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LATEST TRENDS IN POST CONSUMER AND LIGHT GAUGE SCRAP PROCESSING TO INCLUDE PROBLEMATIC PROCESSING MATERIAL SUCH AS UBC, EDGE TRIMMINGS AND LOOSE SWARF

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Recycling, UBC, Scrap, Furnace

Introduction

Developed in the late 1990's by Hertwich, a member of the SMS Group, the Ecomelt furnace has been the best available technology for the processing of post consumer scrap aluminum for many years. Traditionally, charge materials such as painted extrusion profiles, extrusion profiles containing thermal break, painted siding (new and old) and litho scrap, have been charged into the melting unit and turned into molten aluminum whilst minimizing melt losses and attaining the best fuel efficiencies in the industry.

With a greater demand being put on manufacturers and suppliers of aluminum products to produce a 100% recyclable material, the Hertwich furnace is being continually developed to have the ability to process the traditional problematic materials such as loose chips, edge trimmings and used beverage cans (UBC'S).

For many years there have been technologies on the market for the processing of these problematic materials, but with more and more pressure being put on processors of these materials with respect to fuel consumptions, overall metal recoveries and environmental impacts a more efficient process needed to be found. The Ecomelt was able to process these material in a very efficient and safe manner; resulting in the best fuel efficiencies and best overall metal recoveries in the industry.

Aluminium Industry Requirements[1]

For melting of Aluminium scrap the main emphasis is on meeting the ideal ecological and economic conditions in the best possible way. Ever more stringent requirements can be met only with the most up to date melting technologies, to meet the following criteria:

- High product value and quality, avoiding downgrading of scrap
- High yield/recovery, low metal loss
- Low energy consumption
- Oil, plastic and paint = hydrocarbons to energy

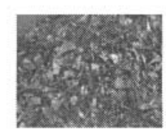
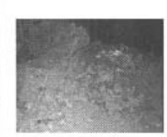
A high percentage of non metallic contaminants of scrap must be permissible. The recycling equipment must be capable of processing non metallic contaminants, the inherent energy of which is reclaimed. Net energy input is considerably reduced.

- Environmental compliance

  Minimizing emissions and pollutants like NOx, Dioxin, VOC, without complex post-combustion, lowest possible and in most cases no addition of salts

- Minimizing risk of accidents, automation
- Low operating costs

Classification of Problematic Scrap Types

Type A <1% VOC primary Al, ingots, sows T-bars, clean profiles, sheets, wires, … Impurities are typically very small amounts of oil, paint or lacquer		
Type B, VOC < 5 % Swarf briquettes, cut wire, foil, profiles, lithographic sheets, … Impurities are typically oil, grease, ink, paint, lacquer, …		
Type C, VOC > 5 % Post consumer scrap such as dirty profiles, UBC, coated sheets ,foil, tubes, wire, … Typically impurities: high amounts of grease, paint, powder coating, …		
Type D, VOC > 10% Dross, Twitch, Engine blocks, profiles with thermal break,… Typically impurities: iron parts, high amounts of plastic, rubber, …		

Although there are four classifications of scrap listed above, for the purpose of this article we will focus on the two main problematic scrap types; Type B and Type C which contain between 1% and 10% V.O.C.

Functional Solution to Effective Recycling

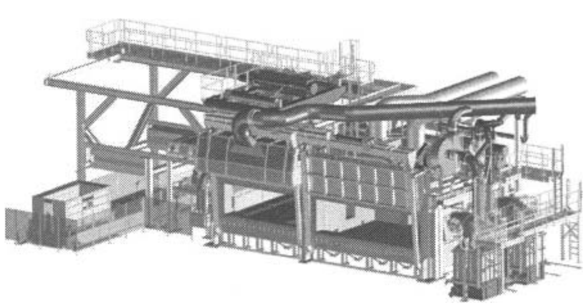
The solution to effectively and efficiently recycle these materials is a melting furnace with integrated scrap preheating and gasification. The HE-Ecomelt (economy, ecology = environmentally sound) Furnace.

This furnace type is designed for remelting of scrap contaminated with oil, paint and plastic.

The total non-metallic, organic substances may reach 10 % of weight, subject to calorific value.

Typical main components of the system:

Charging system
Preheat gasification chamber
Melt chamber
Furnace main chamber

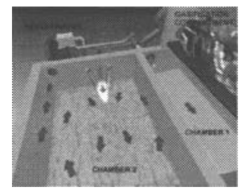


(Two-Chamber Furnace)

Charging
Charging is done automatically with several different mechanisms depending upon application. The volumetric capacity is determined in relation to the specified scrap density, so that no more than three charging cycles per hour are necessary. In case more than one container is to be used, a dedicated buffer storage system can be integrated. Full containers are moved into charging position by a lift system. During charging a lock mechanism prevents escape of flue gases and dust. The scrap load is emptied into the preheat/gasification chamber, upon opening of the containers' bottom flaps.

Scrap preheating and combustion of VOC particles
In the gasification chamber the scrap load is exposed to an intense hot gas flow and organic contaminants are transformed into combustible gases. Part of these pyrolysis gases is pre-combusted at the burner system of furnace chamber 1 (melting chamber).

Thereafter pyrolysis gases are ducted to chamber 2 (main chamber) where they are completely combusted with the adjusted excess oxygen of 2 – 3 %. During peak generation of pyrolysis gases some 50 – 70 % of the energy supply come from combustion of pyrolysis gases and merely 30 – 50 % of the energy needs to be supplied as natural gas, to ensure thorough combustion.

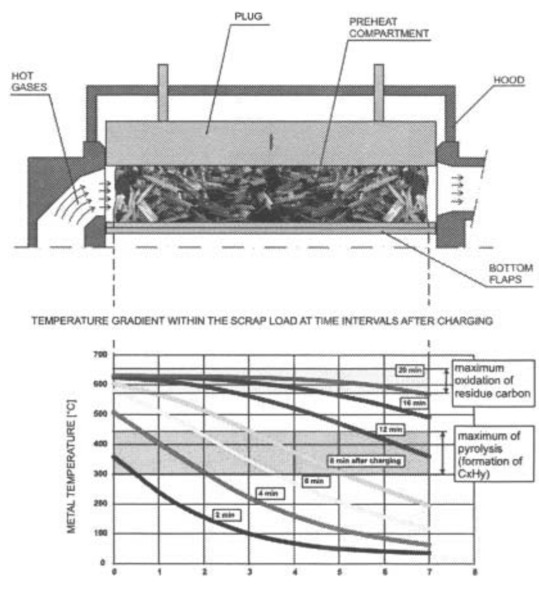


(Preheating and Combustion)

During preheating the scrap charge is heated to a temperature of approx. 500 °C, which at any rate is way below the melting temperature of aluminium. Surface fusing and unnecessary increased oxidation of aluminium in the furnace atmosphere must be minimised.

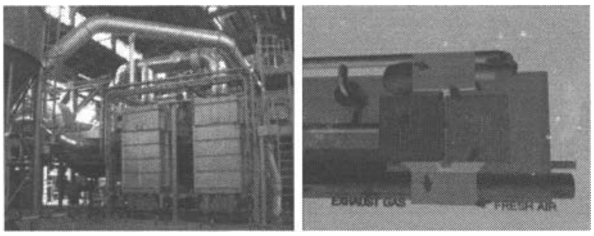
It is imperative that hot gases flow through the scrap load rather than passing along the outer contours of it. The hot air flow through the scrap load allows simple control of the heat front within the scrap load and with that the gasification rate and quantity of pyrolysis gases.

Sudden occurrence of uncontrolled peaks of pyrolysis gases, which are typical for conventional dry charging, can thereby be controlled easier.



Longitudinal section of gasification compartment. The diagram shows the temperature of the scrap charge at time intervals after start of heating. Since the heat front moves gradually from entry of hot gases to the exit, gasification also moves gradually through the charge (see green and yellow band), this avoids peaks in the generation of pyrolysis gases.

Since no scrap is charged into chamber 2 of the furnace, a constant high furnace temperature of more than 950 °C can be maintained. Possible toxic chlorine compounds, which may occur upon gasification of organic contaminants, are no longer stable at such high temperatures and are disintegrated. All flue gases from the furnace are ducted from chamber 2 through the flue gas duct to two alternating regenerators, which cool down the flue gases to below 200 °C within split seconds. The fast cooling down prevents recombination of dioxins in the critical temperature range 600 °C to 250 °C.



(Regenerators)

In the regenerators combustion air is preheated to approx. 800 – 1000 °C. Such intense air preheating in combination with the thermal utilization of pyrolysis gases, leads to extremely low energy consumption values.

During melting of moderately contaminated scrap the typical gas consumption is merely 400 – 500 kWh/t.

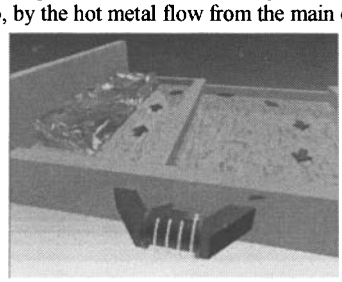
After passing through the regenerators flue gases are ducted to a filter plant.

The Melting Process

The melting process of the clean preheated scrap is as follows:

- Placing of the preheated and de-coated scrap into the melt of the melting chamber is achieved, subject to furnace design, by:
- Opening of scrap flaps in the gasification chamber
- Raising of the melt level to above the dry ramp level (flooding)
- Pushing the scrap heap into the melt by activating an integrated pusher mechanism

In any case a strong melt flow is induced between melting- and main chamber, by an electromagnetic pump. Preheated metal is melted in the liquid metal of the melting chamber or on the flooded ramp, by the hot metal flow from the main chamber.

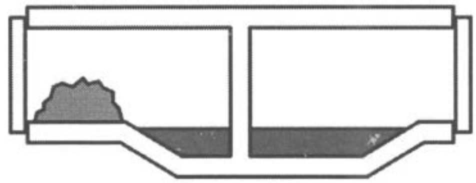


(Melting)

Hertwich Ecomelt Solution for Type 2 and 3 Scrap Materials

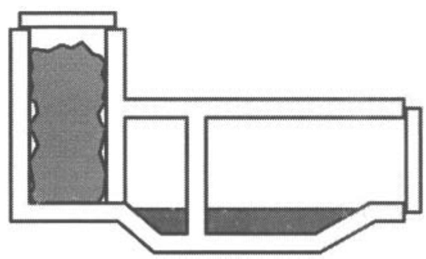
To address the concerns when recycling Type 2 and Type 3 scrap HE have developed two specific types of melting furnace over the past decade. Both of these furnace types have been proven in the industry over the past few years.

Ecomelt PR - Two Chamber Melting Furnace with preheat ramp



PROS:	CONS:
suitable for contaminated scrap (class I + II, VOC<5%)	investment cost
low energy consumption (<550 kW/t) with regenerative burners	long preheating time for proper gasification of organics > 30 min for loose scrap > 45 min for bailed scrap
minimum melt loss (submerge-melting)	melting rates (max. 5-6 t/h in relation to furnace size
feed back on alloy composition immediately after each charge	sophisticated operation required (cleaning, maintenance, automation)

Ecomelt PS - Two Chamber Melting Furnace with preheat shaft



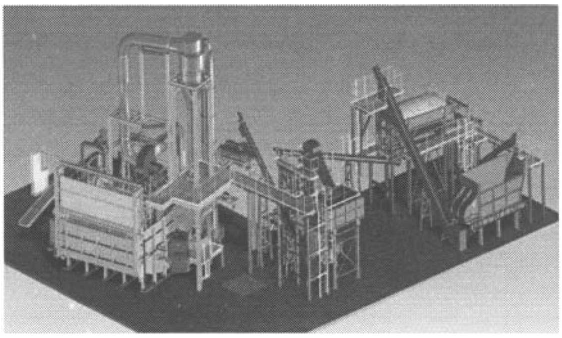
PROS:	CONS:
suitable for contaminated scrap (class I + II + III, VOC up to 10 %)	investment cost
optimum preheating (> 45 min) for proper gasification of VOC	sophisticated operation required (cleaning, maintenance, automation)
low energy consumption (<550 kW/t) with regenerative burners	
minimum melt loss (submerge-melting)	
high melt rates even with low density scrap (up to 250 t/day)	

The ultimate eco-melting system for light gauge scrap and chips

Due to the increasing use of aluminium castings and forgings in the automotive industry, the generation of swarf is on the rise. The worldwide volume of swarf generation is estimated to soon exceed two (2) million tons per year. Today's common practices and routines for remelting of swarf are associated with severe disadvantages and also with negative impact on cost effectiveness such as:

- Low metal yield
- High energy costs
- Extensive handling
- Emission problems of fumes and solid residue (e.g. salt cake)

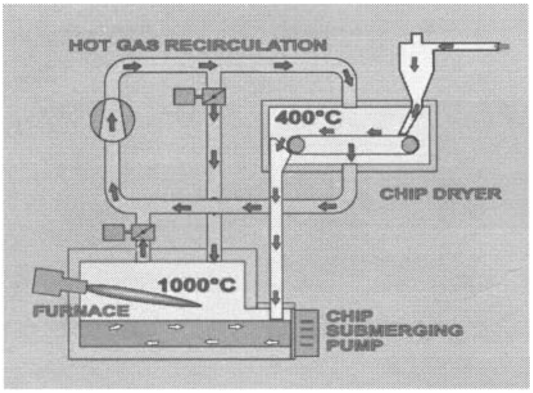
A new concept developed by Hertwich eliminates these disadvantages and especially ensures cost effectiveness.



(Plant Configuration – Swarf Remelt Plant)

After the usual swarf treatment steps such as certifuge, breaker and iron separator, swarf gets to a high speed swarf dryer and is subsequently charged and melted in continuous operation.

The entire process is characterized by the following features:



(Swarf Drying)

- The swarf dryer and melting furnace is combined into one thermo-mechanical system. Energy for heating of swarf is introduced to the dryer in the form of hot gases from the furnace chamber. These hot gases are mixed into the circulating gas flow of the dryer. Exhaust gases from the dryer, which also contain hydrocarbons, are ducted back into the melting furnace, where hydrocarbons are burned in the hot atmosphere of approx. 1000 °C and slight oxygen excess. Therefore an expensive, energy intensive after burner system is not required, but burning of hydrocarbons from the swarf drying contributes substantially to the energy requirement of the melting furnace.

- Swarf is heated to some 400 °C in seconds, and hydrocarbons and moisture are evaporated. Further oxidation of swarf due to lengthy exposure to high temperatures is prevented.

- Swarf is introduced directly to the melting process in hot condition. The inherent thermal energy is retained as dryer and melting furnace is combined into one process.

- Swarf is free from moisture and hydrocarbons. For instance when swarf is left to cool down to ambient temperature in a covered building, the swarf again absorbs 0,1 % of its weight in moisture in a short period of time (= 1 kg per ton) (van der Waal's force[3]). In case this moisture gets into the melt, it supports the increase in hydrogen content as well as oxidation losses of aluminium.

- During charging into the furnace side well, hot swarf meets a vertical, downward melt flow generated by an electromagnetic linear-motor, and is quickly submerged into the melt. Swarf melts by direct contact to the liquid metal without any oxidation.

The first plant of this type was commissioned for a prominent German producer of forgings, where swarf is delivered to the swarf dryer directly from the machining centres.

(Swarf Plant equipped with charge hopper, pre-treatment high speed co-flow dryer)

The Industry Dilemma; Efficient and Effective UBC Recycling.

Used Beverage Cans (UBC's) have always presented the aluminium industry with a problem with respect to effective recycling. By definition, the UBC is a "hybrid" product; consisting of thin gauge aluminium made from varying alloys, various coatings, and due to the nature of the product varying amounts of trap contaminants. When processing in a conventional furnace the product is virtually "unrecoverable". When processed in a rotary salt furnace the resultant salt cake is a disposal issue and when processed with a decoating system and subsequently charged into a reverbatory furnace, the resultant gas usage from both processes is relatively high in comparison.

In order to get a full understanding of the complexities involved in the successful decoating and melting of UBC's Stein Atkinson Stordy[4] did considerable research into the make-up of a typical UBC. The experiments focused on being able to determine the amount of the Volatile Organic Compounds (V.O.C.) evolved from the coatings when subjected to different temperatures in a controlled oxygen atmosphere. Additionally, it was necessary to establish the amount of weight loss relative to the coatings. This information would give a good insight into what temperature was optimal for the successful decoating of the UBC.

The experiments consisted of cutting the UBC's into 3' x ½" strips, weighing the strips and heating at the desired temperature for one minute. The shredded UBC was then allowed to cool, and re-weighted to assess the actual weight loss and hence the VOC loading on each sample.

Temperature increments of 200 degrees Fahrenheit from 300 upwards were conducted up to 1,000 degrees Fahrenheit.. At each temperature the total weight loss for each shred was measured. The results are shown in the chart below:

Air Temperature(F)	% Weight Loss of VOC
300	3.2
500	59.9
700	23.8
900	13.1

It can be seen from the above chart that all V.O.C is removed by the time the peak metal temperature is 900 degrees F. It was also noted during these test that when the peak metal temperature was raised to 1,000 degrees F that the shredded sample began to put on weight, or rather oxidise.

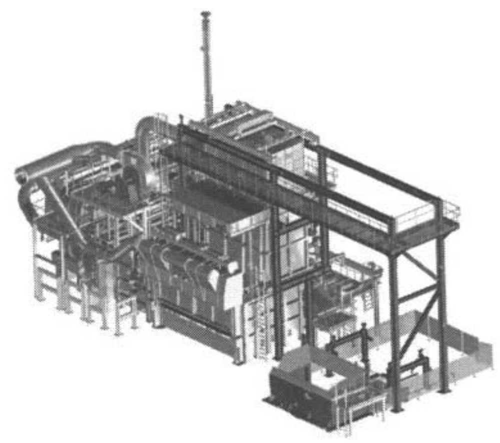
Based upon this information it was deemed that the Hertwich Eco-melt furnace was ideally suited to not only decoat the UBC but also to melt it in one single process.

However, there were some challenges to overcome with the processing of the UBC. The first one was the need to have the product shredded prior to processing to remove the tramp material from the product.

The second, and obvious one was, once shredded into a light gauge scrap component, would the shred allow the through processing into molten aluminium in the submergence melting system that is employed in the melting furnace.

The unique airflow and process that Hertwich developed ensured that the fuel efficiency of the furnace would be superior to that of any other technology available. As a hot gas stream is passed through the post-consumer scrap charge, contaminants in the form of vaporized paint and lacquers are driven off. The resultant gas is then passed through a regenerative burner system. This ensures superior fuel efficiencies. The anticipated fuel usage was expected to be half of the fuel usage when using conventional technologies. Additionally, since the preheat chamber has a controlled oxygen atmosphere, it was hoped that the furnace would operate as expected.

A product furnace was built and the process was evaluated for performance. A computer generate schematic of the furnace is shown below.

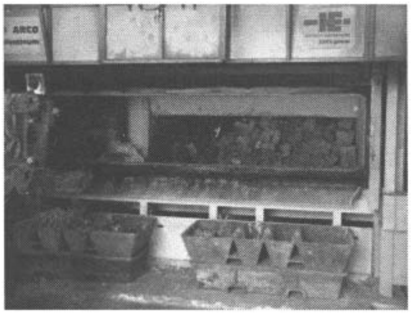


It was noted that when the furnace was running with briquetted product (class scrap used to emulate UBC) as the charge it was operating very efficiently and without problems. However, when the system was running with shredded UBC it was noted that the required production requirement (molten metal output) could not be obtained due to the density of the shredded scrap and bridging of the scrap within the preheat/decoating chamber. After many experiments with briquetted product and briquetters the decision was made to briquette the shredded UBC to a density of between 40 and 60 lbs/cubic ft.

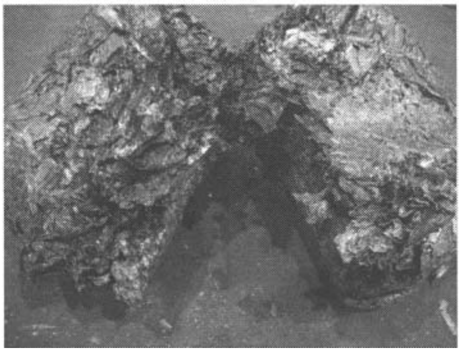
Prior to this decision being made several experiments were made to be certain that the briquetted product could be correctly delacquered prior to melting. Conventional wisdom dictated that the ability to decoat a heavily compacted briquette was non-existent due to the surface of the product not being exposed to the hot air stream.

A series of experiments were conducted within the furnace to disprove this theory. It can clearly be seen in the next series of pictures that in fact, high density briquettes can be efficiently decoated in this form.

The picture below shows the decoated product in the preheat shaft. Clearly the outside of the product has been "cleaned" but the inside cannot be viewed.



Once the briquettes were broken open as shown in the pictures below it was evident that the decoating efficiency of the H.E. melting furnace was exceptional. Based upon these test results it is clear that a dedicated briquetting press to process the shredded UBC prior to charging the melting furnace is necessary.



The recoveries from this furnace when processing UBC are in line with industry standards for short periods and it is hoped that these figures will be improved upon in the upcoming months. The fuel usage obtained with this furnace is 600-800 Btu/Lb (400-500 kWh/t). This is considerably less than conventional melting furnaces. Throughputs of up to 400,000 lb/day of molten metal are readily attainable.

Conclusion and Observations

In conclusion we can clearly state that over the past decade the advancement in the processing of post consumer scrap has increased dramatically. It is now possible to process many different kinds of post consumer scrap aluminium in one single unit. The Hertwich Ecomelt furnace continues to be developed and redesigned to enable operators the ability to process many types of scrap.

This they can do while simultaneous meeting the following criteria:

- Achieve the lowest possible fuel consumptions in the industry
- Realize the best possible metal recoveries in the industry
- Meet and exceed all environmental requirements regarding emissions to atmosphere

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Theorems

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