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RECOVERING ALUMINUM FROM USED BEVERAGE CANS – THE DILEMMA OF 900,000 ANNUAL TONS

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Background

Aluminum beverage cans came on the scene in the United States in the early 1960s. In 1968, several aluminum producers, notably Reynolds Metals Company, being aware of the value of the metal in the used beverage cans (UBC), initiated a buy-back recycling program to recover the metal and capture the corresponding energy content. In this recycling campaign, some 24,000 metric tons were recovered in 1972, and this grew to 974,000 metric tons in 1994. Some 10,000 recycling centers were established nationwide during this period. Recently, the most successful UBC recycling year was 1997 when 66.5% of all cans produced were recycled and some 2.05 billion pounds of metal were recovered by the industry. Since then, the recycling rate has slipped and in 2005 some 51 billion cans were recovered for a recycling rate of 52%. This implies that almost half of all cans produced are lost to the recycle stream and end up in a landfill. Specifically, it has been estimated (Reference1) that some 900,000 tons of aluminum cans are landfilled each year. This value is consistent with an earlier estimate that the total metal loss to the industry through dross losses and landfills is ~ 1.5 million tons per year (Reference2). This is a huge quantity of metal and this paper explores the dilemma of how to reduce these losses

The benefits of recycling are many; first it is now well established that one saves 95% of the energy by recycling a UBC as compared to mining, refining and smelting the metal from the original bauxite ore. **In effect, a UBC can be regarded as an extremely pure form of bauxite ore!** Second, 95% of the environmental emissions associated with metal and can production are also eliminated (Reference 3). Also, the recycling or secondary industry is estimated to employ 1.1 million people nationwide with an annual payroll of $37 billion (Reference 4). Further, ech can collected has a value of ~1cent and this amount can be aggregated for beneficial causes. For example, many organizations (Boy Scouts), charities, and municipalities have benefited from the collection of UBC. Together with the Can Manufacturers Institute, The Aluminum Association has formed the Aluminum Can Council to develop educational messages and encourage recycling and some improvements in can collection have occurred. Also, The Aluminum Association, in conjunction with Habitat for Humanity, has formed Cans for Humanity and since 1997 some $4 million has been collected and 92 homes have been built for needy families.

However, the unfortunate fact still remains that in the U.S., despite the evident value of the beverage can, almost half of all cans produced are disposed of in a landfill. These losses to the metal stream may become more prevalent as the use of aluminum bottles become more common in the future.

Some other nations, notably Brazil, Japan, Sweden and Switzerland have already achieved can collection efficiencies in excess of 80-90% due to a combination of economic forces, social conditions and regulations so it is clearly possible to capture a much greater portion of the cans produced for the overall benefit of society and industry. This paper explores some potential concepts to increase the capture this metal resource of UBC both before and after landfilling.

Economic Incentives

In its Annual Statistical Reviews, The Aluminum Association, the trade association for the industry, tracks the number of cans recycled by industry, for example, see Reference 5. Using this and other information, the Sloan Center for a Sustainable Aluminum Industry at the University of Kentucky recently has estimated that the amount of UBCs discarded annually to landfills is about 909,000 tons (Reference 1). Further, knowing the number of cans that have been collected over the years and assuming the balance have been discarded to landfills, it is estimated that approximately 20 million tons of UBCs have been discarded over the past 3 decades and are currently buried in landfills nationwide. This is a substantial quantity of metal! Assuming a metal price of $2500 per ton, this represents a loss of $50 billion!

If these cans could be recovered either prior to landfilling or from the landfill itself and recycled, it would add an additional capacity of about 909,000 tons to the aluminum industry each year. This is the equivalent of the capacity that could be provided by building 3 new smelters, each of 300,000 ton capacity.

Additionally, since the recycling of aluminum precludes the need for refining and reduction processing, both the capital costs, energy costs and the environmental releases of CO_2 and other compounds, and carbon usage would be substantially lower when recycling this aluminum. Assuming that the cost of a new smelter is around $4000 per annual ton, capital costs of $1.2 billion per smelter (a total of $3.6 billion for 3 smelters) could be avoided though successful capture of these discarded cans. Instead, significantly lower capital costs for remelting capacity would be required, estimated at $180 million. Also, energy consumption would be greatly reduced since it only requires 5% of the energy to recycle aluminum as compared to producing it from the original ore.

Since the US is unlikely to build any additional smelters in the foreseeable future, another way to regard this is that the importation of 909,000 tons of metal could be avoided, with a savings of more than $3 billion. Thus, there are some considerable economic incentives to develop procedures to either prevent the UBC from ever reaching a landfill or recovering UBC following burial in a landfill.

Options for Enhancing the Recovery of UBCs

Many options for the recovery of UBCs can be envisioned but all of these probably can be grouped under three main categories:

Option 1- Collection and sorting by the homeowner, or group of users such as schools or airlines, etc. Many localities require presorting of the recyclables by the homeowner and supply bins for curbside collection. This results in relatively clean materials when they are received at the municipal recovery facility (MRF) and accordingly, the recycle value of these UBCs is relatively high. Any means of community education to enhance this collection method would be beneficial.

Option 2- Collection of the recyclables as commingled wastes following the curbside pickup of trash; this material is then processed at a municipal recovery facility (MRF). The commingling of the valuable recyclables with the trash, though simpler for the homeowner, contaminates the UBC and reduces the economic value of the recyclables, and there is less incentive for the municipalities to recycle this material.

Option 3- mining and recovery of UBCs from a preexisting landfill.

The Pros and Cons of Each Option

It is worthwhile to explore the pros and cons of each of these options in some additional detail.

Option 1. **Collection of "clean" UBC.**

Increasing can collection in this option involves improving and enhancing the "business as usual" or "Boy Scout" approach, where individuals appreciate the inherent benefit of recycling. As mentioned above, 4 nations have recycling rates in excess of 80-90 % due to some combination of cultural forces. The U.S. lacks a population segment that is extremely poor to drive can collection and generally is averse to establishing deposit regulations (though maybe this should be reevaluated) and hence the drivers to increase UBC collection are mostly educational and environmental awareness. As noted above, the Aluminum Can Council has recently been formed with the charter to develop educational messages and programs to encourage UBC collection though school, community and municipal recycling promotions. This option is clearly a minimal cost option as user individuals are the ones who capture and segregate the cans. Cans collected at the curbside are accumulated at some MRF and are separated and baled. Bales of UBC are then shipped to scrap dealers, consolidated further and passed to scrap brokers. Brokers purchase truckloads of the UBC material and send it to the processors for remelting and processing back into canstock and other products.

There is still much room for improvement in this Option 1 as there are some situations where virtually 100% capture should be feasible, e.g. on planes and trains, and yet recycling does not always occur. Several recent articles have explored the reasons for the relatively low rates of UBC recycling (References 1,4,6). Reference 4 points out that the can recycling rates are substantially lower than those now being achieved for the recovery of aluminum from disused and shredded automobiles (`~90%) and from demolished buildings and construction sites (~95%). Unlike these latter two sources, where the collection process has been automated by the shredder and its ancillary sorting processes, the use and collection of cans depends on each individual user, and so recycling depends of the individual whims of the total 300 million population.

Following the actions of EPA in 1988 to propose voluntary guidelines for recycling, there was a large growth in curbside recycling nationwide and in the development of transfer stations and MRFs. As these programs proliferated, they also clashed with the financial reality of municipalities and as a result there have been cutbacks in several municipal programs. While the collection of cans is easily justified financially, unfortunately the UBC compose only a fraction of the overall waste stream.

All the articles (References 1,4,6) stress the need to develop educational messages to enhance can recycling to prevent cans from ending up in a landfill. Specifically, the organization Earth 911 in its evaluation of why can recycling is languishing (Reference 6), stresses the need to educate local government coordinators that there are still more cans to recycle. The organization also advocates improving the efficiency of the existing recycling programs and encouraging can recovery from small retail operations. Also, the organization urges a focus on "smart" recycling, namely to focus on the high value components of the waste stream, i.e. aluminum cans and to a lesser degree, paper.

In their recent article, Das and Hughes (Reference 1) describe a comprehensive study being conducted by the University of Kentucky in association with the Fayette County Recycling Center in Lexington, Kentucky. They note a significant difference in individual behavior concerning recycling when individuals are at "home" or are "away from home". As a result, they propose locating collection bins in key places. Especially, they advocate placing collection bins in all elementary schools. They also point out that the advances made by the industry in can making technology ironically tend to work against increasing the rate of recycling. With the reductions in the thickness of the can walls, it now takes the collection of 33 cans to get 1 lb. of aluminum, to the chagrin of the Boy Scouts and other groups!

Any success in increasing the rate of recycling in this Option 1 will impact the economic trade-offs in the two other more complex and costly Options. It is strongly recommended that programs be continued and bolstered to educate the public about the benefits of curbside collection and to educate school children about the economic and environmental benefits of recycling.

Option 2 Collection of UBC as commingled waste

Increased collection of UBC as commingled waste will certainly be beneficial. The pro here is that the homeowner doesn't have to bother to sort the used material. This is perceived as a benefit as many people in the rush of daily activities feel too busy to take time to do mundane sorting. However, the disadvantage here is that the commingling with all other trash in the general waste stream contaminates the aluminum cans and reduces their economic value.

In this Option when the commingled waste reaches the MRF it is placed on a conveyor belt and the plastic and paper bags are either removed by hand or are blown off. Magnets are used to separate the ferrous materials, glass is removed by a shaker and is subsequently crushed, and the aluminum cans are removed at the end of the belt. In Europe where recycling has traditionally been more accepted, some of the plants are quite sophisticated with automated sorting and picking equipment, magnets for ferrous metals and eddy currents separators for aluminum.

The problem at this point is that the market for the cans recovered from the commingled waste while it does exist, does not pay the same value as the curbside UBC because of the contamination of the material. The UBC recycling facilities do not want it, and it gets melted with high oxide (dross) losses in the rotary salt furnace and is made into low-grade remelt scrap ingot (RSI). The result is that there is much less incentive for the municipalities to go after the cans in the commingled waste (Reference7).

Some cities, i.e. Pittsburgh, Pennsylvania, separate the recyclables after pickup. It is recommended that some of these operations are evaluated and all the specific process steps studied with a view to establishing an overall "best practice". The key issue is to improve the cleanliness of the UBC portion of the waste stream and make it more valuable to the remelt operators. Accordingly, the debagging and loosening of materials should be examined from the aspect of reducing contamination. Alternatively, it is also recommended that some studies are conducted to remove dirt and contamination. Perhaps this can be accomplished by abrasion with gas jets, or by a tumbling process, or some combination of the above. A demonstration pilot plant to evaluate alternative potential cleaning steps would be a valuable technology development. A washing process with waterjets would presumably work but is probably not ideal because of the subsequent need for drying, and for dealing with a contaminated water stream. A successful process that produced a clean UBC would be most significant as it would provide the financial incentive to drive the recycling efforts and could markedly lower the 900,000 ton annual loss.

Option 3 – Recovery of UBC from an existing landfill

This Option is certainly the most complicated and costly, and is probably fraught with complex political, legal liability and regulation issues. On the positive side, the total prize is large with some 20 million tons of UBC estimated to be buried in the nation's landfills over the past 3 decades (Reference1). However, leaving aside for the moment all "political" uncertainty, moving large quantities of earth is difficult and costly. Also, disturbing an existing landfill risks the spreading of other contaminants that are buried there. When a landfill is filled and sealed, decomposition in the sealed volume generates methane under the chemically-reducing conditions. Boring into a landfill will release the methane and this will be counter productive if the gas is being used as a fuel. Increasingly, this methane is being combusted for steam generation and to heat large institutional buildings.

Also, the material recovered from a landfill will certainly be more contaminated than cans retrieved from commingled waste and, as was noted above, these cans are presently not attractive to the remelt operators. Again, then, there is the need to develop technology to clean and beneficiate the waste UBC.

Before attempting to mine an existing landfill it would be important to conduct some surveys of the locality in an attempt to select a landfill with an above average content of UBC. Some preliminary borings would be needed to define areas of the landfill potentially rich in cans. Also, the costs and best methods to loosen the material and to separate the soil would need to be researched. Several factors would need to be investigated and addressed before implementing any recovery process. For instance, it would be important to establish the degree of packing or overburden in the areas of the landfill targeted for recycling, the amount of drying and cleaning required for the recovered UBC, the landfill timeline and the potential capital and operating costs, the potential value of the recovered aluminum and the environmental requirements and costs for resealing the landfill following the recovery process.

Summary and Recommendations

From this short survey it is concluded that the dilemma of the 900,000 tons of aluminum UBC waste is best tackled by working with Options 1 and 2. These options are clearly more straightforward and cost efficient than recovery from an existing landfill, Option 3. Only when these two simpler options have been optimized will it be possible to make a realistic estimate of the benefits of further recovery procedures directly from a landfill.

Concerning recommendations for future work, it is strongly recommended that efforts continue to develop and refine educational and environmental messages to promote the curbside collection of "clean" UBC waste that is attractive to the remelt operators. If there is a sufficient environmental will, there is no fundamental reason why this nation cannot again achieve the recycling rates of ~ 67% that were achieved in 1997. The research that is being conducted by the Sloan Center for a Sustainable Aluminum Industry at University of Kentucky in conjunction with the Fayette County Recycling Center will be helpful in targeting the specific environmental messages. The educational messages on the importance of recycling should have a strong thrust toward the younger schoolchildren.

The second major recommendation is that some pilot scale studies should be undertaken to explore and develop low cost techniques to beneficiate and clean the UBC recovered from commingled waste. One task would be to establish a set of "Best Practices" for the receiving of commingled waste at a MRF in order to minimize contamination. A second and probably more important task will be to develop procedures to remove contamination from the UBC. These procedures could involve some form of mechanical agitation, tumbling or shaking combined with air blasts over a screened area to separate trash from the aluminum materials. A program should be developed to include a remelt operator for the assessment of the cleaning results. Hopefully, this should result in a higher estimate of value for the UBC obtained from commingled waste.

Finally, it is noted that any technical success in the cleaning of UBC from commingled waste will also be highly relevant to material that may be eventually recovered from landfills. However, it is not recommended that landfill recovery is attempted at this time pending the outcome of more aggressive educational and beneficiation efforts cited under Options 1 and 2.

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