REDUCING ENVIRONMENTAL FOOTPRINT OF FILTERS IN BAYER PROCESS: TRIALS OF USED BAGS RECYCLING

Parent L[1], Tremblay Y[1*]

[1]*Mining and Refining Segment, Sefar, Quebec, Canada*

Abstract

Polypropylene filter bags are used in Bayer process for security filtration. The bags service life depends of operational conditions but in all cases they have to be replaced periodically when the targeted filter flow cannot be reached anymore. After use, the polypropylene fabric is covered with a hard scale and must be disposed. Each year, an alumina plant produces many tons of used bags as a waste. In order to reduce the environmental footprint of used bags, recycling attempts have been made. It is necessary to go through some steps before getting a clean polymer able to be re-used. However even if after processing the polymer can be re-used for some applications, it cannot be used to remake new bags. The economics of the different applications shows that recycling is a possible solution only in countries where the cost disposal is high.

1. Introduction

Polypropylene filter bags are used in Bayer process for security filtration. The service life of the bags depends of operational conditions, but in all cases, they have to be replaced periodically when the targeted filter flow cannot be reached anymore. There are two main reasons why bags require replacement in this service:

1 Scale build up on the material used to construct the bags causes plugging which results in the loss in flow rate.
2 Bags also periodically require changing simply due to the abrasive nature of the application causing erosion of the material making up the bags.

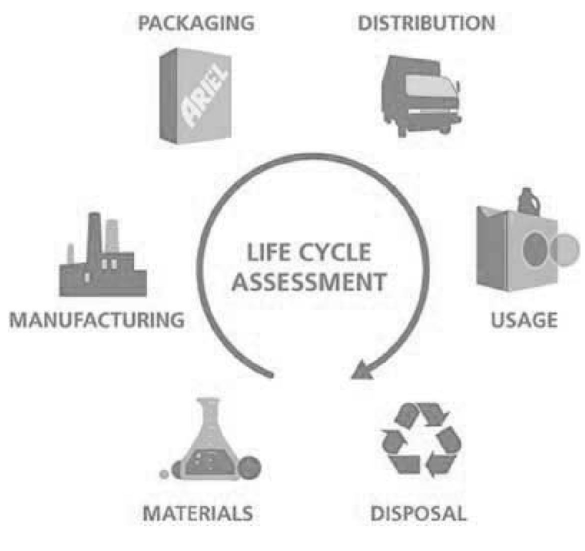
After use, the polypropylene fabric making up the filter bags is covered with a hard scale. These scale encrusted bags must be disposed of in an environmentally responsible manner. Each year, a single alumina plant produces several tons of used bags as waste.

A typical 1.5 million ton per year alumina plant uses about 12 tons of spent bags per year. This is only considering the weight of the bags themselves. Based on typical Kelly bags, this would represent XX square kilometers of material.

The cost of the polypropylene material that is used in a typical Kelly bag is about 20%. Thus the plant referenced above that uses 5000 bags a year, is also using $100,000 USD of polypropylene a year.

Over the years, monofilament fabrics have replaced other alternatives as they have been proven to better resist scale formation and provide good abrasive resistance. In addition, efforts are ongoing to review the reasons for scale formation on the bags and to develop ways to retard this from happening. Greater abrasion resistance is also being investigated. However, even with good advances in this area, bags will continue to be used in alumina production for the foreseeable future. Given the general strength and resistance to decomposition inherent in polypropylene these bags represent an ongoing environmental problem.

Oil is used to construct polypropylene, thus, like any petroleum based product we should take care to use it in an efficient manner. As "going green" is a political drive that will likely affect all industries; this issue is of heightened importance today. Further, the concept of "Product Life Cycle Assessment" is now becoming the norm in the world. Consider the fact that computer manufacturers need to be cognizant of how their screens will be disposed of. Battery manufactures and aluminum can manufacturers have been dealing with this issue for years. The chart on the right illustrates this point:



Reference (1)

In order to reduce the environmental footprint of used bags, it is necessary to consider recycling. The goal of this presentation is to describe the problem in detail, review the efforts made to consider recycling and to describe the conclusions reached.

2. Description of the problem

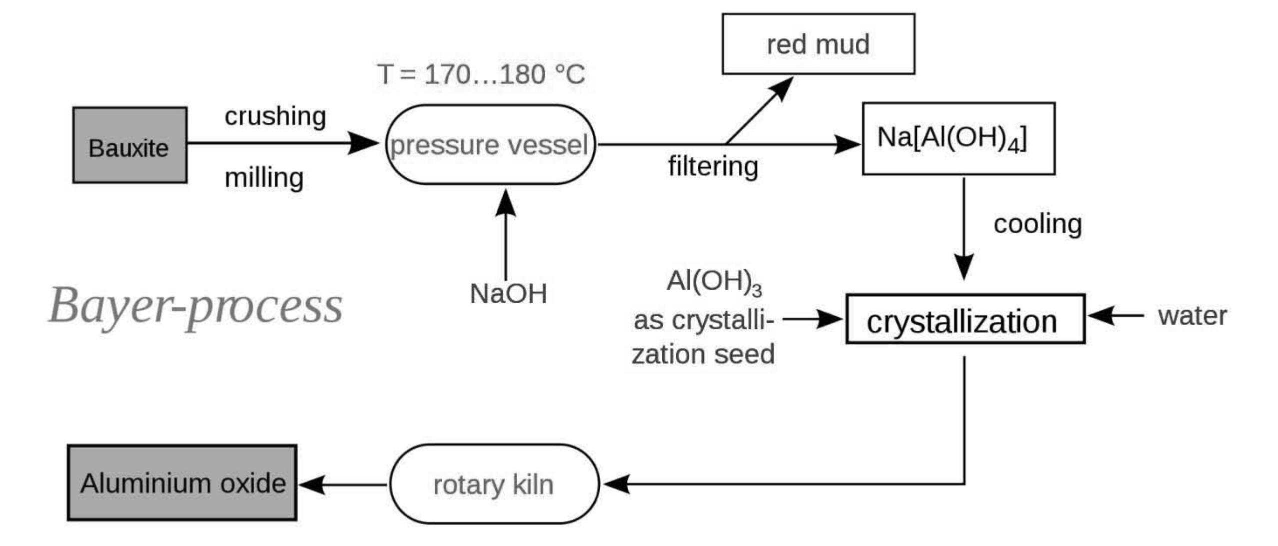
The Bayer process is the principal industrial means of refining bauxite to produce alumina (aluminum oxide).

Bauxite, the most important ore of aluminum, contains only 30–54% alumina, Al2O3, the rest being a mixture of silica, various iron oxides, and titanium dioxide. The alumina must be purified before it can be refined to aluminum metal. In the Bayer process, bauxite is digested by washing with a hot solution of sodium hydroxide, NaOH. This converts the alumina to aluminum hydroxide, Al(OH)3, which dissolves in the hydroxide solution according to the chemical equation:

$Al_2O_3 + 2\ OH^- + 3\ H_2O \rightarrow 2\ [Al(OH)_4]^-$

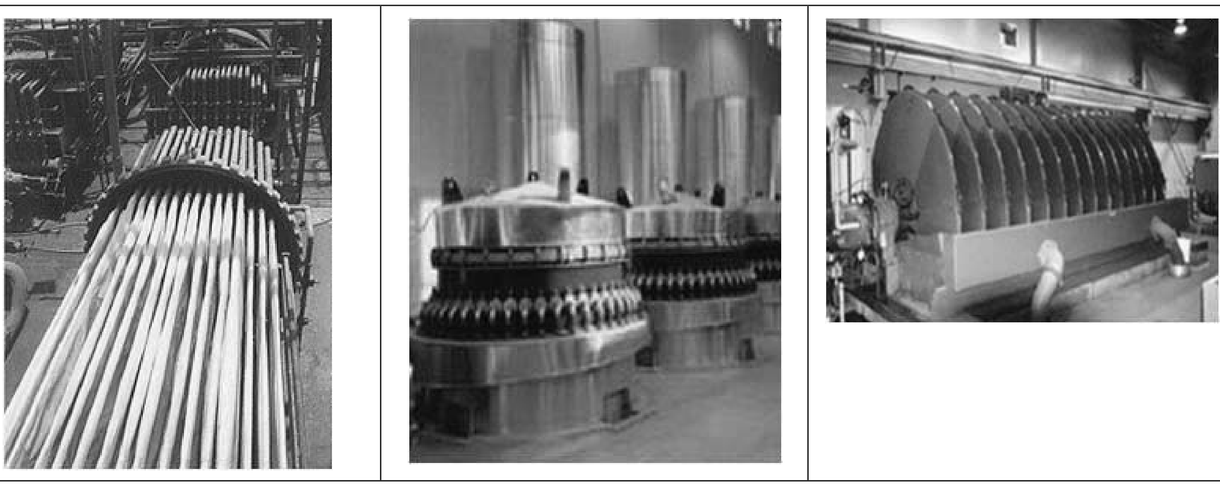
The other components of bauxite do not dissolve. The solution is clarified by filtering off the solid impurities. The mixture of solid impurities is called red mud, and presents a disposal problem. Next, the hydroxide solution is cooled, and the dissolved aluminum hydroxide precipitates as a white, fluffy solid. Then, when heated (calcined), the aluminum hydroxide decomposes to alumina, giving off water vapor in the process:

$2\ Al(OH)_3 \rightarrow Al_2O_3 + 3\ H_2O$



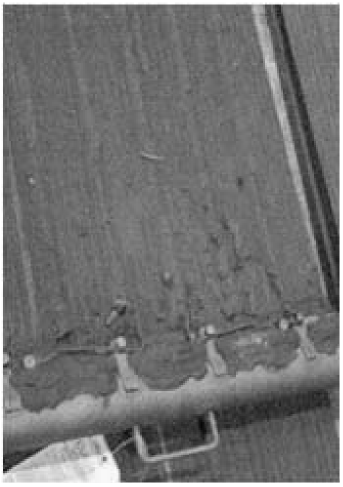
Reference (2)

In general filter designs using high surface area are used to remove red mud. These include Kelly, Diastar and rotary disk filters.



In all cases, polypropylene filter cloth is used as the primary barrier for filtration. These cloths are affixed to frames that provide a support and drainage structure.

Used Kelly Filter Cloth



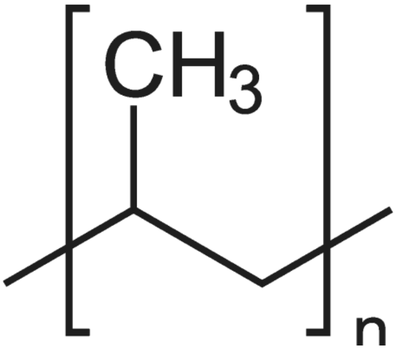
Rotary disk for seed filtration

Spent polypropylene cloths are removed when service life is reached and must be disposed of. Due to the large surface area and great number of cloths used, the disposal of these cloths is an issue. Also, the environmental carbon footprint and the political benefits of showing efforts to "going green" should be factored. Finally the concept of "Product Life Cycle Assessment" for this material needs to be considered.

3. Considering recycling

Polypropylene is a thermoplastic polymer used in a wide variety of applications including packaging, textiles, stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. It is rugged and unusually resistant to many chemical solvents, bases and acids.

In 2007, the global market for polypropylene had a volume of 45.1 million tons, which led to a turnover of about $65 billion USD. Reference (3)



Polypropylene is used as the material of choice for the construction of filters that are used for red mud filtration. This plastic is inexpensive, has great compatibility for the application, is widely used in the world and can be extruded into the monofilament fibers that are best used for manufacturing filtration fabrics.

To recycle the polypropylene, it is first necessary to remove the scale from the individual fibers of polypropylene. It is important to note that the scale as shown in this electron microscope picture is not infiltrating into the fiber itself.

Rather it is maintained on the surface of the plastic. Thus we have found that it can be removed using the following processes:

Step 1:

The spent bags are ground to help remove the scale and separate the polypropylene material. This also creates a product that can be separated.

As can be seen in the photo to the right, the polypropylene fibers and material pieces are clearly visible and the red mud is ground to a fine product.

Step 2:

Vibratory separation is used to allow the red mud to pass through a vibrating screen. This traps the polypropylene on top so it can be collected. Washing and slurring the remaining mud can be done to further clean the polypropylene material.

4. Conclusions

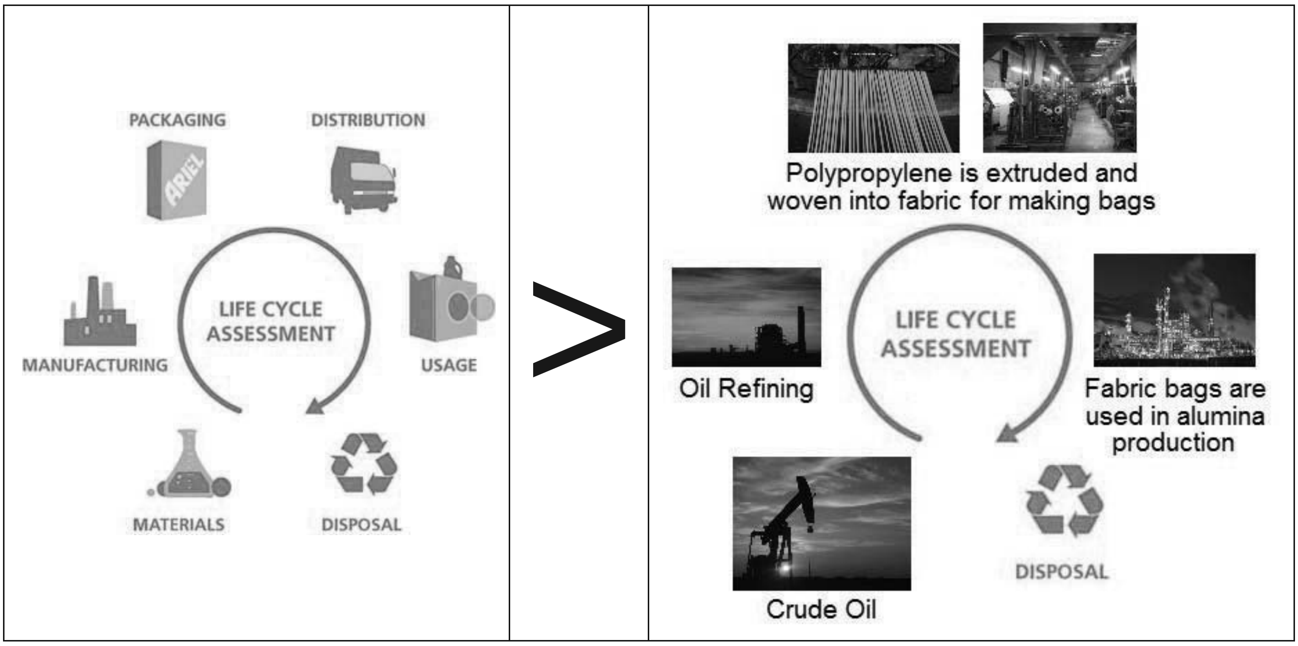
The process of recycling polypropylene is relatively simple and there are many uses for recycled polypropylene. The SPI resin identification coding system is a set of symbols placed on plastics to identify the polymer type. It was developed by the Society of the Plastics Industry (SPI) in 1988, and is used internationally. The primary purpose of the codes is to allow efficient separation of different polymer types for recycling. Polypropylene has been given the designation 5 and is well understood as a plastic that can be recycled and reused.

It is important to note that for filtration applications, typically "virgin" polypropylene is used thus recycled Polypropylene would not generally be used for filtration purposes. However, non critical applications such as buckets, carpet, cement additives and road construction etc would be a target for this material. Most industrialized nations have processes in place to take and reuse spent polypropylene.

By recycling the spent polypropylene that is used every year in the alumina industry XXX tons of polypropylene can be reused. This represents a tremendous untapped potential for "going green" that can benefit the alumina industry both financially and politically. Our dependence in oil also makes this a target for savings and political pressure.

The picture on the left shows polypropylene that has been recycled. Often this polypropylene is not white or clear and will be used as a filler material for other plastics and products that can benefit from its physical characteristics.

As mentioned earlier, the concept of "Product Life Cycle Assessment" is fast becoming a reality and sometimes law in many countries. This can be summarized as, "we own all waste that we produce and are responsible to disposed of it in a legal and ethical manner." If we look at the concept of "Product Life Cycle Assessment" diagram and translate it into what it might look like for the alumina industry and polypropylene waste, we see the following:



Today, aluminum can recycling is seen as a responsibility of the consumers. "The average aluminum can contains 40 percent postconsumer recycled aluminum. Recovering aluminum for recycling saves money and dramatically reduces energy consumption." Reference (4)

Today spent polypropylene represents an ongoing waste stream that is generated while processing alumina. It is not readily biodegradable and will be around for many years to come.

In the case of aluminum cans, the burden for completing the "Product Life Cycle Assessment" rests in the hands of the final consumer.

As a final question: Who do you feel will be tasked with completing the "Product Life Cycle Assessment" with regard to polypropylene waste in the alumina industry?

References

1. http://www.pgbeautygroomingscience.com/Sustainability.html
2. This is a retouched picture, which means that it has been digitally altered from its original version. Modifications: translated to English. The original can be viewed here: Bayer-Verfahren.svg. Modifications made by Hans Erren.
3. "Market Study: Polypropylene". Ceresana Research.
4. http://www.solidwastedistrict.com/stats/aluminum.html