University of Southern Queensland

Faculty of Engineering and Surveying

Analysis of the Recycling Method for Aluminum Soda Cans

A dissertation submitted by

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Abstract

Aluminum has been recycled since the days it was first commercially produced and today almost one-third of the global aluminum consumption worldwide is contributed by recycled aluminum.

The aluminum soda / beverage can is by far the most recycled consumer beverage package globally by units, pounds and percentage recycled. It amounts to more than twice the recycling rate and recycled content percentages for beverage packages of other materials.

The research project seeks to investigate and study on the process of collection to packaging of Lian Gim Aluminum & Supply Pte Ltd with an aim to improve the whole process in terms of cost, quality and safety at the end of the project.

University of Southern Queensland

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ENG 4111 & ENG 4112 Research Project

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Certification

I certify that the ideas, design and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Signature

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Date

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

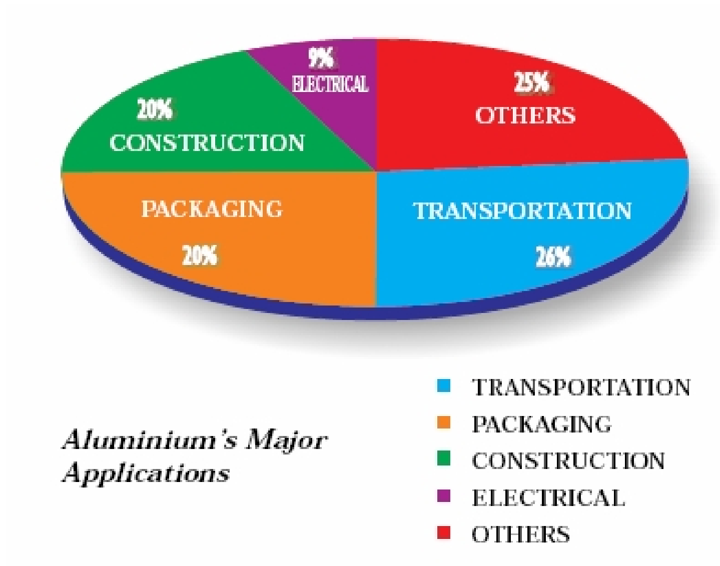
Aluminum compounds form 8 per cent of the earth's crust and are present in most rocks, vegetations and animals. The aluminum is indeed the third most common crustal element and most common crustal metal on earth.

Pure aluminum is a very reactive element and is never found as the free metal in nature. It is very lightweight and soft. It has to be combined with small quantities of other materials like iron, silicon, zinc, copper, magnesium, tin, titanium, lithium for example to produce array of alloys of different properties for different purposes.

Aluminum is considered to be a young and modern metal. It has only been produced on industrial scale in 1886 through electrolysis. Aluminum ore, most commonly bauxite, is plentiful and occurs mainly in Tropical and sub-Tropical areas like Africa, West Indies, South America and Australia. Since aluminum was first commercially produced, the unique combination of properties has enabled designers and manufacturers to develop products to enhance our quality of life.

It had stated in the International Aluminum Institute Report for Aluminum Sustainability that by the end of the twentieth century, the annual production of aluminum had reached more than 32 million tonnes annually, comprising 24 million tones primary aluminum and 8 million from recycled aluminum. Almost 100% of all the production scrap and over 60 per cent of all old scrap is recycled annually. This makes aluminum the second most used metal in the world.

From the above information, it is known that aluminum is a sustainable material as seen in the current primary aluminum production level in the world, known bauxite reserves will still last for hundreds of years. It is known that more than 55 per cent of the world's primary aluminum production uses renewable hydroelectric power. Since aluminum products can be recycled, there is an increase use of recycled aluminum to save both energy and mineral sources for primary aluminum production.



(Source: The Aluminum Industry's Sustainable Development Report)

Figure 1.1 Aluminum's Major Applications

Aluminum makes a key contribution to fuel-efficient engines in transportations. It facilitates the construction of corrosion-resistance and low maintenance buildings. Aluminum is also extensively used in packaging for protection, storage and preparation of food and beverages. Aluminum can be rolled into ultra-thin foils which are light, strong and have a unique barrier and insulation qualities to preserve food and beverages against ultra-violet light, odour and bacteria. Aluminum packages are secured, tamper-proof, hygienic, easy to open and recyclable.

Almost every aluminum product that is produced commercially can be recycled after its end of life, without losing its metal properties or quality. As there is an increased used in recycled aluminum in many different kinds of application, the aluminum metal is also known as the “green” metal.

The focus of this project is mainly on the recycling of aluminum beverage cans. The reason of the focus is due to the fact that aluminum beverage cans are by far the most recycled consumer beverage packages globally, by units, pounds and percentage recycled. It amounts to more than twice the recycling rate and recycled content percentages for beverage packages of other materials.

The Aluminum Association, Can Manufacturers Institute (CMI), and Institute of Scrap Recycling Industries (ISRI) released statistics on May 20, 2005 indicating that Americans and the can recycling industries recycled 51.5 billion aluminum cans in 2004, for a beverage can recycling rate of 51.2 percent. This reflected a 1.2 percent increase over the 2003 rate and the first increase since 1997.

Aluminum Can Reclamation

Year	Pounds of Aluminum Collected (millions)•	Number of cans/pound of aluminum	Number of cans collected••	Number of Cans Shipped (billions)•••	Pct. of aluminum cans collected
2003	1,479	33.72	49.9	99.7	50.0
2004	1,518	33.92	51.5	100.5	51.2
% change	2.6	0.6	3.2	0.8	1.2

(Source: The Aluminum Association, Inc.)

Table 1.1 Aluminum Can Reclamation

Since the recycling of aluminum beverage cans is rising, a study on the recycling method used in my company, Lian Gim Aluminum & Supply Pte Ltd, is carried out. This study and analysis focus on the collection, crushing, packaging of aluminum beverage cans to be sent overseas for smelting.

1.2 Project Aim

The objectives of this study are:

- Research and study on the existing process of recycling of aluminum beverage cans.
- Gather data on the procedures of collection, crushing, packaging of aluminum beverage cans.
- Analyze on key criteria of the whole process including cost, quality and safety.
- Investigate and develop new scientific methods to improve criteria of the whole process.

2.1 Dissertation Outline

This dissertation is divided into an assortment of chapters describing different portions of the project. To facilitate the reader, this section provides the brief overview of each chapter.

Chapter 2: Aluminum Can Life Cycle

In this chapter, the properties of aluminum are discussed. The chapter also goes through the process of production of aluminum cans from aluminum ore. Details of how the beverage is being recycled is also illustrated.

Chapter 3: Recycling Aluminum Can

This chapter discuss on the reason for recycling aluminum beverage cans and the benefits of recycling cans.

Chapter 4: Case Study

This chapter includes a case study on a Singapore company, Lian Gim Aluminum & Supply. Analysis of cost, quality control and safety issues are discussed here.

Chapter 5: Further Work and Conclusion

This chapter gives a brief description of the problems encountered during the development of the project and the recommended further works.

CHAPTER 2

ALUMINUM CAN LIFE CYCLE

2.1 Research Information on Aluminum Can Recycling

Information gathering on aluminum can recycling was carried out at the beginning of the project. The data collected focuses on issues range from formation of the aluminum beverage cans until the execution of scientific methods to the production system in Lian Gim Aluminum & Supply Pte Ltd.

Sources of information were obtained from local library (Temasek Polytechnic, Singapore), USQ library, via Internet and direct from company (Lian Gim Aluminum & Supply Pte Ltd). The scope of literature will revolve around the resources gathered.

Before going into introducing new scientific methods to the company, an understanding of the production of aluminum beverage cans is vital. The International Aluminum Institute and Aluminum Can Group Australia described the process of production of aluminum beverage cans in details.

2.2 Aluminum Properties

Aluminum is a silvery-white metal with desirable characteristics of being light, non-toxic, non-magnetic and non-sparking.

13	Atomic Number
AI Aluminum	Symbol
26.98154	Atomic Weight
2 - 8 - 3	Electron Configuration

(Source: IAI)

Figure 2.1 Aluminum Periodic Symbol

Aluminum's has versatile properties making it easily cast, molded, extruded and rolled into infinite variety of shapes. Aluminum's range of properties can be found in many commercially available alloys. An alloy is a material made up of two or more metals. Alloys are designed and produced have certain specific, desirable characteristics, including strength, formability, and corrosion resistance. The composition and logic of the alloys are regulated by an internationally agreed classifications system or nomenclature for wrought alloys and by various domestic nomenclature schemes for the casting alloys.

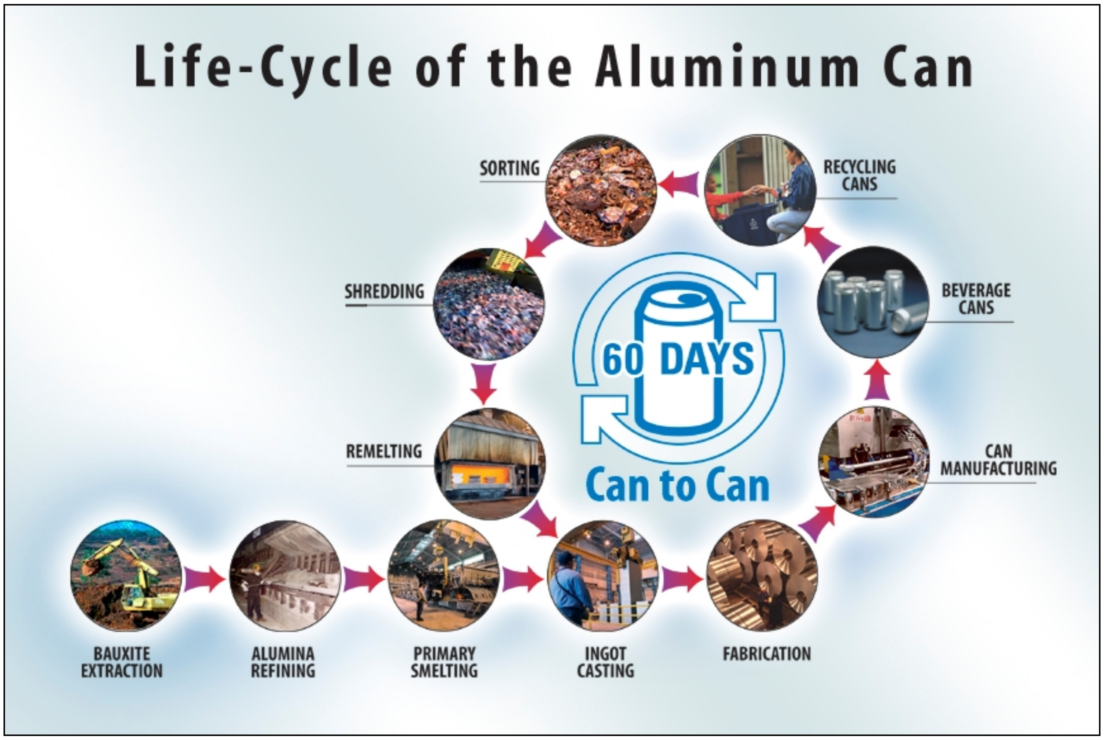
1XXX	Aluminum of minimum 99% purity
2XXX	Aluminum-copper alloys
3XXX	Aluminum-manganese alloys
4XXX	Aluminum-silicon alloys
5XXX	Aluminum-magnesium alloys
6XXX	Aluminum-magnesium-silicon alloys
7XXX	Aluminum-zinc-magnesium alloys
8XXX	Miscellaneous alloys, e.g. aluminum-lithium alloys

(Source: IAI)

Table 2.1 Classification of Aluminum Alloys

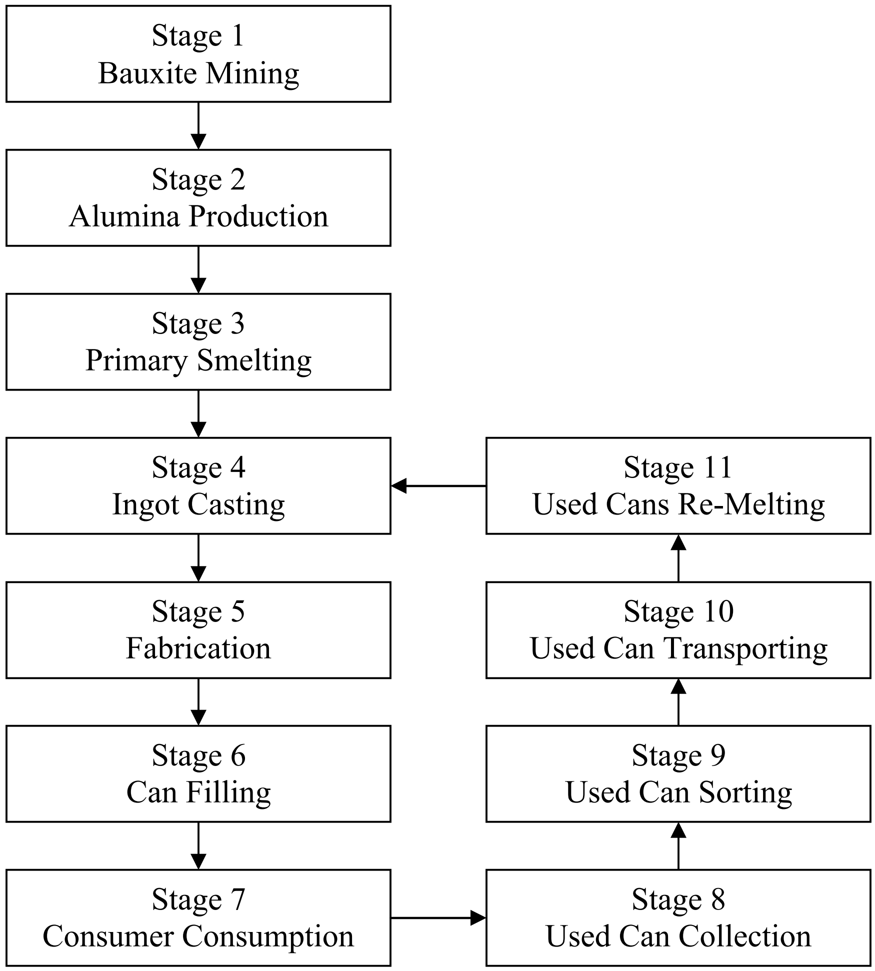
2.3 The Aluminum Can Life Cycle

The aluminum can production, consumer consumption, recycling and back to consumer consumption life cycle process can be divided into 12 stages.



(Source: Novelis Website)

Figure 2.2 Life Cycle of the Aluminum Can



(Source: The Aluminum Can Group, Australia)

Figure 2.3 Flowchart of Aluminum Can Life Cycle

2.3.1 Stage 1: Bauxite Mining

Bauxite is found in **four** types of deposits: **pocket, blanket, inter-layered** and **detrital**. The major bauxite deposit areas in the World include the Caribbean areas, South America, Australia and Africa.

Blanket deposits occur in West Africa, Australia, South America and India. The blanket deposits found in these areas occur as flat layers lying near the ground surface extending over an area covering many kilometres. The thickness of the blanket may very from a metre or less to 40 metres.

Pocket deposits of bauxite occur in Jamaica, Hispaniola and Southern Europe. Bauxite is found in the size of depressions ranging in depth from less than a metre to more than thirty metres. In some cases, a pocket of bauxite may be isolated in an area, while in other areas the depressions may overlap and compose as one large deposit.

Inter-layered deposits are usually found in United States, Suriname, Brazil, Guyana, Russia, China, Hungary and the Mediterranean area. They originally existed at the surface as other types of rocks or volcanic rocks. These formations are usually more compact than in other deposits because of the additional weight of the overburden.

Detrital deposits occur because of the accumulation of bauxite that has eroded from other deposits. The Arkansas bauxite in the USA is mined from detrital deposits.

Almost 80% of the world's bauxite production, mainly from large blanket type deposits, is from surface mines and the rest from underground excavations in Southern Europe and Hungary.

Bauxite mining activities takes place mainly in numerous bauxite deposit areas mainly in the tropical and subtropical regions but also in Europe. Global distributions of bauxite mining areas can be seen labeled in red in Figure 2.2.

(Source: IAI, Sustainability Update 2004)

Figure 2.4 Global Distributions of Bauxite Mining Regions (Red)

Bauxite is extracted in surface mines with large blanket type deposits, typically some 4-6 metres under a shallow covering of topsoil and vegetation. Mining of bauxite begins with the removal of topsoil and overburden (unwanted material overlying aluminum ore), which are conserved for rehabilitation of the mine site. Deposits that are hardened may require blasting with high technology explosives to reduce noise and flying rock while producing adequate fragmentation of the rock. Once the bauxite is loosened into manageable sizes, the hardened deposits together with the bauxite ore are loaded onto trucks by front-end loaders and transported to primary crushers, washing plants or to stockpiles.

Underground bauxite mines are used to exploit pockets or inter-layered deposits. Water in flow is a problem occurring in most underground operations and dewatering shafts are often drilled before mining begins.

Australia is one of the largest suppliers of bauxite in the world. Bauxite is mined from surface mines by Alcoa World Alumina – Australia at 3 locations in the Darling Range in Western Australia as well as by other companies throughout Australia.

Bauxite occurs in three main forms depending on a) The number of molecules of water hydration and b) The crystalline structure. The three structure forms of bauxite are Gibbsite, Bohmite and Diaspore.

	Unit	Gibbsite	Bohmite	Diaspore
Composition		$Al(OH)_3$	AlO(OH)	AlO(OH)
Maximum Alumina Content	%	65.4	85.0	85.0
Crystal System		Monoclinic	Orthorhombic	Orthorhombic
Density	gcm^{-3}	2.42	3.01	3.44
Temp. for Rapid Dehydration	°C	150	350	450

(Source : World-Aluminum Organisation)

Table 2.2 Different forms of Bauxite

Unlike the base metal ores, bauxite does not require complex processing because most of the bauxite mined is often of acceptable grade or improved by a relatively simple and inexpensive process of removing clay. In many bauxites ore mined, clay is removed by some combination of washing, wet screening and cycloning or hand picking.

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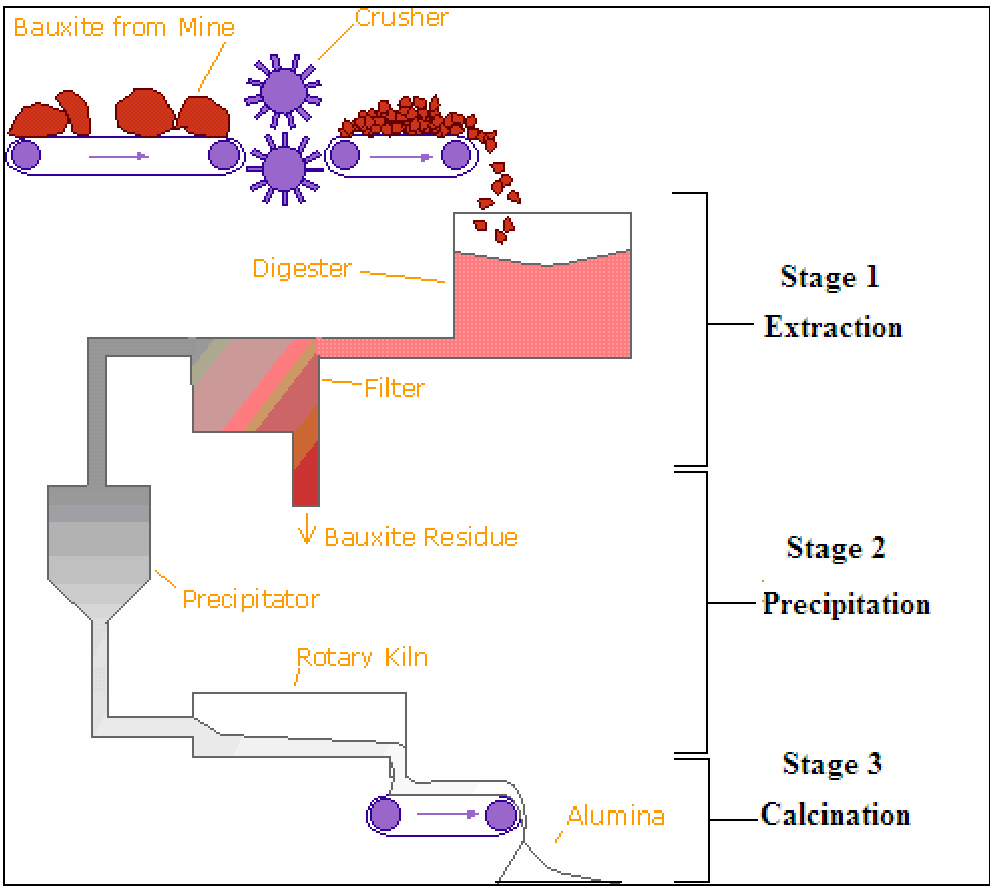
2.3.2 Stage 2: Alumina Production

The Bayer process is commonly used in the aluminum industry for production of alumina from bauxite. The Bayer process is considered in three stages:



(Source: IAI, Bayer Process)

Figure 2.5 Bayer Process

1) Extraction

The aluminum-bearing minerals in bauxite – Gibbsite, Bohmite and Diaspore are selectively separated from insoluble oxide components by dissolving them in a solution of sodium hydroxide (caustic soda). The chemical properties are listed below:

Gibbsite: $Al(OH)_3 + Na^+ + OH^-$ ---> $Al(OH)_4^- + Na^+$

Bohmite and Diaspore : $AlO(OH) + Na^+ + OH^- + H_2O$ ---> $Al(OH)4^- + Na^+$

The bauxite ore might be washed prior to processing depending on the quality. The ore will be crushed and milled to reduce the particle size for mineral extraction. It is then combined with the process liquor and sent a slurry to a heated pressure digester.

The conditions in the heated digester are set according to the properties of bauxite ore. Ores with higher gibbsite content is processed at 140^{o}C. Bohmite and Diaspore is processed between 200 and 240^{o}C. The temperature of the digester monitored strictly, as there will be corrosion problems and a possibility of dissolving of other oxides into the caustic liquor.

After the extraction stage, the insoluble bauxite residue is separated from the aluminum-containing liquor by a process known as Settling. The liquor is purified through filters before being transported to precipitators. The insoluble mud from the first settling is thickened and washed to recover caustic soda which is returned back to the main process.

2) Precipitation

The crystalline aluminum tri-hydroxide (Gibbsite) or “hydrate” is then precipitate from the heated digestion liquor:

$$Al(OH)_4^- + Na^+ \text{--->} Al(OH)_3 + Na^+ + OH^-$$

This process is the reverse of the extraction process where the nature of the hydrate is controlled carefully by plant conditions including seeding or selective nucleation, precipitation temperature and cooling rate. The “hydrate” crystals are classified into different size fraction and fed into the fluidized bed rotary calcination kiln. Undersized particles are fed back into the precipitation stage.

3) Calcination

The “hydrate” is calcined to form alumina for the aluminum smelting process. In the calcination process, water is eliminated to form alumina:

$$2Al(OH)_3 \text{--->} Al_2O_3 + 3H_2O$$

The calcination process is carefully controlled to ensure the quality of the properties of the final alumina. The result is a white powder, pure alumina. The caustic soda is returned to the start of the process and used again.

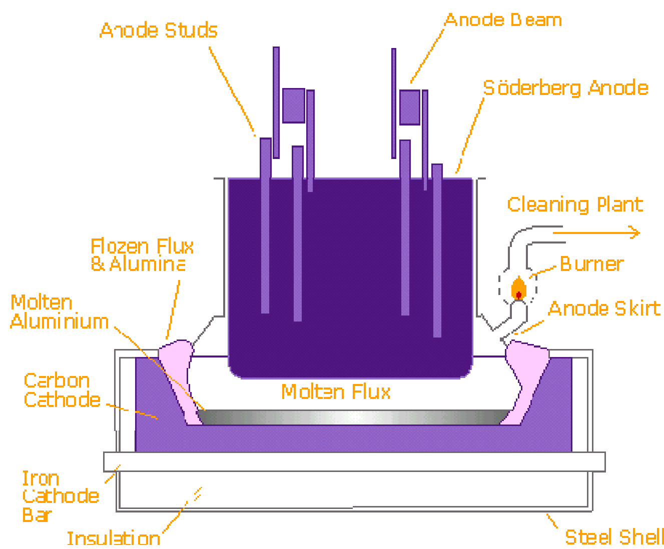
2.3.3 Stage 3: Primary Smelting

Pure alumina after the Bayer process is transported to a smelter. The alumina is fed into a reduction cell at high temperature for dissolving in an electrolytic bath of molten cryolite (sodium aluminum fluoride) with a large carbon or graphite steel container known as a "pot". An electric current with low voltage but very high current (150,000 amperes) is passed through the cryolite, splitting the oxygen from the alumina leaving the remaining aluminum metal to be poured off. Molten aluminum is deposited at the bottom of the pot and is siphoned off periodically, and taken to a holding furnace, often but not always blended to an alloy specification, cleaned and then cast.

There are two main types of aluminum smelting technology:

1) Söderberg Cell

This technology used a continuous anode which is delivered to the pot in a form of a paste and which baking in the pot itself.

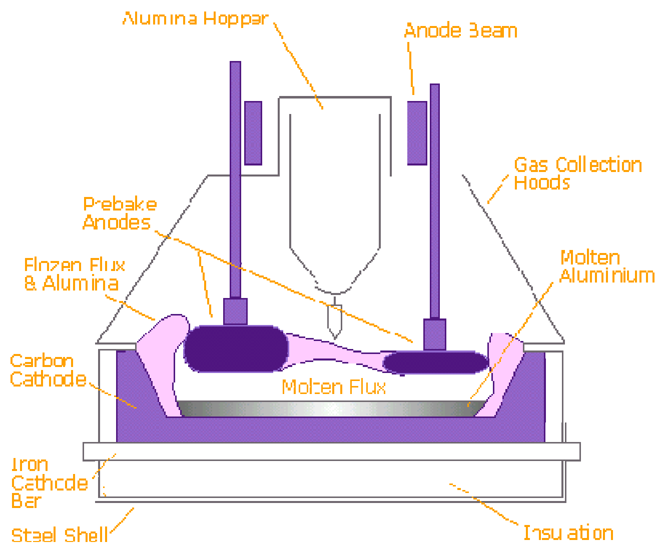


(Source: IAI, technology types)

Figure 2.6 Söderberg Cell used for smelting

2) Prebake Cell

This technology in turn uses a number of anodes in each pot which are pre-baked in a separate facility and attached to “rods” suspending in a pot.

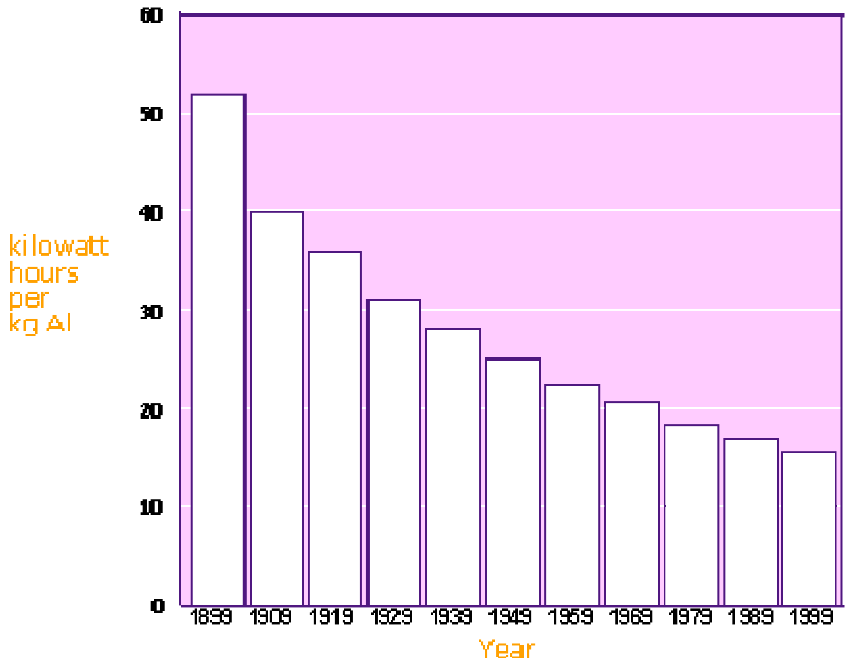


(Source: IAI, technology types)

Figure 2.7 Prebake Cell used for smelting

A typical aluminum smelter will normally consist of around 300 “pots” producing about 400,000 tones of aluminum annually. On average, around the world, it takes about 15.7 kWh of electricity to produce one kilogram of aluminum from alumina. The primary aluminum production process uses very high energy, but throughout the years, improvements in the industry regarding energy consumption and environmental gas emissions have been favorable.

The bar graph on the next page shows that the average energy consumption during aluminum production and the environmental gas emissions per tones when new aluminum is produced have fallen by 70% over the past hundred years.



(Source: IAI, Energy Use)

Figure 2.8 Electrical Power used for Primary Aluminum

Primary aluminum is formed at 900°C, but once formed it has a melting point of 660°C. In many smelters, the remaining heat is used to melt recycled metal. The use of recycled metal in any aluminum product results in an energy saving of up to 95 per cent over the use of primary metal. Blending recycled metal with new metal energy saving and also efficient use of process heat. There is no difference in the quality or properties of primary and recycled aluminum. Many products, for example automotive castings, building products and beverage cans are made mainly from recycled metal.

2.3.4 Stage 4: Ingot Casting

The molten aluminum from the smelting plant is then either cast or rolled into ingots for sale as pure aluminum or mixed with other metals to be used as alloyed aluminum. Different alloys are used for different purposes.

1) Casting

Cast aluminum are used in various applications which includes

- lightweight components for aircrafts, ships, vehicles and spacecrafts
- general engineering components where lightweight and corrosion resistant are required
- architectural structures where lightweight and appearance is needed
- high technology products for commercial and domestic usage

There are two main types of casting techniques, sand casting and die-casting. In general in the casting of rolling ingot, molten aluminum flows from a furnace through a series of treatments to remove gas and impurities into a mould. The bottom of the mould is dropped into a pit and water jets cool the mould until the ingot get solidified. The ingots are then lifted out by overhead crane and ready for transport.

2) Rolling

Rolled aluminum is classified into three categories: foil, sheet and plate. Foil is rolled aluminum that is less than 0.2mm in thickness. It is mainly used for the packaging industry for aluminum cans and wrapping, building insulation, printing industry and electrical applications. Sheet is between 0.2mm and 6mm in thickness and is commonly used in the construction industry and transportation applications. Plate is any rolled aluminum that is more than 6mm in thickness. It is found in military applications and structural components of bridges and buildings.

The process of rolling is separated into a 2-part process: Hot rolling mill and Cold rolling mill. Ingots made during casting pass through a scalping machine where surface oxides are scraped off providing a smooth rolling surface. Ingots are then passed through a hot rolling mill before transferring into a cold rolling mill. Aluminum is presented in a form of ingot state that can be up to 600mm in thickness. This ingot is heated to around 500°C and passed through the hot rolling mill several times to reduce the thickness to around 6mm.

The thinner aluminum is then coiled onto a cylinder and transported to the cold rolling mill for further processing. Subsequent rolling and annealing of the cold metal increases the strength of the aluminum alloy. There are various types of cold rolling mills that is used to produce various types of rolled product with thickness as low as 0.05mm. In general, the type of rolled product depends on the alloy used, the rolling deformation, thermal treatment as well as careful adjustments to the mechanics and chemistry of the process. Rolling mills are controlled with very precise mechanisms and measuring systems.

The final product form the cold rolling mill is trimmed and coiled before packing. The tab stock that is used to open the can is coiled and cut into narrow strips. The end stock that is used for the top of the can is trimmed, leveled, washed and coated. The body stock used for the bottom and sides of the can is trimmed to width. All bare and coated products are oiled to protect the sheets during transport and assist production of aluminum beverage cans by the can manufacturers. The finished and packed coils are loaded onto semi-trailers for transport to export shipping terminals or direct to customers (can manufacturers). Highly specialised packaging is used to prevent damage to the aluminum.

2.3.5 Stage 5: Fabrication

There are three major aluminum products sent from the rolling plant to the can manufacturers:

- the body stock from which the can body is made,
- the end stock for the top of the can and
- the tab stock which is used to open the can.

The can body and the tops (end and tab) of the can are manufactured separately. The can fillers attach the end of the can after it has been filled. There are seven stages to making the body of the can and four stages to making the end of the can.

a) **Seven stages to making body of can**

1) Lubrication

A thin film of lubricant is applied to the aluminum as it is being uncoiled. This lubricant helps the metal pass through the rigorous can making process.

2) Cupper

A circular blank of aluminum is cut out and passed into the cupper machine where the blank is drawn into a cup.

3) Can Body-maker

The cup is moved into the can body-making machine where the cup is pulled out to produce a can and the dome on the can bottom is formed.

4) Trim and Wash

The top of the can is trimmed off to a uniform height and then washed.

5) Decoration

Decorative ink is applied to the exterior surface of the can and passed through to an oven where the decorative inks are dried. A spray is then added to the internal surface of the can and dried in an oven.

6) Necker and Flanger

The can passes through a machine that 'necks in' the can opening, reducing the size of the can end. A flanger creates a lip on the top of the can so that the top stock of the can can be attached after it has been filled.

7) Quality Test and Packing

The can passes through a light test, which checks the can for possible leaks and physical damage. The cans are then placed on pallets and transported to the filler.

2.3.6 Stage 6: Can Filling

Once the can bodies have been made, the cans are sent for filling. When the cans are filled, the end is sealed on straight away to keep the drink carbonated. There are five stages to how soft drinks are made:

1) Purify Water

Water is filter carefully to remove possible impurities.

2) Adding flavouring

Flavourings made from natural and nature identical sources are laboratory tested, and added to a mixture of sugar and purified water. This forms the soft drink base.

3) Carbonate Soft Drink Base

Carbon dioxide is added to the still drink in a carbonator under controlled high pressure and low temperature conditions.

4) Sealing of Can

The carbonated drink is then transferred under pressure to the filling machine. The end stock is placed on the can top and seamed shut. The can is then passed through hot water spray to bring it to room temperature to prevent condensation. Each can undergo quality testing and receives a bar code.

5) Packing of Can

Ready cans are carried by conveyor belt to a packaging machine where they are packed into boxes. The boxes are stacked on pallets and stored before distribution.

Packaging is essential as it protects the content. The aluminum provides the following benefits to the beverage cans manufacturer:

- Processing saves time as the cans fills quickly
- Can chills easily
- The flavour in the can can be retained
- The can is 100% recyclable
- It will not shatter
- The can is totally rustproof
- It is easy to open with no lids or paper labels that end up as litter
- Its lightweight and compact which makes transportation easier and cheaper
- It is safe to carry and does not break.

2.3.7 Stage 7 - 11: Consumer Consumption to Can Re-Melting

Consumers buy the goods they need at prices they can afford. Aluminum beverage cans are a popular packaging material with consumers. Research by the Canmakers Institute in 1998 indicated that consumers liked drinks in aluminum cans for the following reasons:

- Availability
- Price/value for money
- Convenience
- Light and portable.

Consumers consume drinks from a variety of places, not necessarily from where they buy them. Most households recycle their used aluminum beverage cans through local council recycling programs, and in many public places, such as beaches and parks, where separate bins for recyclable containers and non-recyclable rubbish are available.

(Source: JJ Richards & Sons PTY. LIMITED)

Figure 2.9 Aluminum Can Recycling Bins in Toowoomba

Australia has one of the highest consistent aluminum beverage can recycling rate of 80% followed by Japan at 78.5% and USA at 63%. The purchase price of recycled aluminum beverage cans is based on the monthly average price of aluminum at the London Metal Exchange less the cost of reprocessing into new aluminum beverage cans.

The used aluminum beverage cans are baled in different collection centres in the world and then transported to re-melting plants. At the re-melting plant, bled cans are fork lifted into a gas-fired rotary furnace that melts the aluminum in temperatures as high as 780°C. The paint and coating on the aluminum cans melts and is captured by a salt material called dross which later sent to a scrap metal dealer who extracts any remaining aluminum.

The melted aluminum is then poured out of the furnace into a crucible and tested to determine its alloy content. The molten material is added with primary metals like magnesium, copper and manganese so that it is of the right consistency to make the alloy for beverage can sheet. It is then poured to create an ingot which goes into the rolling mill for can sheet production.

Used aluminum beverage cans that are recycled in Australia are primarily recycled back into beverage cans. Aluminum does not 'degrade' during the recycling process and can be recycled repeatedly. Recycled aluminum is also used in both high quality cast and wrought products. The final aluminum product will vary in its make-up of other elements according to the end use.

CHAPTER 3

RECYCLING ALUMINUM CAN

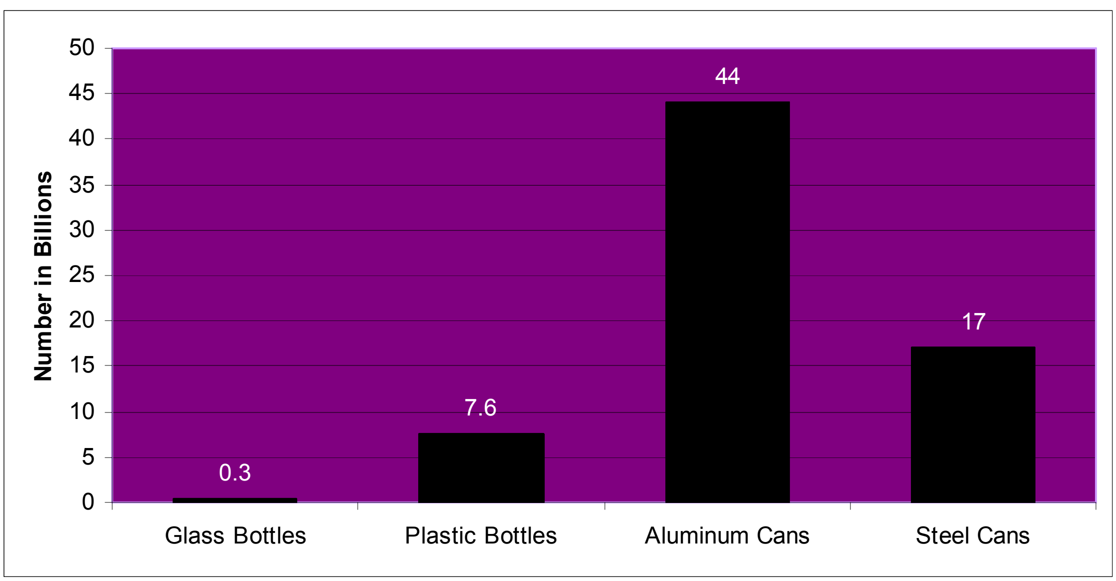
3.1 Value of Recycling Aluminum Cans

Anything that is made from aluminum can be recycled repeated. Aluminum cans, foil, plates, window frames, furniture, automotive components are melted down and use to make similar products again. Recycling an essential part of the aluminum industry is economical, technical and ecological. Aluminum companies have invested in dedicated state of the art secondary metal processing plants to recycle aluminum. The recycling of aluminum requires only 5% of the energy used to produce primary aluminum (new aluminum from ore) and only generates 5% of greenhouse gas emissions as compared to producing primary aluminum.

All aluminum that is recycled can be described as either "new scrap" or "old scrap". New scrap is that surplus material that arises during the manufacture and fabrication of aluminum alloys up to the point where they are sold to the final consumer. Examples include the trimmings from the edges of sheet aluminum, turnings and millings from aluminum fabrication and surplus extrusion discards. New scrap tends to come from the manufacturing industry and tends to be of a known quality and composition and can be processed with very little preparation.

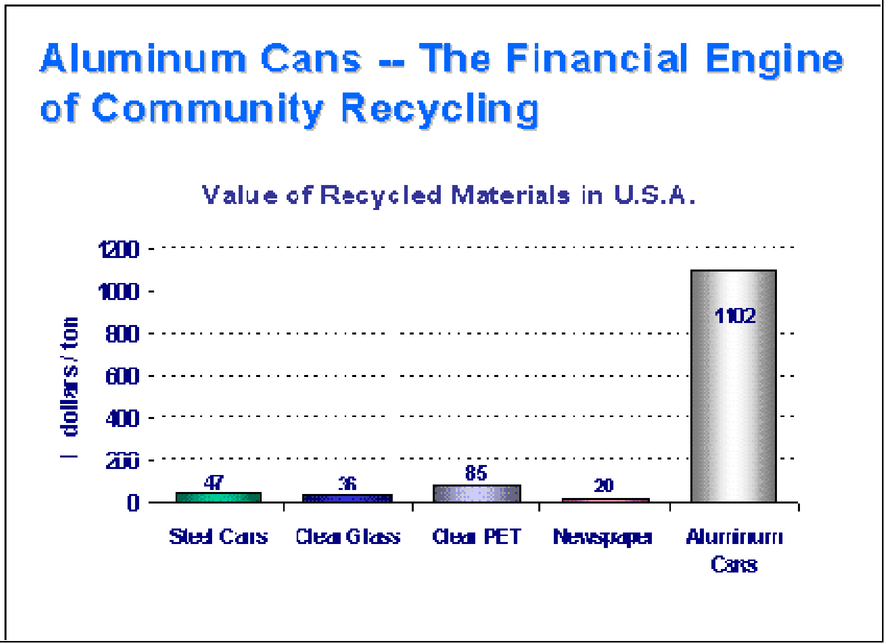
Old scrap is aluminum materials which have been used by the consumers and subsequently discarded. This include a wide range of items such as used beverage cans, car cylinder heads, window frames or electrical cabling.

The aluminum can is considered to be the most recycled consumer beverage packages globally. The used beverage aluminum cans are gaining a significant value and the market scrap prices have been increasing throughout the years. In the International Aluminum Institute 2005, it is known that almost 60% of cans recycled that year were aluminum cans. Almost 44 billion aluminum cans were recycled compared to the 17 billion steel cans, 7.6 billion plastic bottles and 0.3 billion of glass bottles.



(Source: International Aluminum Institute Report 2005)

Figure 3.1 Amount of Beverage Cans Recycled Globally in 2005



(Source: U.S. Senate Committee on Environment & Public Works)

Figure 3.2 Value of Recycled Materials in USA

In the data collected daily from the metal prices website , it can be seen that the average market price for UBCs (used beverage cans) have been increasing.

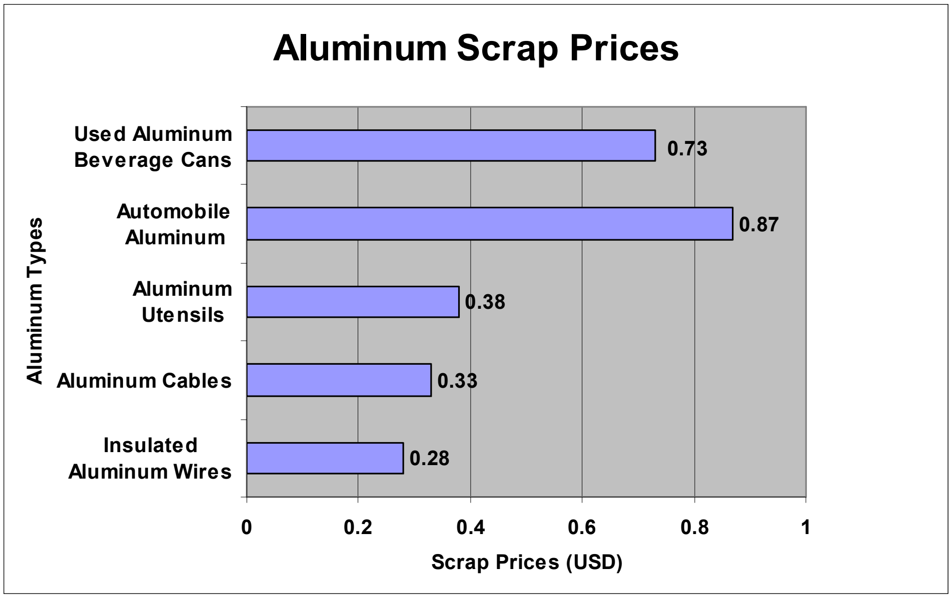


Figure 3.3 Annual Scrap Prices of different aluminum products

The recycling rates due to the efforts of the global government authorities through the coming years have been increasing significantly. The table below shows the amount of used beverage cans collected globally in 2002 and 2003.

Country	Recycling Rates (2002)	No. of Cans Recycled in billion (2002)	Recycling Rates (2003)	No. of Cans Recycled in billion (2003)
Asia	79%	18	81%	27
Brazil	87%	10	89%	19
Europe	45%	23	48%	36
USA	53%	57	54%	60

Table 3.1 Amount of Cans Collected Globally

3.2 Aluminum Can Recycling Process

All aluminum products can be recycled after use. Every two out of three aluminum cans produce being the recycling process either at local recycling centers, community drop-off sites, recycling bins. Aluminum cans from these sources are then gathered at large scrap processing compounds.

Scrap aluminum is then transported to the scrap compounds where it is checked and sorted to determine its composition and value. If the scrap is of unknown quality, the scrap aluminum will first be passed through large magnets to remove any ferrous metal. Then they are condensed into briquettes or bales and ship off to aluminum companies for re-melting.

Depending upon the type of contamination present, the condensed cans will be shredded, crushed and stripped off their interior and external lacquer via a burning process. Then the shredded pieces of aluminum cans are loaded into melting furnaces, where the recycled metal is blended with new aluminum. The molten aluminum is then poured into ingots.

The ingots are fed into rolling mills that reduce the thickness of the metal. The metal is then coiled and shipped to can manufacturers who produces can bodies and lids. They in turn deliver cans to beverage companies for filling. The new cans are then ready to return to store shelves in less than 60 days.

3.3 Benefits of Aluminum Can Recycling

Aluminum can recycling provides many environmental, economic and community benefits to individuals, communities, organizations, companies and industries.

a) Environmental Benefits

Recycling aluminum cans saves precious natural resources, energy, time and money which will benefit the earth and also the economy and local communities. Aluminum can is a sustainable product that can be recycled repeatedly. Each aluminum can be recycled and turned into a new can within 60 days and be sold on the store shelves again. In 2003, almost 54 billion aluminum cans in USA were recycled, and this saves energy that is equivalent to 15 million barrels of crude oil essential for America's gas consumption for one day.

b) Economic Benefits

The aluminum can is the most valuable packaging to recycle and is the most recycled consumer product in the world today. Each year, the aluminum industry pays over $800 million for empty aluminum cans in US. This money goes to charity organizations. Money that is recovered form recycling aluminum help countries and their communities rebuild homes for the poor and support the needy.

c) Community Benefits

Aluminum can recycling enables many charitable organizations and groups to earn funds to further local projects. The money earned enhances programs, communities and improves the quality of people's life.

3.4 Different types of Scrap Can Packaging

The Institute of Scrap Recycling Industries, Inc. (ISRI) (http://www.isri.org) publishes specifications and practices for aluminum used beverage cans purchased and sold in the worldwide. ISRI publishes four definitions for used beverage cans scrap:

a) Shredded,
b) Densified,
c) Baled and
d) Briquette

3.4.1 Shredded UBC Scrap

The shredded UBC should have a density of 12 to 17 pounds per cubic foot. The shredded material should contain maximum 5 percent fines less than four mesh (U.S. standard screen size) and no more than 2.5 percent fines less than 12 mesh (U.S. standard screen size). The material must be magnetically separated and free of steel, lead, bottle caps, plastic cans and other plastics, glass, wood, dirt, grease, trash, and other foreign substances. No other items other than used beverage cans are acceptable.

3.4.2 Densified UBC Scrap

The densified UBC should have a density of 35 to 45 pounds per cubic foot. Each package should not to exceed 60 pounds. There should be banding slots in both directions of each package to facilitate bundle banding. The bundle range dimensions this is acceptable are 41" to 44" (length and width) and 51" to 56" (height). The only acceptable tying method would be using a minimum of 5/8" wide by 0.02” in thickness steel straps. The bundles are to be banded with one vertical band per row and a minimum of two horizontal girths.

c) Baled UBC Scrap

The baled UBC must have a minimum density of 14 pounds per cubic foot, and a maximum density of 17 pounds per cubic foot for un-flattened UBC and 22 pounds per cubic foot for flattened UBC. The minimum bale range dimensions would be 24" to 40" by 30" to 52" by 40" to 84". The only acceptable tying method would be as follows: Four to six 5/8" x 0.20" steel bands. The baled UBC are to be magnetically separated material and free of steel, lead, bottle caps, plastic cans, and other plastic, glass, wood, dirt, grease, trash, and other foreign substances.

d) Briquette UBC Scrap

The briquette UBC scrap should have a minimum density of 50 pounds per cubic foot. The nominal briquette dimension should range from 12 to 24 inches x 12 to 24 inches in uniform profile with a variable length of 8 inches minimum and 48 inches maximum. Briquettes shall be bundled or stacked on skids and secured with a minimum of one vertical band per row and a minimum of one girth band per horizontal layer. The maximum total package height should be 48 inches. The weight of each briquette bundle must not exceed 4000 pounds. Material must be magnetically separated, plastic, glass, dirt, and all other foreign substances.

The average price of the different UBC scrap packaging is shown in the table below. The average is taken from a period of 6 months: April 2006 to September 2006.

Different UBC Scrap Package	Average Price Per Pound (USD)
Shredded	0.70
Densified	0.71
Baled	0.73
Briquette	0.75
Loose	0.28

Table 3.2 Average Price of Different UBC Scrap

CHAPTER 4

CASE STUDY

4.1 BACKGROUND OF COMPANY

This case study is done on a Singapore company, Lian Gim Aluminum & Supply Pte Ltd, dealing with scrap metal processing. The company is located in 44 Woodlands Industrial Park E. The company have been operating for close to 10 years but the business have been stagnant due to the traditional operational methods used. During the process of the case study, it is noticed that there is no proper system to deal with the

a) Safety issues in the working area
b) Quality control for packaged aluminum cans sent for re-melting
c) Financial control of the whole process

In this case study, the problems of the company's system will be researched and listed out. Scientific methods are implemented to improve the whole operation system.

4.2 Analysis of the company's system

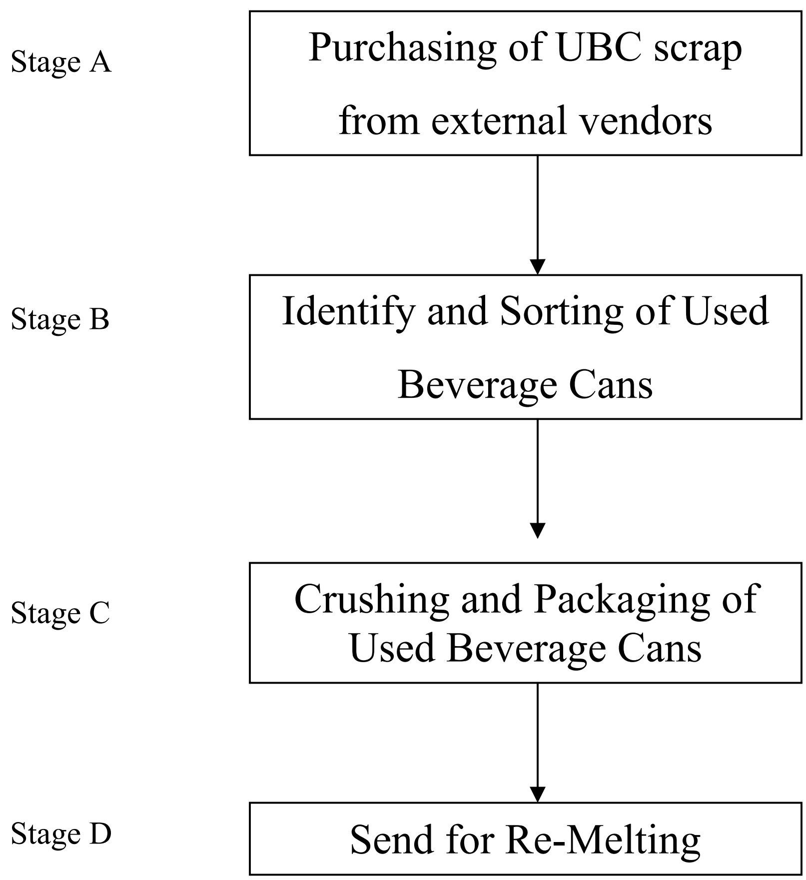


Figure 4.1 Current Process Used in Company

The total process of the collection to packaging for re-melting takes 30 days. In Stage A, the first 20 days of every month is used for purchasing and collection of UBCs from external vendors. No other activities is done during this 20 days. After 20 days of collection, Stage B will take around 4 days to complete, followed by 4 days of crushing and packaging of UBCs into bales. 2 days in taken in Stage D for loading of bales into transportation to be sent for exporter who will send the bales to either China or India for re-melting.

4.2.1 Techniques Used to Improve System

The current process of the company takes a long period of time to finish. It shows that the flow of the process can be shorten by using the Critical Path Analysis.

There are 3 phases in Critical Path Analysis:

a) Planning

In the planning stage, the sequence of activities that have to be carried out in order to complete the project is recorded down. A network representing the activities is drawn.

b) Analyzing and Scheduling

The critical path is then determined. A check is done to see whether the critical path can be shortened. An analysis table is drawn up to indicate the earliest and latest start and finish times for all activities and their available float.

c) Controlling

If delays are experience on the critical path, an action is decided to make up for the time loss through either overtime or more men and resources.

4.3 Cost Analysis of the System

From the system flow, it shows that there will be heavy workload towards the end of month. The table shows the approximate cost break down of the expenditure during the whole process. Approximation values are given due to the confidentiality of the company.

Day	UBCs Purchases	Wages	Overtime Wages	Utility Payment	Transportation	Total Expenditure
1	√	√		√		$350
2	√	√		√		$350
3	√	√		√		$350
4	√	√		√		$350
5	√	√		√		$350
6	√	√		√		$350
7	√	√		√		$350
8	√	√		√		$350
9	√	√		√		$350
10	√	√		√		$350
11	√	√		√		$350
12	√	√		√		$350
13	√	√		√		$350
14	√	√		√		$350
15	√	√		√		$350
16	√	√		√		$350
17	√	√		√		$350
18	√	√		√		$350
19	√	√		√		$350
20	√	√		√		$350
21		√		√		$150
22		√		√		$150
23		√		√		$150
24		√		√		$150
25		√		√		$150
26		√		√		$150
27		√		√		$150
28		√		√		$150
29		√	√	√	√	$1,000
30		√	√	√	√	$1,000

Table 4.1 Expenditure Break-down

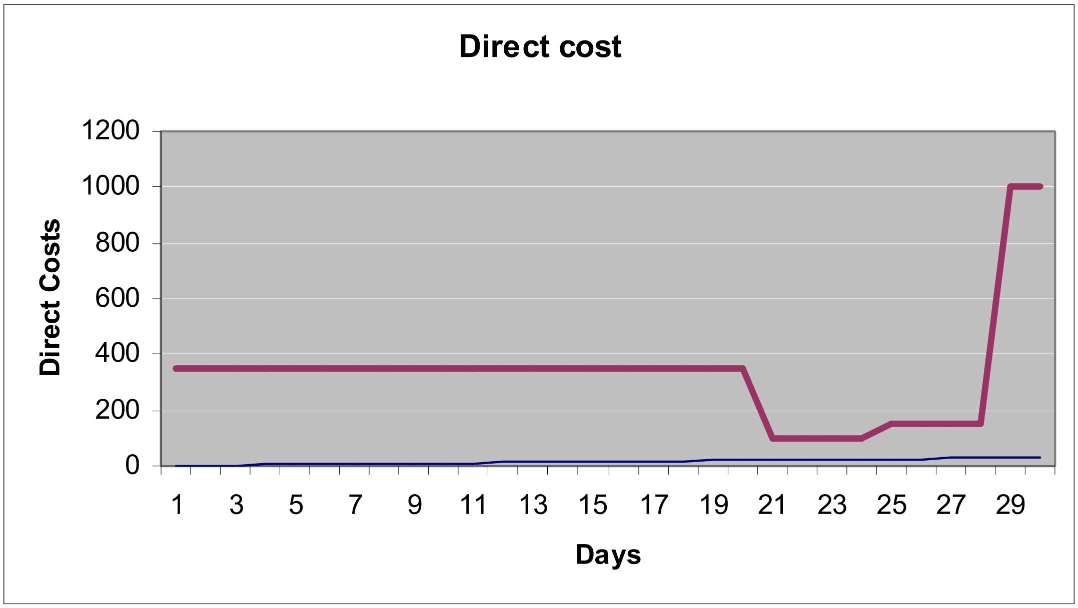


Figure 4.2 Graph of Expenditure Breakdown

Cost optimization can be used in cost analysis. In the cost analysis, there are 2 main factors to be considered: Direct cost and Indirect cost. The direct cost are cost that directly affect to the individual activities including wages, overtime, equipment rental, purchases and transportation. The indirect cost will include the costs which cannot attribute to any individual activity but are incurred in the operation of the company. This includes the employees' accommodation, administrative charges; utility charges. As seen in the graph, the expenditure at the end of the month is very high due to the cost incurred for the transportation of packaged scrap cans to exporters and the overtime wages. The direct costs and indirect costs are totaled and a graph plotted will determine the most economic Cost Schedule.

4.4 Safety Issues in the Working Area

4.4.1 Safety Problem 1

From the pictures below, the crushing machine is surrounded by many other equipments and items which will hinder one's working area and may cause serious injuries. It is also noticed that the employee working with the crushing machine is not in the correct attire for heavy duty work.

Figure 4.3 Dangerous Placement of Machine

Figure 4.4 Narrow Workspace

4.4.2 Safety Problem 2

In the picture shown below, there is not fencing around the crushing machine. It is dangerous for the worker to be operating the machine without proper fencing.

4.4.2 Health and Safety Management

An accident is any unplanned, uncontrolled, unwanted or undesirable event which interrupts an activity or function. Everyone from the top to the bottom of the organization has the responsibilities to avoid accidents. The above safety issue mentioned should not only be the employees' problem but also it concerns the whole management. A safety policy should be implemented to avoid unwanted accident.

Causes of an accident can be classified under several headings:

a) Plant which includes narrow walkway, electrical hazards
b) Equipment including dangerous equipment, defective guard
c) Environment including high noise, poor lighting, poor ventilation
d) People whom are careless, unskilled, over stress, untrained
e) Systems which are of poor procedure, bad housekeeping

The effects of these accidents will generally be:

a) Injury
b) Damage to Equipment
c) Loss of Life
d) Emotion that follows injury, pain and death.

To prevent unwanted accidents happening to the company, a systematic planning can be implemented. A system for managing safety should include:

1) workplace inspection
2) accident inspection and follow up
3) safety training

Workplace inspection should include audits and reviews, surveys, tours, sampling, hazard and operability studies. Accident inspections require the collection of data and the checking, selection and analysis of evidence. The result of the investigation used to decide the causes of the accident, notifying the injured person, recording and report findings. Safety training must be systematic and follow the plan-do-check-act procedure for continuous improvement.

4.5 Quality Analysis of Bale Scrap Cans

There is no quality control standard currently used by the company to control the size of the baled scrap cans. A random measurement to different bale stacks show that without a quality control for the crushing process, the bale stacks come in all sorts of sizes. The universal standard size for baled stack is 24” to 40” (width) x 30” to 52” (length) x 40” to 84” (height). Without a standard, most of the bale stacks measured was more or less than the required dimensions. The dimensions of the bale will be with standard when the number of cans is in the range of 8000 to 10000 and the weight of the cans in the range of 130 kg to 170kg.

Baled Stack	No. of Cans	Weight (kg)	Width (24" to 40")	Length (30" to 52")	Height (40" to 84")
1	11000	185	X	X	√
2	8500	142	√	√	√
3	9000	150	√	√	√
4	10000	167	√	√	√
5	10500	175	X	√	√
6	7000	116	X	X	√
7	8000	133	√	√	√
8	9500	158	√	√	√
9	7500	125	X	√	√
10	8400	140	√	√	√

Table 4.2 Random measurement check for bale dimension

The bales that are within the standard can be sold at $325 to $425. The company will make a loss when the bales are out of standard. The exporters of scrap bales pay for additional dimensions and deduce cost for lesser dimensions. Therefore there is a need to set up a quality control system for the bale sizes so that the dimensions of the bales are in constant sizes and the company will not make a loss.

Four main steps can be used to set up a control standard for the bale scrap cans:

1) First through the London Metal Exchange Website, the standard bale size is set up.

2) Use of the standard number of cans during crushing to ensure that every bale is within the standard range.

3) Measurements of random bale batches to ensure that the standard is kept constant.

4) Every random result is compared with the standard.

5) Corrective actions are taken when necessary.

The acceptance sampling method and control chart method can also be used.

CHAPTER 5

FURTHER WORK & CONCLUSION

5.1 Problems Encountered

The major problem of faced in developing this project is the improper project aim chosen during the initial stage. This resulted in having too much topics to research and the scope of project went too broad. Instead of focusing on one topic in the case study, there were three topics. As the topic scope was too broad, my focus was diverted into different sections and ended up with unnecessary information for the project.

5.2 Achievements of the Aims and Objectives

This study aims to provide readers with more knowledge on aluminum and its recycling properties. It also aims to study the life cycle of both aluminum and recycling cans.

The project have successfully completed with the main objectives of this study obtained.

- A research and study was done on the existing process of recycling of aluminum beverage cans.
- Data was gathered on the procedures of collection, crushing, packaging of aluminum beverage cans.
- The analyze on key criteria of the whole process including cost, quality and safety.
- New scientific methods were recommended to improve criteria of the whole process.

5.3 Further Works

A further comprehensive study can be made to the company to make this research more valuable. Several works can be made in the future:

- Focusing on a main point (Safety, Quality or Cost) so that better results can be obtained.
- The scientific methods can further researched and implemented into the company's system.

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Appendix A

Project Specification

University of Southern Queensland
Faculty of Engineering and Surveying

ENG 4111/2 Research Project

PROJECT SPECIFICATION

PROJECT TITLE:	**Analysis of the Recycling Method for Aluminum Soda Cans**
STUDENT NAME:	He Minqian Belinda / 0050015037
SUPERVISOR:	Dr. Harry Ku
SPONSER:	Lian Gim Aluminum & Supply Pte Ltd

PROJECT AIM:

The project seeks to investigate and study on the whole recycling process of current aluminum soda cans from collection to smelting with an aim to recommend scientific methods for improvement of the whole process at the end of the project.

PROGRAMME:

1. Research and study on the existing process of recycling of aluminum soda cans.
2. Gather data on the procedures of collection, crushing, packing and smelting of aluminum soda cans.
3. Gather data on key criteria including cost, quality and safety
4. Analysis on the key criteria of the whole process including cost, quality and safety
5. Investigate and develop new scientific methods using technique used in Engineering Management Science and Production Engineering to improve the key criteria of the whole recycling process.

AGREED: Belinh (student) ____________ (Supervisors)

He Mingqian Belinda
0050015037.

(date) 26 / 03 / 06

Appendix B

Aluminum Cans & Scrap Commodity Report

Metals: Aluminum Cans & Scrap

COMMODITY PROFILE

North Carolina Department of Environment and Natural Resources
DIVISION OF POLLUTION PREVENTION AND ENVIRONMENTAL ASSISTANCE

MARKETS ASSESSMENT 1998

OVERVIEW

According to the U.S. Geological Survey, the estimated primary aluminum production (from virgin material) for 1997 was 3.6 million metric tons, while secondary aluminum production (from scrap material) was 3.7 million metric tons. Of this recovered metal, 59 percent came from new (manufacturing) scrap and 41 percent came from old (discarded aluminum products) scrap. Old scrap accounted for approximately 17 percent of the total apparent domestic consumption. Apparent consumption is total aluminum production plus net imports plus stock changes.[1]

Used (aluminum) beverage can (UBC) scrap is the major component of processed old scrap, accounting for approximately one-half of the old aluminum scrap consumed in the United States. Most UBC scrap is recovered as aluminum sheet and manufactured back into aluminum cans. Most of the other types of old scrap are recovered in the form of alloys used by the die-casting industry; the bulk of these diecasts are used by the automotive industry.[2]

Overall, the aluminum industry produced 100.5 billion cans, or 1.5 million tons, in 1997, with the weight of the average can declining 2.1 percent to 32.57 cans per pound. The typical aluminum beverage can has a recycled-metal content of 54.7 percent.[3] The total estimated UBCs recovered nationally in 1997 was 63.3 billion cans (972,000 tons), representing an overall recovery rate of 63 percent. The average end-user price for UBCs in the Southern United States region for 1997 was $1,142.50 per ton or $0.57 cents per pound.

In North Carolina, out of an estimated total supply of 42,891 tons of UBCs, approximately 21,076 tons were recovered by the public and private sectors. This represents a 49 percent overall recovery rate for UBCs in North Carolina in 1997.

Figure 1: Supply of Aluminum Cans

Year	Number of Cans Shipped (Billions)[1]	Number of Cans Per Pound[1]	Pounds of Cans Shipped	United States Population[2]	Per Capita Consumption (Pounds)	Per Capita Consumption (Number of Cans)
1993	94.2	29.51	3,192,138,258	257,752,702	12.38	365.47
1994	99	30.13	3,285,761,699	260,292,437	12.62	380.34
1995	100.7	31.07	3,241,068,555	262,760,639	12.33	383.24
1996	99	31.92	3,101,503,759	265,179,411	11.70	373.33
1997	100.5	32.57	3,085,661,652	267,636,061	11.53	375.51
Average	**98.68**	**31.04**	**3,181,226,785**	**262,724,250**	**12.11**	**375.58**

Source: 1) The Aluminum Association
2) U.S. Census Bureau

SUPPLY

Generation

The domestic supply of aluminum cans is presented in Figure 1. The weight of an individual aluminum can has been decreasing during the past five years as manufacturers have improved production efficiency. The number of aluminum cans produced by a pound of aluminum has increased from 29.5 cans per pound in 1993 to 32.6 cans per pound in 1997. Thus, when determining the trend of per capita supply, it is necessary to look at the number of cans rather than pounds being supplied. From 1993 until 1995, the quantity of aluminum cans consumed per person per year rose from 365 to 383, an increase of 18 cans per person. In 1996, that figure dropped to 373 cans per person per year, but began to rise again in 1997. The 1997 estimate is very close to the average of the past five years (approximately 376 cans), showing no definite trend of increase or decrease.

The generation and recovery estimates of UBCs in North Carolina are presented in Figure 2. The projections for generation of UBCs for 1998-2002 were estimated by taking the 1997 per capita UBC supply rate (11.53 pounds per person), multiplied by the anticipated North Carolina population for the next five years. The generation figure assumes that the number of aluminum cans per pound will remain relatively constant, and the average consumption per person will remain constant as well. However, the supply of UBCs during the next five years depends largely on the effects of increasingly popular alternative beverage container materials. The PET plastic bottle is one material that has seen significant growth recently. Much of the growth in PET usage has been attributed to its aggressive capture of market share in the soft drink container business. The fastest growing market for PET bottles is single serve containers, especially 20-ounce drink bottles.[4]

Recovery

Based on survey results from North Carolina's private industry and local governments, the estimated total UBCs recovered in North Carolina in 1997 was 21,076 tons. This translates into a recovery rate of 49 percent, showing a four-percent increase from the 1994 estimated UBC recovery rate of 45 percent. The State of North Carolina implemented an aluminum can ban in July 1994, but even with this mandate, a significant portion of the UBCs continue to be landfilled. In Figure 2, the projected quantities of UBCs recovered for 1998-2002 are based on the current per capita recovery rate (5.67 pounds per person), adjusted for future population estimates.

The national recovery rates for UBCs are presented in Figure 3 along with recovery rates for North Carolina. In 1997, the estimated national recovery rate for UBCs was 63 percent. This figure is an average of the estimated recovery rates reported by The Container Recycling Institute (59.1 percent) and The Aluminum Association (66.5 percent). According to the Container Recycling Institute, approximately 7.4 billion cans out of the 66.8 billion recycled in 1997 are imported cans.[5] Although it is difficult to accurately determine the exact quantity of cans being imported for recycling, an estimated figure should be taken into account to accurately reflect domestic generation and recovery.

Other Aluminum Scrap

Aluminum UBCs continued to make up the largest portion of the scrap aluminum purchased domestically in 1997. However, discarded aluminum products (old scrap) other than UBCs are also significant sources. Figure 4 shows a breakdown of the total amount of purchased old scrap for 1996 and 1997. Purchased old scrap includes the materials that are purchased from post-consumer sources and

Figure 2: Estimated Generation and Recovery of Aluminum Used Beverage Containers (UBCs) in North Carolina

	1994[1]	1997	1998	1999	2000	2001	2002
Generation (Tons)[2]	43,740	42,891	43,504	44,073	44,601	45,055	45,513
NC Population[4]	7,024,000	7,436,690	7,542,996	7,641,684	7,733,097	7,811,951	7,891,238
Estimated NC Recovery (Tons)[3]	19,683	21,076	21,377	21,657	21,916	22,140	22,364

Sources: 1. N.C. DENR, Assessment of the Recycling Industry and Recycling Materials in NC: 1995 Update
2. The Aluminum Association
3. North Carolina Recycling Survey, 1998
4. North Carolina Office of State Planning

Figure 3: Estimated North Carolina and National Recovery rates for UBCs

	1991	1992	1993	1994	1997
Estimated North Carolina Recovery[1]	14.5%	22.6%	38.8%	45%	49%[3]
Estimated United States Recovery[2]	62.4%	67.9%	63.1%	65.4%	63%

Sources: 1. N.C. DENR, Assessment of the Recycling Industry and Recycling Materials in North Carolina: 1995 Update
2. The Aluminum Association
3. North Carolina Recycling Survey

Figure 4: United States Consumption of Purchased Old Aluminum Scrap for 1996-1997 (Metric Tons)

Material Type	1996	Percent	1997	Percent
Aluminum Cans	871,000	51%	949,000	57%
Castings, Sheet, and Clippings	764,000	45%	587,000	35%
Other	61,700	4%	110,000	7%
Aluminum – Copper Radiators	17,800	1%	25,400	2%
Total	**1,714,500**	**100%**	**1,671,400**	**100%**

Source: U.S. Geological Survey, 1996 and 1997 Annual Reports for Aluminum, Table 4.

does not include in-house or pre-consumer scrap derived from the aluminum production process. Aluminum UBCs were 57 percent of all the old scrap aluminum purchased domestically in 1997. Castings, sheet, and clippings have the second largest share, at 35 percent. Aluminum-copper radiators and other aluminum make up the remaining small portion of old scrap.

Figure 5 shows the generation and recovery of all aluminum for 1993-1997, including old and new scrap. The total secondary recovery figures are different from the figures for scrap aluminum purchased in Figure 4. The total secondary recovery is the estimated total quantity (tons) of aluminum and aluminum alloy products manufactured by secondary aluminum producers derived from purchased aluminum scrap. On average, for the past five years, old and new scrap have held an approximately even share of the total scrap consumed.

Of the total available supply, the percentage of all aluminum recycled remains at around 40 percent. However, a large portion of aluminum products are durable goods, and

Figure 5: Generation and Recovery of the Total Domestic Aluminum Supply (thousand metric tons)

	1993	1994	1995	1996	1997	Average
Recycled from New Scrap	1,310	1,580	1,680	1,730	2,160	1,692
Recycled from Old Scrap	1,630	1,500	1,510	1,580	1,530	1,550
Total Secondary Recovery	2,940	3,090	3,190	3,310	3,690	3,244
Apparent Supply	7,920	8,460	8,010	8,330	8,850	8,314
Total Secondary Recovery (Percent)	37%	36%	40%	39%	42%	39%

Source: U.S. Geological Survey, 1997 and 1998 Annual Reports for Aluminum, Table 1.

Figure 6: United States Aluminum Industry Net Shipments (thousands of metric tons)

Major Market	1995	% of Total	1996	% of Total	1997	% of Total
Transportation	2,608	27.3%	2,640	27.5%	2,990	29.2%
Containers & Packaging	2,308	24.1%	2,175	22.6%	2,220	21.7%
Building & Construction	1,215	12.7%	1,325	13.8%	1,325	12.9%
Electrical	657	6.9%	671	7.0%	708	6.9%
Consumer Durables	621	6.5%	655	6.8%	694	6.8%
Machinery & Equipment	570	6.0%	569	5.9%	626	6.1%
Other	279	2.9%	291	3.0%	318	3.1%
Domestic, total	8,258	86.3%	8,325	86.6%	8,881	86.8%
Exports	1,307	13.7%	1,287	13.4%	1,355	13.2%
Aluminum Total	**9,565**	**100.0%**	**9,613**	**100.0%**	**10,237**	**100.0%**

Source: The Aluminum Association

it is important to note that the apparent supply of aluminum is going to be more than the amount of aluminum actually available for consumption as scrap within the same year. Since no data are available for the amount of aluminum (other than UBCs) recovered locally in North Carolina, the recovery rates are assumed to be similar to the national rates.

DEMAND

The demand for UBCs and other aluminum scrap is dependent upon the supply and demand for primary aluminum derived from virgin material. The demand for primary aluminum is determined by the domestic and international demand for aluminum ingot and aluminum finished products. In 1997, domestic primary production was estimated to be 3.6 million metric tons, which shows no relevant increase in production from 1996.

Transportation accounted for an estimated 32 percent of domestic consumption in 1997; containers and packaging, 26 percent; building and construction, 16 percent; electrical and consumer durables, eight percent each; and other uses, 10 percent.[6] The international distribution of United States goods, which is included in the United States aluminum industry net shipments (Figure 6). is as important as domestic consumption. Exports for aluminum remain the third largest component of all shipments, with a 13.2 percent share, making international markets for aluminum vital to the industry.

The containers and packaging segment of US shipments of aluminum is decreasing. The increasing use of plastics in soda bottles is having a negative effect on the overall demand for aluminum packaging. Figure 6 shows the decreasing percentage of containers and packaging in United States shipments of aluminum for 1995, 1996, and 1997, with the percentages being 24.1, 22.6, and 21.7 respectively.

Figure 7. Demand Estimates for Aluminum Scrap in the United States and North Carolina

	1997	2002
Old Scrap Aluminum Consumed in United States (tons)	1,671,400	1,772,158
North Carolina Population (thousands)	7,243	7,891
North Carolina Demand (tons)	47,260	50,109

The aluminum industry currently is attempting to counter the use of plastics through a series of advertising and marketing efforts supporting the use of aluminum cans.

The largest and most promising segment of United States shipments of aluminum is the transportation industry. Aluminum is a desirable material in the industry because of its relative strength and lightweight properties. The average aluminum content per passenger car jumped to 252 pounds in 1996, up from 191 pounds in 1991.[7] If the use of aluminum in automobiles continues to grow, then the prosperity of the transportation industry may determine the demand for aluminum. Since the demand for lighter cars with increased fuel efficiency is expected to rise, this presents a competitive advantage for the aluminum industry over the steel industry.

Overall, losses in the packaging industry should be offset by the increased use in the transportation industry, allowing for continued growth. Additionally, a strong international (global) economy will continue to be the driver for all aluminum goods, and should be considered the best indicator of what the demand for aluminum will be in the future.

The per capita demand for all scrap aluminum can be calculated by dividing the 1997 scrap consumption rate (Figure 4) by the national population in 1997 and the projected population for 2002. Figure 7 shows the estimated demand for scrap aluminum in North Carolina for 1997 and 2002. A per capita demand rate was established for 1997's current demand (12.7 pounds per person) and projected outward for 2002. Demand is expected to continue to exceed supply of aluminum scrap in North Carolina. Depending on the prices for primary aluminum, the industry should easily be able to absorb additional amounts of aluminum scrap as it becomes available.

Specifications

Since most aluminum cans are processed into new cans, it is imperative that only high quality scrap is generated from processors. If secondary aluminum needs any additional processing, then limited cost savings will be realized by using scrap. According to the Institute of Scrap Recycling Industries, UBC scrap must be free of steel, lead, bottle caps, plastic cans, and other plastics, glass, wood, dirt, grease, trash, and other foreign substances. All UBC scrap must undergo a magnetic separation process to ensure the removal of all ferous materials; any free lead is basis for rejection.[8]

Profiles of Major End-Users

The aluminum industry encompasses a group of highly specialized businesses. For UBCs to be recycled back into new cans, they pass through many different handling and processing stages, which are listed below.

1. UBCs are collected curbside or at local drop-off centers by residents. Also, some individuals and businesses collect cans and bring them to market.
2. UBCs are collected by intermediate processors such as material recovery facilities (MRFs) and are separated from other food and beverage containers. Some MRFs have balers, which allows them to ship the UBCs to end users, brokers, or toll processors.
3. MRFs without balers and businesses or individuals that wish to market UBCs individually may bring their cans to a scrap dealer. Scrap dealers consolidate volumes of UBCs and sell them to larger scrap dealers with balers.
4. Baling operations consolidate bales of UBCs until large truckload quantities are generated.
5. Brokers and can sheet manufacturers purchase the truckload quantities of baled cans.
6. Can sheet manufacturers typically have arrangements with toll processors to refine the metal and melt it into ingots. Toll processors act as contractors and are paid by can sheet manufacturers to process the materials and typically are not involved in purchasing or selling the aluminum materials.
7. Can sheet manufacturers melt the ingots into can sheet.
8. Can manufacturers punch out cans from the can sheet, produce lids for the cans separately, then sell the cans back to the beverage industry.

Figure 8: UBCs Five-Year Price History

End Users Price (per ton)	1993	1994	1995	1996	1997
Quarter 1 (March)	$690.00	$750.00	$1,390.00	$1,100.00	$1,170.00
Quarter 2 (June)	$660.00	$800.00	$1,320.00	N/A	$1,130.00
Quarter 3 (Sept)	$700.00	$1,070.00	$1,280.00	$990.00	$1,140.00
Quarter 4 (Dec)	$580.00	$1,310.00	$1,150.00	$1,010.00	$1,130.00
Average	$657.50	$982.50	$1,285.00	$1,033.33	$1,142.50

Source: *Recycling Times*, "The Markets Page."

While North Carolina does not host any end-users, the surrounding Southeastern United States has a considerable share of the major United States end-users. These companies are described below. These descriptions do not imply endorsement by the North Carolina Division of Pollution Prevention and Environmental Assistance (DPPEA) or the North Carolina Department of Environment and Natural Resources (DENR) of any company or its products.

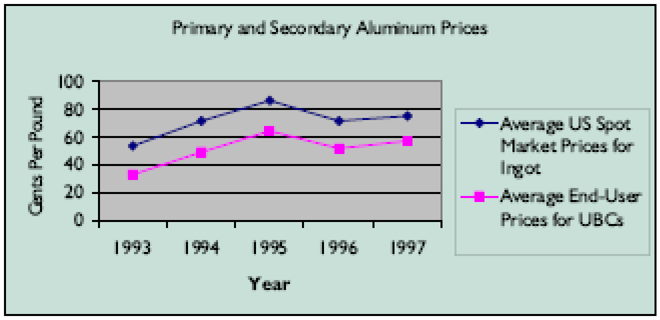
Alcan Aluminum Corp., Mayfield Heights, Ohio, recycles cans at its U.S. facilities in Berea, Kentucky; Greensboro, Georgia; and Oswego, New York. In 1997, Alcan bought 577 million pounds of scrap cans, capturing 28 percent of the market. The company paid suppliers $375 million for UBCs.[9] In addition to the company's can recycling activities, Alcan's Shelbyville, Tennessee, secondary aluminum facility annually recycles approximately 115 million pounds of post-consumer scrap, such as cookware and lawn furniture to produce alloys primarily for the automobile industry.

Reynolds Metals Company, Richmond, Virginia, took in 398 million pounds of UBCs last year (a 19-percent share), up 11 percent from 1996. The firm also bought 35 million pounds of other aluminum scrap at its other locations nationwide in 1997. Reynolds subsequently sold its consumer recycling division to Baltimore-based Wise Metals.[10] Reynolds operates two processing facilities in North Carolina: in Clayton, near Raleigh, and in Charlotte. Aluminum cans are processed through a magnetic separator and are shredded. Shredded UBCs are primarily shipped to Reynolds' reclamation facility in Sheffield, Alabama. Other aluminum scrap is processed, baled, and shipped to another reclamation plant in Richmond, Virginia.

Anheuser Busch Recycling Corporation – ABRC, St. Louis, Missouri, is the largest aluminum recycler in the world, a position it has held for 10 consecutive years. It recycled more than 648 million pounds of aluminum in 1997, equal to 20 billion cans. The firm captured 32 percent of the market, an increase of nearly seven percent during the previous year.[11] In 1996, ABRC recycled the equivalent of more than 110 percent of the Anheuser-Busch beer cans that were sold. Cans that are purchased by ABRC from processors are shipped to major can sheet manufacturers such as Alcan and Alcoa. Metal Container Corporation (MCC), which is a subsidiary of Anheuser Busch, purchases the can sheet from these manufacturers and makes 60 percent of Anheuser Busch's cans. MCC is also a major supplier to the soft-drink industry, producing more than 21 billion cans and 22 billion lids in 1997.

Aluminum Company of America – Alcoa, Maryville, Tennessee, operates the largest aluminum can sheet production facility in the world in Alcoa, Tennessee. Alcoa Recycling Company, a wholly owned subsidiary of Alcoa, purchases aluminum can scrap for this mill, and its other facility in Newburgh, Indiana. The company uses two materials processors in North Carolina to process UBCs for end-use: United Metal Recyclers in Kernersville and Wagram Paper Stock in Scotland County. Alcoa also buys cans from the Western part of the state for direct shipment into its Marysville, Tennessee, processing facility. Alcoa also currently operates a primary aluminum production facility in Badin, Stanly County, North Carolina.[12]

IMCO Recycling, Irving, Texas, is the world's largest secondary aluminum recycler and also recycles magnesium and zinc. IMCO's primary business is the recycling of customer-owned materials in exchange for a processing fee. Its customers include aluminum companies such as Alcoa, Kaiser Aluminum, and Wise Metals who use recycled aluminum to produce containers, building construction materials, and automotive products. The company processes the aluminum at 16 United States plants and also owns a 50-percent interest in a German plant. IMCO owns two processing facilities in Tennessee. Their Rockwood facility has an annual melting capacity of 220 million pounds and the Loudon facility has an annual capacity of 180 million pounds.



Sources: 1) *Recycling Times*, The Markets Page
2) U.S. Geological Survey, *Minerals Commodity Summaries*, January, 1998.

SUPPLY / DEMAND RELATIONSHIP

Price History

The five-year price history for UBCs is displayed in Figure 8. The price fluctuations paralleled those for primary aluminum ingot (Figure 9).

Major international economic events (both positive and negative) appear to be the largest contributor to fluctuations in supply and demand for aluminum. In the first half of 1998 the UBC market experienced an inter-related effect of a major economic downturn in Asia, and a contrasting booming United States economy. Recyclers in the scrap metal industry, as well as other recycling industries, claim that the boost in the value of the United States dollar is a double-edged sword. On one hand, the dollar is so strong, that importing raw material from overseas is cheaper than buying abroad. On the other hand, Asian currencies have devalued greatly compared to the United States dollar.[13] Without the significant demand for finished aluminum products from Asian markets, major surpluses are resulting, causing a slump in prices for both primary and secondary materials.

As of June 1998, the price of UBCs had dropped to around 35 cents per pound, down 22 cents (39 percent decrease) from last year's average price of 57 cents per pound. According to one local processor, aluminum UBCs are typically a low margin / high volume commodity. With the current low prices, it becomes difficult to obtain the desired volumes and, consequently, difficult to move the UBCs.[14]

CONCLUSION

Unlike most recyclable commodities, the prices for UBCs and other aluminum scrap are derived from perceived demand. If there is strong global demand for primary aluminum in the future, then the demand for aluminum UBCs will continue to be favorable as well. Regardless of the fact that aluminum prices are currently relatively low, the demand for UBCs and other aluminum scrap still remains strong enough for the material to be recycled by local governments and private industry. The cost savings and actual revenue generated from recycling aluminum cans should enable UBCs to continue to be included in all recycling programs.

At the average 1997 price of 57 cents per pound, the estimated 23,000 tons of UBCs that were disposed last year had a value of approximately $26 million dollars. Although UBCs are a high volume / low margin commodity, with $26 million dollars worth of available supply, there is still an opportunity for new or existing collection and processing businesses to capture the materials profitably.

In North Carolina, the current estimated recovery rate of approximately 50 percent is significantly lower than what would be anticipated from a 100 percent diversion mandate. The aluminum can ban, which went into effect in North Carolina in July of 1994, has resulted in an estimated increase in recovery of only approximately five percent. Although there are no calculations of secondary end use capacity available, there are no indications that the aluminum industry would not be willing and able to adapt to the consumption of all aluminum cans supplied from North Carolina in the future. Thus, an increase in the aluminum recovery rate statewide depends more on improved collection efficiency, and not necessarily increased capacity or markets for the material.

RECOMMENDATIONS

The state should take the following steps to increase UBC recycling:

- *Determine why aluminum cans are still being sent to landfills.* The state should analyze existing recycling programs in all counties and make sure that residents and businesses have adequate access to recycling. Either drop-off or curbside services need to be available locally for UBCs to be properly diverted from disposal. This alternative is more viable than enforcing the aluminum can ban by visual inspection at local landfills.
- *Educate local government recycling coordinators that there are still UBCs to be recovered.* A barrier to increasing aluminum can recovery is the misperception that UBC recovery is at or near its peak, because of the landfill ban and the relatively high value of UBCs.
- *Improve efficiency of existing recycling programs.* To increase the quantity of aluminum collected throughout the state, equitable, waste reduction based collection systems such as pay-as-you-throw (PAYT) should be encouraged. PAYT programs charge system users based on the amount of waste generated, providing financial incentives to reduce and recycle. Consistent, targeted educational campaigns have also been shown to increase participation in recycling programs.
- *Encourage small retail / commercial sector recovery.* The first step the state should take to encourage recovery from this sector is to work with counties to increase awareness of the law among businesses. Since the can ban went into effect more than four years ago, awareness may have waned, and it may be time now to emphasize the importance of complying with the law. In addition, municipalities and counties should be encouraged to examine the feasibility of adding small businesses to existing recycling programs, since UBCs are a revenue generating material.
- *Determine the number of multi-family units in North Carolina that are not being serviced with recycling.* A potentially significant amount of UBCs from the residential waste stream may be discarded in multi-family units. Determine the feasibility of including these units in existing local government recycling programs would help capture additional UBCs.

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[9] "Recycling levels Rise." *Resource Recycling.* March 1998. p. 64.
[10] Ibid.
[11] "Recycling levels Rise." *Resource Recycling.* March 1998. p. 64.
[12] N.C. DENR. *Assessment of the Recycling Industry and Recycling Materials in NC: 1995 Update.* p. 4-53.
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APPENDIX C

Development in Aluminum Recycling

Developments in aluminium recycling

by S Pownall*

Recycling aluminium conserves resources but also requires less energy to process than beuxite or alumina. Rising energy costs have led the secondary aluminium industry to consider where savings can be made. This article describes the development of an aluminium recycling plant which incorporates the latest furnace technology and takes environmental considerations into account whilst maximising energy efficiency.

The first impression of the secondary aluminium industry may well be of an industry which is overshadowed by the primary producers. However, it is an industry with an extremely important role to play, in terms of energy saving, environmental protection, and in the development of new energy saving and pollution control technology – technology which will not only improve its own processes but which will also have inevitable spin-offs into other industries.

The aluminium scrap business is of major importance to the aluminium industry. Consumption of aluminium in the UK is about 510,000 tonnes a year, with up to 30% of that being reclaimed from scrap. Using secondary aluminium conserves energy; the production of primary aluminium from bauxite and alumina requires 250 GJ and 233 GJ per tonne of ingot respectively, whereas secondary aluminium melting requires only 14–15 GJ per tonne. In addition to saving energy, recycling helps to conserve resources and relieves the pressure on overburdened dumping sites, contributing to environmental protection.

Until recently, energy conservation within the secondary aluminium industry was not considered critical. Priority has always been given to finding feed material at the right price, blending it, to maximise the financial return, and finding a market for the product. However, the rising cost of energy since the mid 1970s has stimulated research to develop new and more efficient processes for aluminium scrap recovery. Since the secondary aluminium industry uses up to 3.10 million GJ/year of energy for melting, there is a direct saving to be gained from even the smallest increase in fuel efficiency. In addition, there are further savings to be made indirectly; 20 tonnes of usable secondary aluminium can be produced with the same amount of energy needed to produce 1 tonne of primary aluminium. Any extra metal recovery within a secondary melting furnace can, therefore, be justified twenty times over. A properly designed furnace can result in reduced dross formation, leading to significant energy savings on dross milling and remelting. The use of new technology could also allow the economical recycling of materials which are currently being wasted.

Sources of scrap

The largest sector of the secondary aluminium industry consists of secondary smelters, which recover over 150,000 tonnes a year of aluminium scrap, converting it to secondary ingot by remelting or refining, figs 1 and 2. However, the quality of the scrap available to the secondary smelters is deteriorating. The primary and wrought industries are using increasing amounts of clean scrap, leaving the secondary smelters with the contaminated material. The secondary smelters are, therefore, having to develop energy efficient methods of dealing with such scrap in order to stay in business, fig 3.

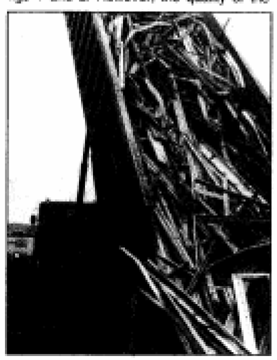


Fig 1 *Raw material being delivered to the secondary smelter*

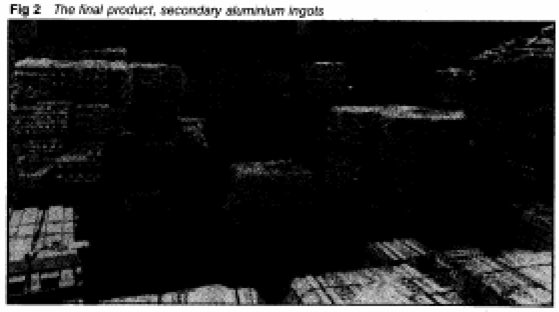
Technically it is possible for smelters to recover almost all types of scrap; in practice, recycling is constrained by economic factors. The high cost of controlling toxic furnace emissions, for instance, is a restraint on recycling scrap containing plastics and other organic materials. Potentially recoverable aluminium totalling 12,500 tonnes a year is lost as a contaminant in non-ferrous and ferrous metal scrap, for example because its separation is uneconomical. There are also complex types of aluminium scrap which cannot yet be recycled economically. This complex material includes glazing bar with lead flashings, thermal barrier window frames, and low-grade coated scrap and laminates. In addition to the complex and contaminated scrap, about 77,000 tonnes of aluminium foil and packaging are thrown away because it is uneconomical to collect and its recycling is dogged by heavy melt losses using conventional equipment.

A good source of secondary aluminium is cans. In the United States over 55% of all aluminium cans are recycled, whereas in the UK less than 1% are recovered. This too is an area into which the secondary aluminium industry is planning to develop. Can collection schemes are being instigated, and, once the public is sufficiently informed, it is hoped that these will begin to improve the percentage recovery rate, fig 4.

Recycling plant and equipment

The secondary industry is moving towards the design of energy efficient furnace plant and equipment which can deal with the new types of scrap efficiently, and towards the optimisation of plant already in existence, to reduce energy consumption. A certain amount of energy has already been saved by the producers at very little cost, by keeping furnaces well maintained, measuring fuel consumption and planning production for greatest efficiency. Some plants have been retrofitted with updated energy saving equipment, and improved by the installation

Fig 2 *The final product, secondary aluminium ingots*



* S Pownall BSc is at J McIntyre (Non Ferrous) Ltd.
At the time of writing this article, the McIntyre plant was under construction. It was commissioned in November 1987 and will start production this month.

Fig 3 *Typical aluminium scrap,* **above** *cast aluminium,* **below** *baled old rolled aluminium*

of better combustion equipment. The incorporation of recuperators, the control of air to maintain consistent combustion, the use of new ceramic-fibre linings and the recovery of waste heat have all contributed to energy saving within the industry.

Three types of secondary aluminium furnace are presently available from British suppliers: the large reverbatory furnace, and rotary furnace both of which can be oil or gas fired, and the induction furnace. Reverbatory furnaces are the most widely used for aluminium melting but in many cases recuperators have still not been fitted and their efficiency is generally about 8–10%. Large volumes of scrap can be charged into the well of these furnaces; however, direct flame impingement tends to result in substantial melt losses. Rotary furnaces are efficient in terms of metal recovery and are widely used for melting low grade scrap; melting and refining is assisted by the rotating action of the furnace. In normal operation, a quantity of metal is melted in a molten bed beneath a flux, thereby minimising oxidation. However, the use of salts necessitates costly, large volume, fume filtration control, and the furnaces are difficult to feed. Induction furnaces are also efficient in terms of metal recovery, with the exception of melting slightly contaminated, high surface area to volume ratio, coated scrap. This type of furnace is unsuitable for salt flux refining, and tends to be used only for high grade scrap. Like the rotary furnaces, a large volume capacity of fume treating equipment is required, for which energy costs run at about £1000/year per 1000 cfm. On initial observation, induction appears to be the most energy efficient of the three furnaces, converting about 50% of the electrical energy into the metal charge. However, because electricity is converted from fossil fuel at about 34% efficiency, the overall energy efficiency can only be considered to be about 17%, fig 5.

An energy efficient recycling system

Although the secondary aluminium industry is moving towards equipment which is both energy efficient and able to melt all types of aluminium scrap without associated pollution problems, there is as yet no system available on the market which meets these criteria. In deciding to update its aluminium operation, J McIntyre (Non Ferrous) Ltd therefore found it necessary to develop a furnace system in conjunction with its sister company J McIntyre (Machinery) Ltd to incorporate all the recent advances in energy efficiency, pollution control and furnace technology and create the complete aluminium recycling plant.

The new secondary aluminium melting plant which is currently under construction at J McIntyre (Non Ferrous) Ltd is a combination of new and existing technology, based on a closed well and a dry hearth furnace. The system takes a different approach to aluminium melting, both in terms of the shape and design of the furnaces used, and in the installation of new equipment. This includes hot gas recirculation with flue gas purification, an efficient recuperator/regenerator heat recovery system, and an innovative process whereby pyrolysis gases of sufficient calorific value can be fed back into the furnace as hot, clean gas. The most important components of the plant are described below.

Closed well furnace: The traditional closed well furnace offers quite good metal recovery but suffers from slow melting rates and high energy costs per tonne of ingot. To overcome the energy consumption problem, a furnace floor with a calculated slope has been developed for the new system, resulting in a substantial improvement in heat transfer. It is expected that the new design will improve the ratio between bath capacity (tonnes) and melt rate (tonnes/hour) in the well from about 40:1 to 13:1.

An additional problem with the standard closed well furnace was that immersion of plastic coated metal into the liquid metal bath leads to rapid pyrolysis which can cause excessive metal losses and increased dross formation. The new system therefore includes a hot gas recirculation system designed to ensure controlled pyrolysis of all contaminated scrap before it sinks into the well. This ensures clean, preheated, decoated scrap and a correspondingly high metal recovery rate, which has not been attempted before. Scrap melted in this furnace will tend to be light and voluminous; this is the most difficult material to deal with in terms of metal recovery and has often been found uneconomical to process, fig 6.

Dry hearth furnace: Since this is the most universal furnace available for secondary aluminium melting it was also incorporated into the new system design. The equipment can be charged with all types of aluminium, including contaminated scrap, and any iron attachments can be dragged out via the front of the furnace; but direct flame impingement, high energy costs, and low metal recovery rates negate the usefulness of

Fig 4 **above** *Thermal barrier window frames, a typical example of complex aluminium scrap,* **below** *aluminium can scrap*

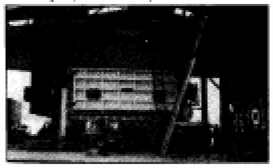
Fig 5 *Tipping remelted aluminium scrap from an induction furnace*

the dry hearth under certain circumstances. Redesign of the furnace and fitting of a hot gas recirculation system allows scrap to be decoated by pyrolysis of the organic components, and not until this is complete will the burners come into operation. By melting the clean preheated scrap under a controlled flame, metal recovery rates are expected to be greatly improved. On becoming molten, the aluminium will separate and run to the back of the dry hearth chamber. The slope of the furnace has again been calculated to allow it to hold 4–5 tonnes of liquid aluminium. This means that the furnace can melt a certain amount of scrap in the liquid bath rather than by direct flame, increasing metal recovery still further.

The innovative dry hearth furnace is expected to achieve an average recovery of between 0.85 and 0.9 using 3 GJ/tonne of energy. This represents an increase in recovery of at least 2% over the use of a direct gas or oil fired reverbatory furnace. Using the new closed well furnace, the average recovery rate would be between 0.9 and 0.95 with energy consumption of 3.2 GJ/tonne. This represents an increase in recovery of 4% or more over the use of a standard reverbatory furnace, fig 7.

Hot gas recirculation system: This serves for both the decoating and preheating of the aluminium scrap, resulting in increased metal recovery and a much lower energy usage than has previously been possible. In the closed well furnace, the basis of the system is the bleeding of hot air from the flat bath into the area above the liquid metal well. This provides sufficient hot gas for pyrolysis and preheats the metal before its immersion into the molten metal bath. The hot gas recirculation system within the dry hearth furnace uses the heat available within the chamber to decoat and preheat the scrap until it is near to its melting point. This results in much reduced metal losses and energy usage, and it is the first time that preheating has been attempted using the heat from within a furnace. Previous designs have involved the use of heat which has already passed outside the furnace chamber and into recuperators where heat transfer is inefficient. The system also provides a longer residence time for the burning gases within the furnace, resulting in complete combustion of organic contaminants within the metal charge, and therefore in the decoating of scrap.

Fig 6 *The new closed well furnace at J McIntyre (Non Ferrous) Ltd*



In addition to being efficient in terms of preheating and decoating the metal, recirculation of gases provides a solution to environmental problems since large volumes of air are not required to remove the contaminants. Any gases which have insufficient calorific value for reusage travel out of the furnaces at a controlled rate and pass through an afterburning unit and a low volume bag filtration unit. By the time the flue gases reach the baghouse, all combustibles have been removed by burning. The gas is, therefore, relatively clean at this stage. It is also cool, having been passed through the recuperator/regenerator system. The additional cleaning by dry lime scrubbing ensures complete pollution control. Only low volume equipment is required because maximum exhaust through the whole plant will be 10,000 cfm, which is very low. In short, the gases coming out of the plant will actually be cleaner than those going in with the result that the plant will operate well within the toughest environmental rules.

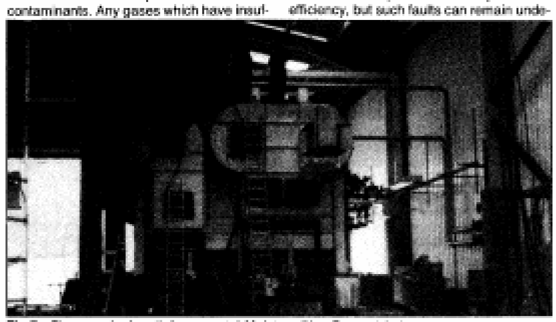


Fig 7 *The new dry hearth furnace at J McIntyre (Non Ferrous) Ltd*

Heat recovery system: This consists of a unique afterburner/recuperator combination. Each of the installed burners is connected through a separate line of 'storage radiator' type heat transfer units and is correspondingly fed with preheated combustion air. The amount of heat taken out through the recuperator walls reduces the flue gas temperature from 1000 to 400°C. As an additional energy saving measure, door sealing systems have been fitted to both furnaces to prevent emission of fumes and assist in retaining heat, allowing a constant furnace pressure to be maintained.

Process control: An essential part of the new system is process control, which not only covers the return of the hot pyrolysis gas but also controls and co-ordinates the hot gas recirculation systems within both furnaces, ensures that furnace pressures are kept uniform and that there is no ingress of cold air or exit of hot gases through the furnace via any part except the flue. Process control thereby allows for increased efficiency while providing the operator with data on furnace performance, furnace temperature, flue gas temperature, and effectiveness of recuperators. For example, it has been shown that even a small hole in a recuperator severely reduces efficiency, but such faults can remain undetected for a long time. By continuous measurement of flue gas temperatures in and out of the plant, any problems can be detected immediately.

Conclusions

The newly developed aluminium recycling plant described in this article is expected to be three times more energy efficient than conventional equipment performing similar functions, and represents the largest technological development by the industry for many years. Many of the techniques used will benefit other furnace users, and it is hoped that these developments will improve energy efficiency and pollution control within the whole of the secondary aluminium industry.

Acknowledgements

Industry figures were taken from the Energy Technology Support Unit (ETSU) Market Study Number 5, Aluminium Recycling. ETSU are supporting the McIntyre plant with a £160,000 grant. ■

APPENDIX D

Fact Sheet on Recycling Metal

What a load of rubbish!

FACT SHEET 6 RECYCLING METALS

CITY OF TEA TREE GULLY Naturally Better

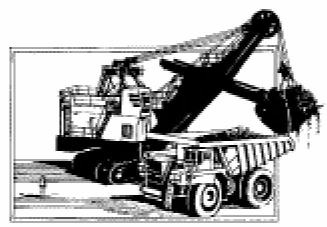
Metals are generally made from ores, which are metal rich rocks. The ores need to be mined and transported to purification plants (smelters). The processes that produce metals from their ores vary but can often involve large amounts of energy. Recycling can save a lot of energy and reduce the need for mining. The two most commonly recycled metals are **steel** and **aluminum** although copper, gold, alloys and other metals can often be recycled.

Steel

Steel is produced from iron ore in a series of steps. First cast iron is made in a blast furnace by heating iron ore, limestone and coke. Steel is then made from the cast iron in a second furnace in a process called basic oxygen steel (BOS) making. This second stage is carried out at 1700ºC and uses some scrap steel and oxygen.

Steel cans which are used for food such as soup, tinned fruit and pet food are made from tin plate, which is steel coated with a thin layer of tin. This tin needs to be removed before the steel cans can be recycled.

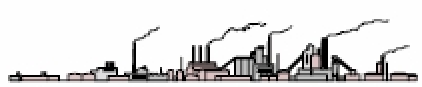
Used steel is 100% recyclable and can be used to manufacture new steel or can be recycled in special electric arc furnaces called "mini-mills". Steel recycled in SA is sent to the BHP plant in Whyalla where it is a component of new steel products such as railway lines and steel beams. Steel cans are also recycled in Port Kembla where the tin coating is removed and the steel is recycled into new products such as white-goods and car components. Making new steel from recycled steel use 75% less energy than making steel from iron ore and coal.



Aluminium

Aluminium is made from bauxite (aluminium ore). The bauxite is first converted to alumna and then smelted to pure aluminum. Among the common aluminum products that we use are such things as drink cans and car parts. Aluminum is also the preferred material for overhead power lines. Like steel, aluminum is 100% recyclable.

In fact making new cans from recycled aluminum is cheaper, easier and uses 95% less energy than making the cans from raw materials. After the old cans are collected, they are baled into bricks and sent to plants where they are melted at 700ºC. The molten aluminum is then cast into ingots and sent to be made into new cans or other products.



Now what do I do with it?

What a load of rubbish!

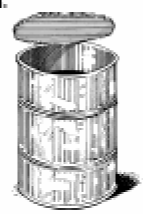
Recycling Metals in Tea Tree Gully

In the City of Tea Tree Gully metal items can be recycled in three ways:

1) Via a weekly kerbside collection where residents can put out a recycling crate on the same day as their Mobile Garbage Bin. Rinsed steel and aluminum cans, clean aluminum foil and empty aerosol cans may all go in the recycling crate.

2) All metals items, including fridges and whitegoods, can be recycled by taking them to Enviro Care Sunday between 10am and 2pm, on the second and last Sunday of each month at St Agnes Recreation Park, Smart Rd, St Agnes.

3) The City of Tea Tree Gully also operates an "on call" kerbside metals collection as part of its hard refuse service. Larger metal items such as whitegoods and sheet iron can be recycled using this service. Phone the Greenline on Freecall 1800 10 10 44 to book a collection.



The City of Tea Tree Gully's weekly kerbside recycling service collected over 120 tonnes of metal in 1998, including:

4½ tonnes of Aluminium cans. That's more than 250,000 drink cans.

116 tonnes of steel cans, which equates to over 2 million average sized food tins.

The table below shows how most metal items can be recycled in the City of Tea Tree Gully by using a combination of the three services described earlier.

Recycling metal saves natural resources and landfill space. Metal items can make up as much as 3% of the domestic waste stream. In the City of Tea Tree Gully the amount of metal in domestic waste could be as high as 1000 tonnes a year.

If you require further information on any of the Disposed Resource Management Services provided by the City of Tea Tree Gully please call the **Greenline** on Freecall **1800 10 10 44**

References:

Recycle 2000, Fact Sheet 5, Aluminum and Aluminum Can Recycling.
Recycle 2000, Fact Sheet 14, Steel and Steel Can Recycling.
ALCOA of Australia Publication, 1992.
BHP, Steel Can Brochures.

Metal Item	Weekly kerbside Recycling	Enviro Care Sunday	On Call Hard Refuse Service
Steel cans	✓	✓	
Aluminum cans	✓	✓	
Aluminum foil	✓	✓	
Empty aerosol cans	✓	✓	
Alloys		✓	✓
Copper		✓	✓
Fridges		✓	✓
Other white-goods		✓	✓
Sheet iron		✓	✓
Metal guttering		✓	✓
Other common metal items		✓	✓