Proceedings of the 12th International Conference on
Aluminium Alloys, September 5-9, 2010, Yokohama, Japan

pp. 206-213

A New Used Aluminum Beverage Can Recycling System

So Yoshida [1], Hitoshi Baba [2]
[1] 75 Hiramatsu Susono-city, Shizuoka-pref., Japan, Mitsubishi Aluminum co., Ltd.
[2] 1500 Suganuma,Oyama-cho, Sunto-gun, Shizuoka-pref., Japan, Universal Can Corporation

This report introduces the used aluminum beverage can (UBC) recycling system of Mitsubishi Materials Corporation Group (MMCG). MMCG has been aiming to construct a recycling-based economic society from the viewpoint of resource saving, energy saving and waste reducing, and has carried it out by building up a CAN-to-CAN recycling system of Rolling -> Can manufacturing –> UBC collecting –> Slab casting for can stocks -> Rolling, since 1975 soon after started aluminum beverage can manufacturing business.

Instead of the conventional UBC recycling system dispersed in three plants of three companies, MMCG established a new integrated UBC recycling factory in 2001 that is the first one in Japan and keeps it operating, for a further development of the UBC recycling business and for the effects expected on an overall energy reduction of cutting transportation among plants and melting-casting processes. The process in the new factory ranges from accepting compressed UBC to casting slabs for can body stocks. As a result, energy consumption and environmental loading exhausts including CO_2 are reduced more than 30% and 35%, respectively, and the yield is also improved.

Considering both of can body stock quality and environmental load reduction, the new factory adopted equipments for casting slabs of the can body stocks that ensure the highest level of quality for sheet metal products, equipments for disposing of exhaust gas without drain through a drying process and equipments for killing insects around UBC.

1. Introduction

Aluminum beverage cans started to be produced through drawing and ironing（DI）process of manufacture by Kaiser Aluminum first in the world in 1955. Then those cans have spread fast why aluminum has good properties that are lightness, corrosion resistance, manufacturability, and heat conductivity.

Mitsubishi Materials Corporation Group (MMCG) started the enterprise of aluminum beverage can production in 1972, that was the next of the year when those cans started to be produced in Japan. MMCG has been aiming to construct a recycling-based economic society from the viewpoint of resource saving, and energy saving, to discharge our duties of disposing UBC.

Aluminum raw metal for many companies in Japan almost depends on import from foreign countries, and it was the fact that UBC recycle enterprise was important to keep the source metal for can stock and to reduce the cost of raw material as the company strategy.

MMCG divided the enterprise of recycling UBC into 3 works corresponding to 3 companies of its group in the early stage. The first one was recovery of UBC, to sort out foreign substances, and to cut into pieces, the second was to melt those UBC, and to reclaim metal, and the third was to remelt and to cast slab ingots from reclaimed metal. But MMCG had to reconstruct the enterprise of UBC for cost down of raw material and for reduction of discharging environmental load substances through rationalization in sever economic circumstances in the latter half of 1990's. Then MMCG established UBC through process from reception to casting, to increase efficiency among transportation, melting, and casting. (Fig. 1) The recycle system for UBC is built with Universal Can Corp. as a leader now.

We roughly explain its UBC through process in Mitsubishi Aluminum after 2001, and report the reduction of energy, and of environmental load substances. We propose some problems of this system, and future themes.

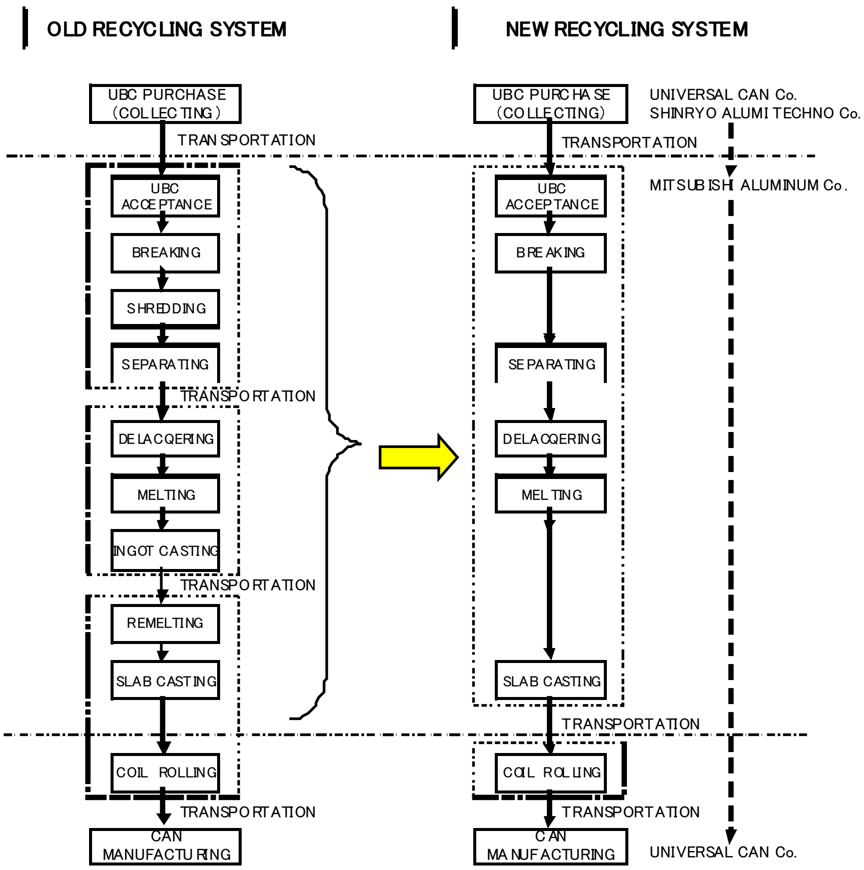

Fig. 1 Comparison between new system and old one of UBC recycle

2. The explanation of UBC recycle process

2.1 Reception of UBC and its quality

UBC is almost received as a condition of baling press for transport efficiency. That is inspected to sort out foreign substances with some fragments sampled from its UBC. It is important to grasp the quality change as that influences to yield of UBC, and the quality is useful when we buy UBC materials.

Good UBC contains high density of aluminum ingredient, and there are foreign substances which consist of water of rain and drink remainder, organic matter for can coat of paints and laminated film, and others of sand. Those three substances compose 10% of UBC raw material. Foreign substances influence not only UBC yield worse, but also removal of paints (we call "delacquer") by heating, make the operation unstable, and deteriorate energy cost. Water of UBC raw material and organic matter affect worst.

Fig. 2 indicates change of ratio of UBC water content in a year. UBC water content is affected by precipitation and atmospheric temperature, and then UBC contains water most in winter in a year, because that freezes and evaporates very slowly. Therefore the yield of UBC reclamation is lowest, and we meet many troubles in winter.

It is effective to dry raw material naturally in factory yard, in order to restrain the influence less. (If there is no

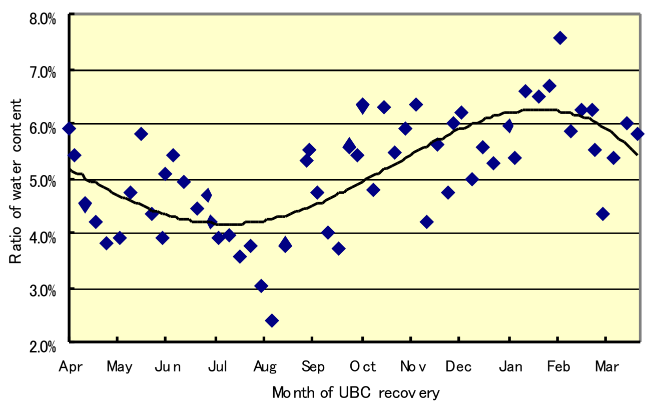

Fig. 2 Change of ratio of water content a year

frozen water, water content will be no more than 1% after keeping in yard for about seven days.) But water content is not controlled low enough, as raw metal quantity received cannot be controlled well, and we don't have wide yard enough. We think it the theme to set up a compulsory dry system which gets heat discharged from a combustion plant.

Cans laying film laminated on those surfaces increase the organic matter content in UBC recently, which makes recyclability worse than the previous age. Those cans contain 2.5 times content of organic resin as much as ordinary cans, and generate 2.2 times heat per one can as much as these cans. That makes aluminum metal content decrease, and makes temperature control difficult in delacquering process which will be explained later.

Business paying and its keeping are necessary to continue the UBC recycle enterprise, and then we think it the important theme to establish the commercial transaction with the standard reflected buying condition for UBC quality. (UBC price must be estimated reasonably for its quality)

2.2 Outline of UBC recycle process

Fig. 3 shows the through process of UBC recycles. The process starts to receive UBC baled. Received UBC is stocked in the factory yard. The manufacture line consists of continuous process from smashing UBC into pieces to casting to slab ingot.

We explain outline of each process, and future themes.

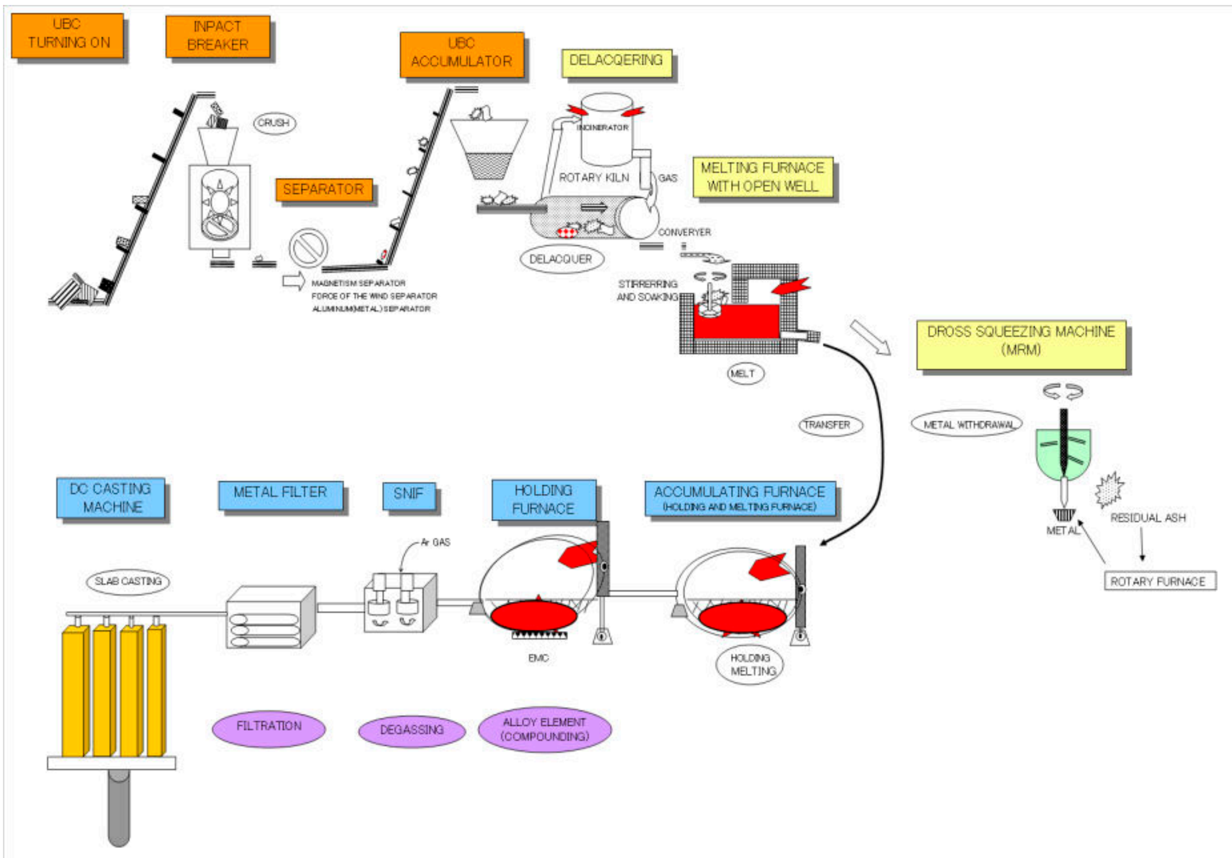

Fig. 3 The flow chart from throwing UBC to casting ingot

2.2.1 Smashing process into pieces

UBC pressed to bale is untied and smashed into pieces to remove foreign substances and paints. (delacquering later) The old system had shredding process after this smashing process, but present system omitted its process, because small pieces were scattered in convey line and in counterblow wind in delaquering line, and we had to reduce electric power consumption.

Smashing machine has a drum cycling very fast and plural hummers, smashes UBC baled with these hummers. The machine has impact & crush method with repeating impact between hammers and back plates. The machine is large-size enough to smash bulky UBC, contributes to make restricting condition ease to receive UBC.

We think the next theme that a higher performance machine should be set up to make the condition easer even in case of large size UBC baled for the change of raw material circumstances in future. And we think another important theme that we must make sure the best shredding process at the view point of resources-saving, discussing the merit and demerit of shredding process, and considering balance of both. (Remained carbon derives from non-exposure face in delacquering process)

2.2.2 Sorting out foreign substances

We need sorting out process to separate harmful metals except aluminum, plastic bottle, paper, and other foreign substances from UBC. This process has grown important for the UBC quality fluctuating widely according to sudden increase of recycle ratio recently, in order to prevent material from being spoiled by harmful metals mixed in melting process and from burning abnormally in delacquering process.

Sorting out process consists of 3 parts of machines. The 1st one is the magnetic selection machine to remove ferrous metal like steel cans. The 2nd one is the wind force selection machine to remove light plastic and paper from heavy non-ferrous metal (air-knife). And the 3rd one is non-ferrous metal selection machine to select aluminum from insulator. As plastic shrink cans are started to sell, and plastic bottles grow many, the role of non-ferrous metal selection machine becomes important. If we sort out too severely, there are aluminum cans sorted conversely in the foreign substances, that is to say which cause loss of aluminum. We adopt a plural-stages-machine to improve the yield of aluminum as non-ferrous metal selection machine shown in Fig. 4.

As this sorting out process is unnecessary process for UBC recycle essentially, we expect that the role of sorting out process is reduced through the permeation of resources recycle for aluminum and other materials.

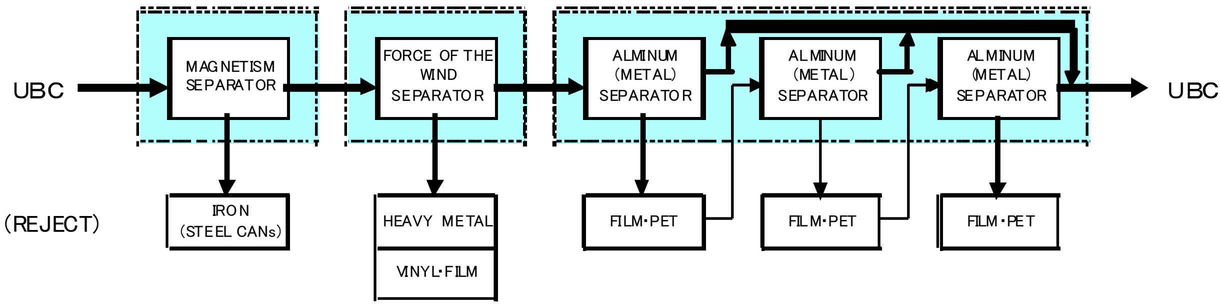

Fig. 4 The flow chart of our sort out process

2.2.3 Delacquering (removal of paints)

The purpose of delacquering is to improve the yield of aluminum reclamation by reducing the loss of metal in melting process through heating surface paints of can and resolving those. MMCG got result to improve the yield of aluminum about 4% by delacquering, therefore this process is said the most important process in the UBC recycle system at the view point of economy and resource-saving. This process is also useful to prevent molten metal from exploding with vapor by water in UBC in melting.

Gas and tar in organic matters volatilize by heating process shown in Fig. 5, and char (brack carbon) remains after all. This char is oxidized and resolves in the condition of high temperature at which aluminum is not oxidized (namely no flame, oxygen content is no more than 9%). That temperature must be not lower than 723K (=450℃) for resolving various organic matters. They say for resolving char that the temperature is about 813K (=540℃), and that the content of oxygen is not less than 4%. We remove the paints (organic matters) of can surface through using this mechanism.

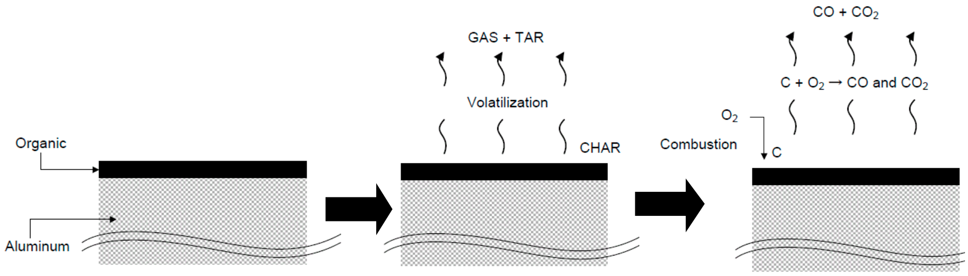

Fig. 5 The flow chart of delacquering process [1)]

Fig. 6 shows our delacquering process of rotary kiln with counter flow method based on the technology of Gillespie & Powers, Inc. Counter flow delacquering system roughly consists of the incinerator as a heat source, the rotary kiln, and the controller of gas circulating in system.

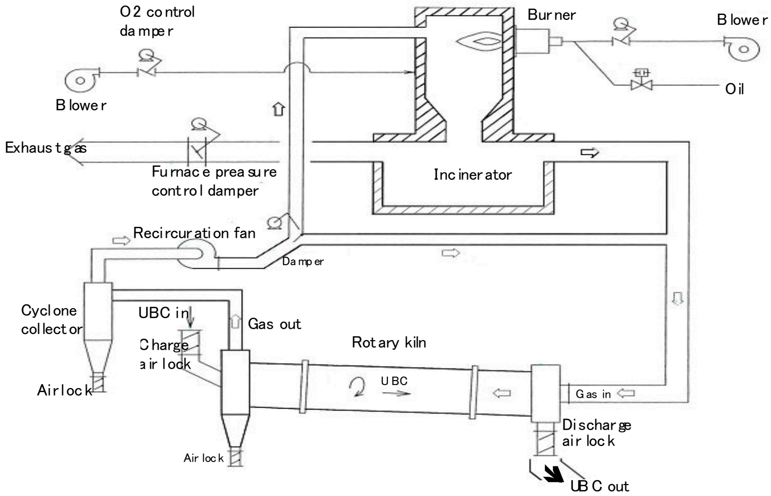

Fig. 6 Delacquering system by the rotary kiln of counter flow method

This system has problems which opera--tion is not stable, and which there are non-exposure surfaces hardly to remove organic matters inside of cans due to lack of shredding process. Instability of operation is concerned to its low ability to correspond to fluctuation of the quality and the quantity of UBC raw material due to heat capacity in the system. And combustion troubles often occur, why the temperature of gas disposed cannot keep the level of the dew point of volatized organic matters, and gas dews on the inner surface of the chimney. Support system for combustion by high temperature exhausting gas is not enough still to solve those problems.

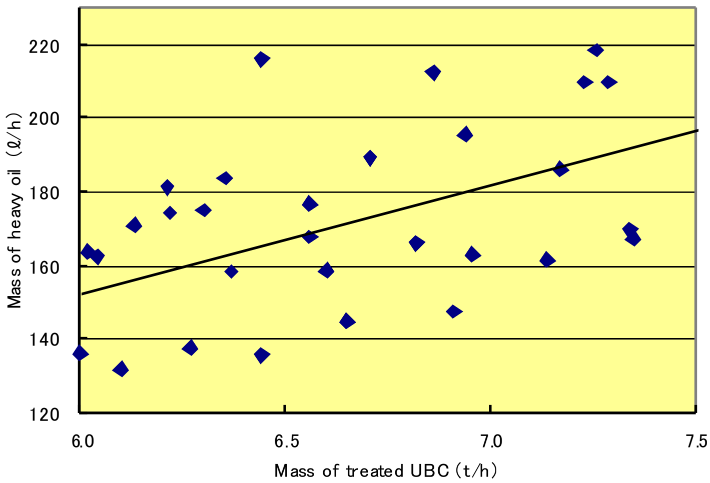

Fig. 7 Mass of heavy oil for mass of treated UBC in delacquering process

Shredding process must be useful as a counter-measure for char remain of inner surface of can. We will estimate the shredding process carefully to consider minute fragments under 5mm in diameter changing into dross.

At the view point of energy-saving, we think it effective to energy reduction to increase amount of treating UBC in the delacquering process. (Heat output by paints 600kJ/UBCkg > Heat for temperature rise of aluminum 500kJ/UBCkg) But Fig. 7 shows that increase of amount doesn't contribute to energy reduction, therefore we think the reason why that is influenced by imperfect delacquering and organic matters deposit in the chimney. That is also influenced by water in UBC, and we guess heat of exhaust gas effective, which supports to remove water before delacquering and to prevent organic matters from depositing in the chimney.

2.2.4 Melting

Dross produced from melting UBC is more than that from aluminum scrap in construction. The reasons why dross from UBC is generated much are seemed that UBC is thin, that organic matters on the surface carbonize, that carbon on the surface burn and assist to generate dross, and that earth and sand mixed in UBC accompany metal. As UBC is thin, it almost changes to dross before melting by oxidization with direct frame in air. Therefore we use the immersing method in metal melting beforehand for UBC to prevent UBC from contacting air. Fig. 8 shows the rough sketch of our UBC melting equipment of the reflection furnace having a preheating furnace.

Delacquered UBC is immersed immediately in molten metal by stir-immerse-melt method with the rotary fans. Molten metal in the melting furnace is circulating by the pump from the open well having the UBC immerse tank to main well generating heat. That method reduces dross in melting, and improves the efficiency of flux (mixture of chlorides and a little fluorides) for refining molten metal. And then the method contributes to minimize the dross contamination by flux.

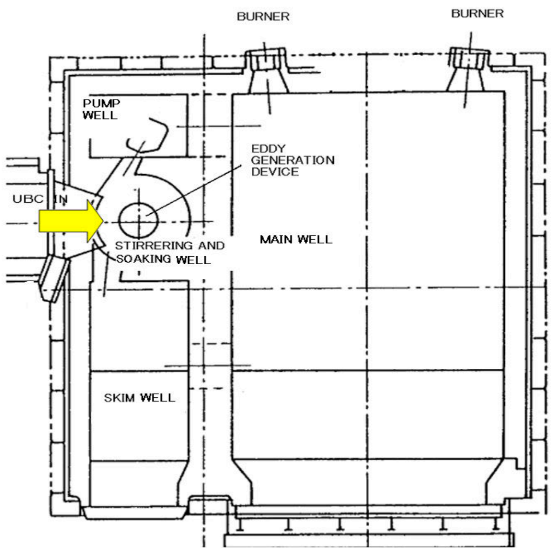

Fig. 8 The rough sketch of UBC melting equipment [2)]

Dross is scratched away brushing off molten metal sticking to oxide in the skim-well. Mass of scratched dross depends on the ability of the operator, and the method influences the yield of metal. We have not made its scratching operation automatic yet, as the complex condition of dross needs to various measures and skill for us against much loss. The guidance and the result control restrain the dispersion of its skill, but we think a automatic system desirable in future because that operation takes long time and compel operators severe environment.

2.2.5 Disposal of dross

Dross in melting (hot dross in the rest) consists of aluminum as metal, oxide and nitride. The most part of dross is aluminum. Ratio of metal recovery from dross influences the yield of UBC recovery more than other aluminum scrap.

We adopt rotary-fans-stir method (MRM) for recover metal from hot dross. Metal in hot dross is minute and contains much carbon. As the operation to recover occasionally causes abnormal heat-up and makes much dust, the cooler and the dust catcher are necessary equipments for remained ashes. This method has simple structure and

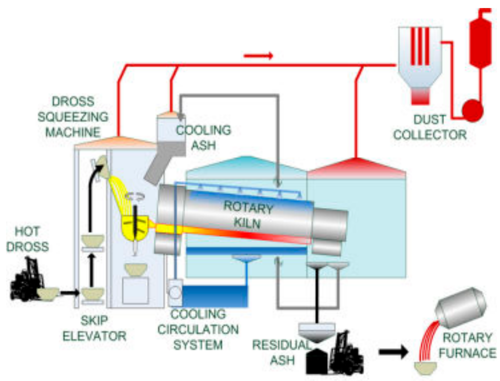

Fig. 9 The flow chart of hot dross disposal

makes the operation easy, and is suit for hot and severe environment. It is adopted widely in Japan as well as our company. Fig. 9 shows metal recovery system of MRM for dross. Ratio of metal recovery through MRM is no less than 60% of whole UBC process, and metal recovery almost depends on MRM.

This operation needs skill for operators, because operators must judge the measure from change of dross and operate heat-up or cool-down. Dross becomes factory wastes after the final process, and is almost reused as flux for treating steel now . This system cannot be continued for ever, therefore the industry intends various objects to develop new uses and to make ashes harmless. (measure for remained aluminum, chloride, and nitride)

2.2.6 Store of molten metal (melt & hold)

Molten metal from UBC is moved to accumulating furnace. This furnace mainly carries out a buffer role for time to adjust the composition in the next holding furnace, to remove gas, and to cast slab ingot, while it melts scrap which is produced incidentally in the sheet-rolling and the can-manufacture. Therefore we adopt the combustion system of the regenerative burner which has high performance for recovery of exhaust heat. This accumulating furnace is useful for us to operate stable even using raw metal except UBC, in order to correspond to amount fluctuation of arrival of UBC.

2.2.7 Adjustment of composition and removal of gas

An aluminum can consists of the body of 3004 (3104) alloy as Al-Mn-Mg series and the end lid of .5182 alloy as Al-Mg series except a bottle type of can able to close again. UBC recovery metal mixed with body alloy and end alloy seems to be difficult to recycle from 100% of raw material, but as magnesium is lost much by oxidization in melting, the composition tends to be suitable for the body alloy 3004. This is explained in Table 1. Si, Fe, and Ti tending to increase through recycle seems to be harmless by dilution from end material.

Table 1 Typical compositions of current can parts and UBC recovery actual value (mass%) [3)]

part or category		Si	Fe	Cu	Mn	Mg	Ti
body material (actual value)		0.25	0.43	0.21	1.04	1.32	
end material (actual value)		0.09	0.25	0.04	0.30	4.42	
body + end (calculated)		0.22	0.40	0.18	0.87	2.02	
actual value (average) from UBC recovery		0.26	0.40	0.20	0.86	1.22	0.04
JIS limit of 3004	max.	0.30	0.7	0.25	1.5	1.3	0.10
	min.				1.0	0.8	

2.2.8 Treatment of molten metal and cast of slab ingot

As slab ingots for cans are requested highest quality of the rolled sheet, we remove gas by in-line system, clean the molten metal through ceramic-tube-filter system, and cast slab ingots for cans by direct chill (DC) casting method. We think it necessary for the quality requested from customers that the operator aware the cost of the product, that the operator is made understand the operation control including the equipment about cast machines.

2.2.9 Environmental equipment

Exhaust gas which is produced in combustion equipments including delacquering process is discharged out of the system after purification in the exhaust gas equipment. We adopt dry-filter type without drain for the exhaust gas equipment. It has the catalytic filter specially for the measures to dioxin. We analyze the exhaust gas periodically and open the value to its neighbors.

We collect dust by the dust catcher for factory environment at the equipment producing dust. We scatter insecticide just after receiving to kill insects from UBC. But the measure for factory environment is not enough, and we advance the improvement intentionally.

3. Summary

We got the following results as energy reduction and environmental effect comparing with the old process, by reduction of transportation process and melting process and by the measures for environment through new UBC recycle system.

(1) Reduction of energy : about 30%
(2) Reduction of CO_2 product : about 35%
(3) Reduction of NOX product : about 30%

We also got the effect of the reduction of melting process, but the improvement of the yield of all system is 4% without that effect. It becomes about 5%, if we take that effect into account. We have been working that the improvement of the yield is the most important theme. Its improvement links the cost-down of UBC recycle as well as resource-saving.

We are not satisfied with only the results from new UBC recycle system, and will solve the present problems steadily, and make the system grow. And we will contribute to protect the earth environment through resource-saving and energy-saving.

4. Postscript

We think that MMCG could make Japanese nation recognize with symbolized "CAN-to-CAN" campaign as well as those enterprise of the actual UBC recycle. The present ratio of aluminum can recycle in Japan has grown to about 90%, which is very high. This result must be brought by local self-governing body arranging routes of recover as well as by MMCG promoting the recycle enterprise.

References

1) Francois Tremblay, Marko Litalien, David Stephens :"Third International Symposium on Recycling of Metals and Engineered Materials" The Minerals, Metals & Materials Society, (1995)
2) Jun-ichi Ninomiya, Hiromori Uranishi, "Industrial Heating" Vol.29, No.1, (1992), pp.42.
3) Ryutaro Yamamoto :"Metal", AGNE Gijutsu Center Vol.65-6 (1995), pp.141-151.