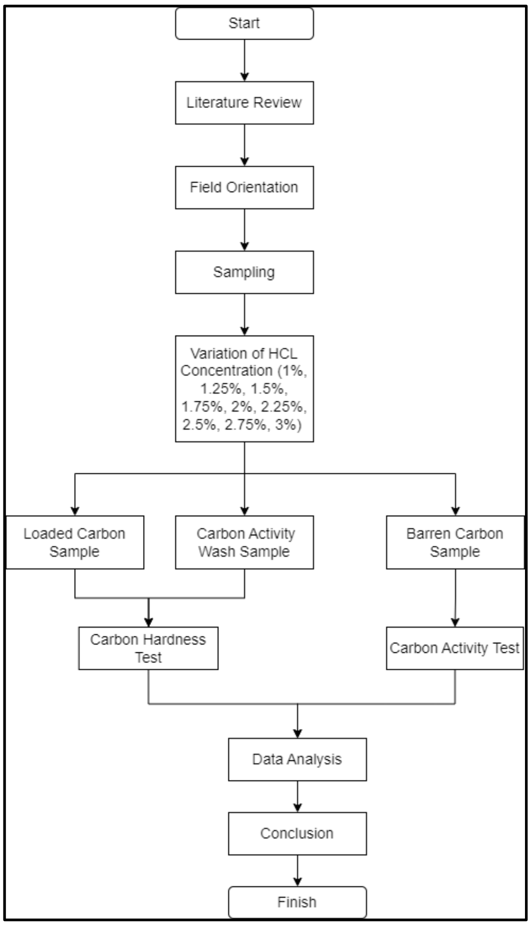

Figure 1 Research flow diagram
Source: obtained from primary data, (2023)

Result and Discussion

Results of Research

The data used to determine acid wash efficiency is obtained through the carbon hardness test, while data regarding absorption capacity can be observed through the results of the carbon activity test. Apart from that, there is data regarding gold and silver recovery which is based on the results of the elution process. Finally, there is also cost benefit analysis data obtained from cost data for each variation in HCl concentration.

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1) Acid Wash Efficiency

It can be seen in Figure 2, that at a HCl concentration of 3% (baseline) the highest efficiency was 57.74%, while the lowest efficiency was obtained at a HCl concentration of 1% with an efficiency of 43.98%.

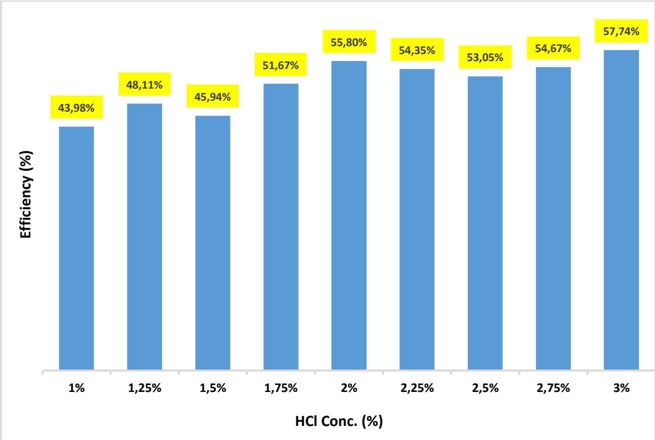

Figure 2 Acid wash efficiency
Source: obtained from primary data, (2023)

1) Carbon Activity

Based on the figure 3, it shows that the highest absorption capacity was obtained at a HCl concentration of 3% (baseline) with an absorption capacity of 31.37%, while the lowest absorption capacity was obtained at an HCl concentration of 1.25% with an absorption capacity of 22.92%.

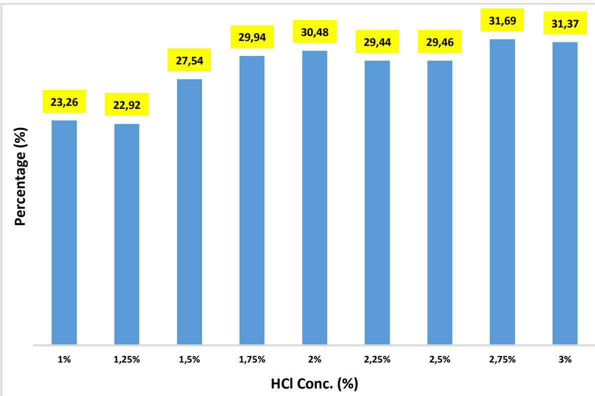

Figure 3 Carbon adsorption activity
Source: obtained from primary data, (2023)

2) Au and Ag Recovery

Based on the figure 4, the gold and silver recovery that has undergone variations in HCl concentration tends to fluctuate and is unstable, the highest gold recovery was

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obtained at an HCl concentration of 2.25% and the highest silver recovery was obtained at an HCl concentration of 1.75%.

3) Cost Benefit

Based on the table 1, it can be seen that the costs required for each variation of HCl concentration are obtained with the highest costs obtained at a HCl concentration of 3% and the lowest costs obtained at a HCl concentration of 1%.

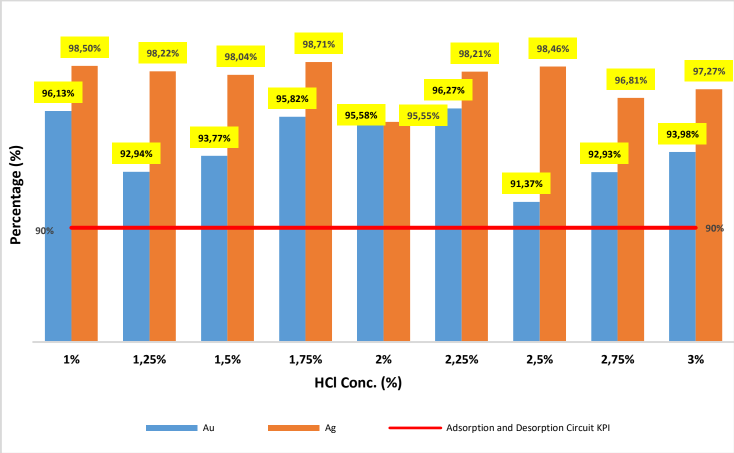

Figure 4 Au and Ag Recovery
Source: obtained from primary data, (2023)

Table 1 Costs for each HCL variation

% HCl	*HCl Flow (m3/hr)*	*HCl Consumption (m3)*	*HCl Consumption (ton)*	*Cost (USD)*
1%	0,56	0,28	0,32	94,68
1,25%	0,70	0,35	0,40	118,35
1,5%	0,84	0,42	0,49	142,02
1,75%	0,98	0,49	0,57	165,69
2%	1,13	0,56	0,65	189,36
2,25%	1,27	0,63	0,73	213,03
2,5%	1,41	0,70	0,81	236,70
2,75%	1,55	0,77	0,89	260,37
3%	1,69	0,84	0,97	284,04

Source: obtained from primary data, (2023)

Discussion

1) Acid Wash Efficiency on Adsorption and Desorption

Based on the data that has been collected and processed, it can be observed that

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the desorption aspect is maintained. This can be seen in Figure 4, where the recovery of Au and Ag is not affected by variations in HCl concentration. Even though at 1% HCl concentration there was a higher recovery compared to 3% HCl concentration (baseline), variations in HCl concentration overall did not have a significant effect on desorption. Furthermore, variations in HCl concentration also do not interfere with the desorption process which can be seen in Figure 4, where each variation in HCl concentration still reaches the ADR KPI with a minimum Au and Ag recovery of 90%.

The effect of acid wash efficiency on adsorption can be observed in Figure 2, the absorption capacity at varying HCl concentrations reaches a constant point at HCl concentrations of 1.75% to 3%, while at HCl concentrations of 1% to 1.5% there is a significant decrease, this is in accordance with journal on Metalliferous Mining (2010), where the higher the concentration of HCl, the higher the absorption capacity of carbon because according to collision theory the higher the concentration of HCl, the higher the content of HCl ions which have a greater possibility of colliding with Ca ions, Ca here it acts as an impurity in the form of crust on the pores and carbon surface which can inhibit the adsorption process (Forson, Adam, dan Sarpong 2018).

2) Cost Benefit Analysis

The results showed that an HCl concentration of 2% was proven to be the most optimal concentration in the tested context. In this concentration, there are several benefits that can be obtained. First, the desorption results still meet the ADR KPI, showing the effectiveness of the acid wash process in returning gold and silver to solution. In addition, the acid wash efficiency at a concentration of 2% is close to the baseline value, indicating a good ability to clean carbon from impurities.

Even more interesting, if there is a reduction in HCl concentration from 3% to 2%, there is potential for cost savings of 33.33% in one stripping. This suggests that the use of lower HCl concentrations can provide significant economic benefits without compromising process performance. Therefore, it is recommended to consider the use of 2% HCl concentration as an optimal choice in wider operational practices to achieve efficient and economical results in the acid wash process.

Conclusion

Through data analysis and results obtained from a series of research that has been carried out, there are several conclusions that can be drawn as follows:

1. Based on carbon activity data, it is shown that the acid wash process does not have a significant effect on carbon reactivation.
2. In the desorption result data, it was revealed that the acid wash process did not have a significant influence on the Au and Ag recovery which still reached the ADR KPI.
3. At a HCl concentration of 2%, it can be seen that there is the best efficiency compared to variations in concentrations lower than the baseline (HCl 3%). However, at concentrations below 2%, especially between 1 to 1.75%, a significant decrease in

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efficiency occurs, indicating that lower HCl concentrations are not effective in achieving the desired results.

An HCl concentration of 2% was proven to be the optimal concentration in the tested context based on the research results. In this concentration, there are several benefits that can be obtained. The success in achieving desorption results that still meet the ADR KPI confirms that the acid wash process does not have a significant influence on the desorption process. In addition, the acid wash efficiency at a concentration of 2% is close to the baseline value, indicating good ability to clean carbon from impurities.

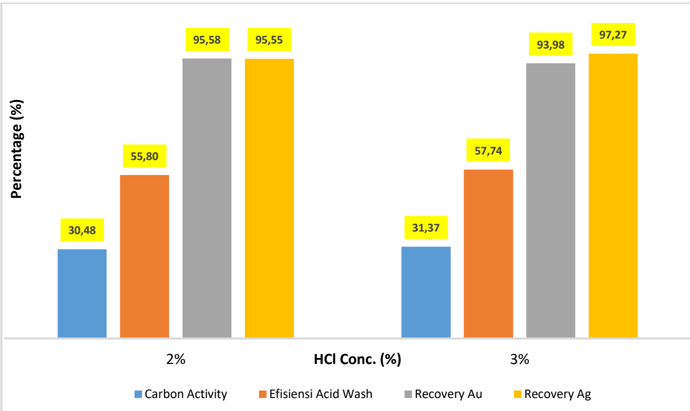

Figure 5 Comparation between HCL 3% with HCL 2%
Source: obtained from primary data, (2023)

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