Flocculant-assisted Vanadium Removal: Enhancing Purity and Economic Recovery

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Abstract

Vanadium is an undesirable impurity in the Bayer process, as it can negatively affect alumina quality and processing efficiency. Its removal is crucial for maintaining product purity and optimizing Bayer process performance. If not properly managed, vanadium can lead to operational inefficiencies, increased maintenance costs, and impact on final alumina quality. One effective method for vanadium extraction involves precipitating vanadium compounds from spent Bayer liquor through controlled cooling. This process promotes the formation of vanadium-containing crystals, which can then be separated from the liquor.

To enhance the recovery of these precipitated vanadium crystals, the use of a dedicated flocculant can significantly improve solid-liquid separation, increasing process efficiency and yield. This approach not only reduces vanadium contamination in alumina production but also presents an economic opportunity. Vanadium is a valuable metal used in high-strength alloys, catalysts, and energy storage applications, making its recovery financially attractive. By integrating a flocculant-assisted precipitation process, refineries can improve both environmental sustainability and profitability.

Experimental results indicate that this method enhances vanadium crystal sedimentation, facilitating efficient extraction and minimizing losses. Additionally, the implementation of such a strategy aligns with industry trends toward resource valorisation and waste minimization. These findings highlight the dual benefits of impurity removal and the recovery of valuable by-products, reinforcing the importance of advanced separation techniques in modern Bayer process operations.

Keywords: Vanadium, Flocculant, Impurities, Spend liquor.

1. Introduction

1.1 Vanadium Stakes

Vanadium is a strategically important metal due to its unique properties and wide industrial applications. It is primarily used in steel alloys for industries such as aerospace, automotive, and construction. Vanadium also plays a crucial role in vanadium redox flow batteries (VRBs), which are crucial for large-scale renewable energy storage and energy transition. Its scarcity and geographically concentrated supply make vanadium a critical resource for industrial and technological security. With growing demand and limited primary resources, recovering vanadium from secondary sources, such as processes like Bayer, is an important economic and environmental challenge [1, 2].

1.2 Vanadium Extraction from Bayer Process

In the Bayer process, vanadium originates from bauxite impurities and dissolves as vanadates in the caustic liquor during digestion. After alumina extraction, vanadium remains in the spent liquor, where it can be recovered through precipitation, ion exchange, or solvent extraction. This recovery prevents contamination of the process and allows vanadium to be used in industrial applications. The efficiency of extraction depends on factors like pH, temperature, and the presence of other metal ions [3].

The most cost-effective and efficient method for recovering vanadate from Bayer liquor involves cooling a portion of the spent liquor to below 60°C before reintroducing it into the digestion process. This cooling step promotes the precipitation of vanadium compounds, which are then extracted from the solution. The solid vanadium compounds can be separated from the remaining liquor using well-established liquid/solid separation techniques, such as flocculation.

1.3 Vanadium Crystallization Process

The spent process liquor (SPL) is introduced into the evaporation system at 64 °C. After evaporation, its temperature decreases to 48 °C before entering a plate heat exchanger, where it is further cooled to 38 °C. The cooled SPL is then transferred to large conical tanks for a holding time of up to seven hours, allowing vanadium to crystallize and settle in the underflow (U/F). The crystallized vanadium is subsequently separated by centrifugation (see Figure 1), yielding a dry product containing up to 18 % vanadium by total mass. The final product is then stored in bags for dispatch.

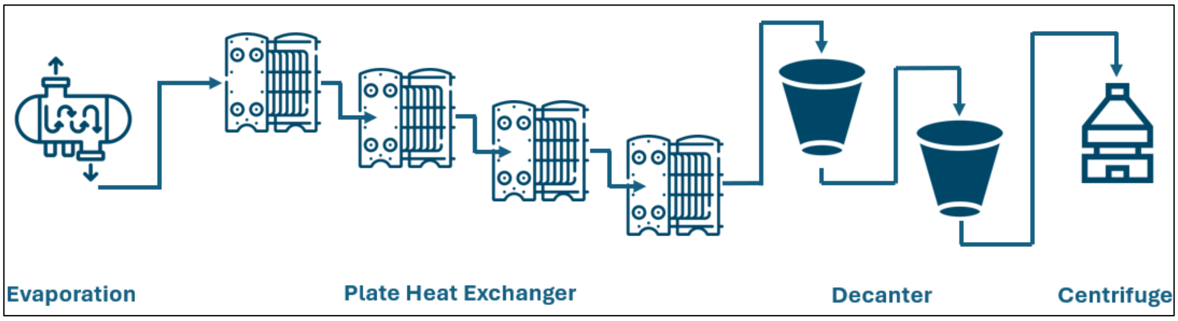

Figure 1. Schematic process of vanadium recovery from spent liquor.

In addition to vanadium, primarily present in the form of vanadate, the slurry also contains significant amounts of alumina hydrate, which constitutes the main solid phase in suspension.

2. Materials and Method

2.1 Materials

2.1.1 Chemicals

The vanadium flocculant used in this paper consists of polysaccharide molecules, manufactured by SNF SA through an innovative proprietary enzymatic process, under the name Flomin ALX NGP. This innovative process is successfully implemented, at industrial and commercial scale, Finally, in the studied case, the use of Flomin ALX NGP results in an approximate 2 % increase in overall gains. In other words, for every 1 USD spent on Dextran, a return of 2 USD is achieved.

6. Conclusions

In conclusion, this study demonstrates that the recovery of vanadium from spent liquor is a straightforward, economically viable, and sustainable approach to improving industrial resource efficiency. The findings highlight that the method enhances process performance, reduces vanadium losses, and increases the value of the recovered product – ultimately contributing to greater sustainability.

Laboratory results show that the use of the SNF Dextran product improves vanadium slurry purity by 15 % and increases economic recovery by 3.1 % compared to the 2023 baseline. These improvements clearly support the implementation of flocculant-assisted vanadium removal to boost both process efficiency and profitability.

From a financial perspective, for every single USD invested in the SNF Dextran product, the process delivers a return of 2 USD, making a strong business case for its adoption in vanadium recovery operations.

7. References

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