GREENMELT

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1. INTRODUCTION: ALUMINIUM & ALUMINIUM RECYCLING

Aluminium is the second most available metal in the world, being lighter of weight and possessing non-corrosive properties. Compared with iron, aluminium has a fast growing future. The application of aluminium in the packaging industry has already been a long practice, due to its low weight, good formability, good heat conductivity, strength and non-corrosiveness. These outstanding properties also led to the application in areas such as automation, construction, the aeroplane and car industry and (fast) shipbuilding. Because of these reasons aluminium production has doubled in the past 20 years and this trend is continuing. In Western Europe the consumption of primary aluminium grew at an average rate of 2% to 4.7 Mio tons per year; this is approximately 20% of the world-wide consumption.

But one of the most important and economic attractive properties of aluminium is the fact, that it can be used and reused, without loosing any of its properties. Whilst the energy consumption of new ("primary") aluminium production from bauxite requires 148 MJ per kg aluminium, the remelting followed by the reuse requires only 7.4 MJ per kg aluminium. Production of secondary aluminium thus only requires 5% of the energy of primary aluminium. Aluminium recycling is born and has a bright future.
2. GREENMELT: BACKGROUND, TARGETS AND RESULTS

Corus Aluminium NV (formerly Hoogovens Aluminium NV) in Duffel (Belgium) is a daughter company of the CORUS Group, a leading multi-metals company, formed by merger of Koninklijke Hoogovens (NL) and British Steel (UK) late 1999. The CORUS Group is active in steel, aluminium and stainless steel.

With a yearly production capacity of 240,000 ton, Corus Aluminium NV in Duffel is one of Europe's largest producers of aluminium semi-finished products, where high value aluminium alloys are transformed for very diverse applications.

In the casthouse of the plant scrap created during production, external (clean) scrap and primary metal is remelted and alloyed to the specification of the client, which depends on the application. These applications range from beverage cans to automotive body sheet. In Duffel induction furnaces are mainly used for melting; the produced liquid aluminium is then transferred into holding furnaces from which rolling slabs and extrusion billets are casted. (Fig. 2.1)

The rolling slabs (approx. 500 mm thick) are transferred to the rolling mill, where furnaces preheat them. The hot rolling mill reduces the gauge to 2,5 - 8 millimetres, after which the strip is coiled. This strip can be further cold rolled down to a minimum gauge of 0.08 mm. The products of the rolling mills are sheet, strip or circles. The extrusion department has several presses, which produce rods, sections and tubes.
The so-called Greenmelt installation is a new addition to the casthouse of Duffel. Construction started in 1996; start-up was in August 1997. The installation is designed specifically for remelting aluminium scrap, containing organic contaminants such as lacquers, oil and plastic coatings, in an environmentally friendly way (therefore the name “Green”).

The realisation of Greenmelt was important for a number of reasons:

- The environmental impact of the company has been reduced: the melting of contaminated scrap is now performed in a remelting facility that is using the best available technology to ensure that the regional and international environmental criteria regarding flue gas emissions are well met.
- The company has succeeded to increase the consumption of secondary aluminium (scrap) at the expense of the use of primary metal (melting ingots and rolling slabs). In 3 years time the scrap consumption at Corus Aluminium NV has risen from 18,000 ton/year in 1996 to 37,000 tons/year.

Fig. 2.1: Metal flows in Corus Aluminium NV

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ton/year in 1999. This means that the level of primary metal per ton production has decreased
with app. 12%.

- The investment enables Corus Aluminium NV to convert diverse scrap types of the aluminium
  transforming industry into liquid aluminium that is of the same quality as “new” (primary)
  aluminium and transform it to the same kind of products by means of rolling or extruding.
  With Greenmelt, Corus Aluminium NV introduced more scrap melting capacity and increased
  the demand for well separated aluminium scrap, which leads to more efforts to keep the scrap
  separate at the source and means a boost for recycling activities.
- Greenmelt is a showcase for other major producers of aluminium semi-fabricated products. It
  is now clear that it is possible to make an economically attractive activity from an investment,
  triggered by environmental considerations.
  Thus Greenmelt strengthens following trend: an increase of the aluminium consumption will
  lead more easily to an increase of the scrap remelting capacity rather than to additional
  primary aluminium production (which is a very energy intensive process)

2.1 Background and investment triggering

The interest to remelt more external, more contaminated scrap at Corus Aluminium NV was
continuously growing.
Remelting of aluminium scrap is an interesting activity: the scrap price is lower than the price of
primary aluminium (which is produced from an ore called bauxite). If a suitable processing
installation is available, the economic profits from this price difference outweigh the remelting
costs and the lower metal yield.
Remelting is also of interest for the Duffel clients; Corus Aluminium NV had been requested to
take back their (often coated or oiled) production scrap as a feed material to produce new semi-
fabricated products.

At the same time, a new environmental law (Vlarem 2) had been introduced, limiting the
processing of such types of scrap in the existing casthouse; the existing installations could not
meet the imposed emission levels if the scrap was somewhat contaminated. These aspects
formed the base for the decision to realise Greenmelt.

The scope of the Greenmelt project was the design, erection and commissioning of a melting
furnace (and additional equipment) with a capacity of 30,000 ton/year and capable to remelt
(external) aluminium scrap with contaminants like paint, plastic, oil, etc. (max. 6%)
The alternative was to equip the existing melting furnaces with additional flue gas treatment installations (“end of pipe technology”). Because of the compact layout of the casthouse, problems with technical adaptations, high costs and considering the facts that the grade of input material still would have to be high (low contamination) and casthouse production would not increase, this turned out to be less attractive.

2.2 Strategic importance

The project fitted into the strategy of Corus Aluminium NV to recover scrap from their clients at favourable conditions, thereby providing improved service. It also complied with the strategy to make important progress on environmental issues. More types and more contaminated qualities of scrap could be processed in an environmentally sound way and at the same time the environmental impact of the total plant would improve by solving the emission issues of the existing casthouse installations.

2.3 Targets

The goal was to realise a melter with a capacity of 30,000 ton/year, using advanced and environmentally friendly technology which would enable Corus Aluminium NV to process a wide variety of (organically contaminated) scrap and giving the existing casthouse a desired production increase (thanks to the input into the existing furnaces of remelted aluminium in liquid form). The advanced state of the technology used had to result also in a high recovery, in being energy efficient and in very low emissions while creating little waste.

Being able to process a large spectrum of scrap alloys was very important. (The customers of Corus Aluminium NV transform aluminium for very diverse applications.) Besides conceptual implications for the melting furnace, efforts had to be made to fit the produced composition into the production logistics of Duffel. Several existing casting lines are present, followed by several rolling and extrusion installations, each with continuous changes in alloys and qualities. It was a challenge to couple the scheduling of Greenmelt in such a way to the scheduling of the casthouse that the right scrap types would be molten so that the result (liquid aluminium) would fit in one of the casthouse melting furnaces just in time to realise a maximum production gain. For this purpose mathematical models had to be developed.

The sum of all these design considerations in a single installation make this project unique.
Important aspects connected with this project are:

- the new concept of the technology used;
- the full scale demonstration of the applied environmental technologies resulting in meeting easily the emission levels imposed by the authorities;
- a decrease of the environmental impact of the company;
- the stimulating effect on other companies: it is possible to make an economically attractive activity from an investment, triggered by environmental considerations.
- The effect on macro scale: more scrap melting capacity for and demand for well segregated aluminium scrap leads to more efforts to keep scrap separated at the source and recycling activities are stimulated.

Greenmelt had to be an example of an innovative, profitable and environmentally clean new melter.

In order to achieve a new type of melter, which can process a broad spectrum of scrap types, which gives a high metal yield, has little negative environmental effects, with a design concept of high technological value, having a new efficient method to change to different alloys, and with high energy recovery, risks have been taken to get a head start on competitors with respect to production costs, flexibility and environmental improvements.

The subsidy of the LIFE-Environment program of the European Committee was important for the realisation of this installation.
2.4 Results of Greenmelt

Two years after the start-up of Greenmelt, many of the important issues have been realised in several discussed areas: technology, economy, ecology and public awareness of this advanced installation.

2.4.1 Global results

2.4.1.1 Scrap remelting capacity

The external scrap input of Corus Aluminium NV has practically doubled since 1996. (Fig. 2.2) The shift of scrap types from the furnaces of the casthouse to Greenmelt did not result in a higher consumption of primary metal. The Metal Purchasing department, which has been extended, succeeded to find sufficient clean (causing no emission problems) aluminium scrap to compensate the volumes shifted to Greenmelt. So the remelting of external scrap has increased with more than the predicted 12,000 ton; 19,000 ton extra external scrap has been molten in comparison to 1996. In 1999 external scrap made up 18% of the realized production of semis.

More demand for well-segregated aluminium scrap leads to more efforts to keep different scrap types separate at the source. And because of the higher value, scrap dealers will find it worthwhile to better separate the different aluminium scrap types from other metals and into different grades and alloy groups. That way it is possible to re-use scrap to produce the same kind of products as the scrap originated from.

Furthermore, if more large aluminium transformers follow the Corus example, smaller foundries (often producing casting alloys) will be forced to use the lower grades of (non-segregated) scrap, which are (still) unusable for large semi-plants like Corus Aluminium NV. To be able to do so, eventually they also will have to invest in more efficient and clean technology.

Of the total external scrap volumes processed at Corus Aluminium NV, only some 20% is originating directly from customers. These are mostly large customers, which can send back on regular base full truckloads of scrap. Most of the scrap comes from scrap collectors which play an important role in the aluminium life cycle: they concentrate smaller lots of scrap of different local sources and can separate the scrap from other metals (for instance iron) and into alloy groups and grades.
Fig. 2.2 : Metal flows Corus Aluminium NV before and after realization Greenmelt (figures in kT)
2.4.1.2 Impact on the environment

Before the realization of Greenmelt, now and then the measured emissions of the melting furnaces exceeded the allowed levels. (for instance particulate level in the flue gases: Fig. 2.3)

The cause was the processing of external scrap, somewhat “contaminated” due to the transforming processes of the end customer. (often oily scrap)

By shifting these problematic scrap types to Greenmelt, no violations of the norms happened any more. (allowing also a lower measuring frequency)

The higher amount of scrap in the charges of the casthouse has resulted in 12% less use of primary aluminium (in the form of melting ingots and rolling slabs).

By proving that remelting of scrap in an efficient and environmentally friendly way can be profitable, Greenmelt promotes aluminium scrap processing in preference to primary aluminium production.

2.4.2 Greenmelt installation

2.4.2.1 Some of the results after 2 years of production

- The emissions of Greenmelt are far below the maximum levels put on the installation by the authorities. The dioxine content in the flue gases is 10 times lower than the limit of 0.1 ng/Nm³ Teq.
- The production level (remelt capacity) is on average above 85 ton/day with a maximum of 90 ton/day.
- The consumption of primary aluminium is low (< 4% of the capacity). This means that the furnace is effectively used to remelt scrap.
The average metal yield varies between 90% and 92%, but is of course strongly dependent on the type of scrap processed and the contamination percent and type. Clearly there is room for improvement. Experience has shown that for example an optimal use of all available methods to charge the scrap (see further on) improves the metal yield as a function of scrap type.

Waste:
The only real waste is baghouse dust, separated in the flue gas treatment installation. (6kg/ton production) This dust is sent as class 1 industrial waste to a recognised waste processor. The skimmings (dross) which are produced, are in fact a secondary aluminium source, out of which app. 60% aluminium can be gained at external processors, thanks to the measures which are taken to prevent further oxidation after removal from the furnace. App. 10% of dross is formed on average.

More than 98% of the liquid metal produced by Greenmelt is used in the casthouse in liquid form, demonstrating that the production scheduling system is functioning well.

2.4.2.2 Important lessons

Scrap buying needs much attention. Development of good contacts in the scrap world, a database and a good method to test the bought scrap are essential to purchase the right scrap at the right price. An effective control of the Metal Purchasing Department by the Production and Planning Department is necessary.

Well-educated people having the necessary equipment and procedures to inspect and validate the scrap bought and processed, are essential.

A good tool for production planning and composition calculations is necessary for an optimal validation of alloying elements in the scrap and to schedule the liquid metal input in the casthouse in such a way that optimal productivity is obtained. This last aspect needs further attention in the coming years.

Continuous attention from the production personnel and the management remains necessary to get optimal results out of the installation; technologically speaking, Greenmelt is a high-grade installation which requires well trained and motivated personnel.

2.4.2.3 Technological modifications after start-up

Reference: chapter 3 : Greenmelt, a new technology

The originally installed gas collection system on top of the scrap-charging door has been completely redesigned : the fume evacuation during skimming was not sufficient.

The refractory lining and –construction has been modified considerably (the lifetime was far too short).
• The originally installed charge well has been replaced by a smaller one to get a better circulation of the metal in the furnace.
• The ladle-cleaning machine has been modified.
• The scrap charging installation was not sufficiently “robust” and had to be modified to cope with the mechanical forces and the temperature.

In the coming years more work will be done to optimise the plant. The full potential of the plant has not yet been obtained, and results are expected to improve even further.

2.5 Future

The different aspects of Greenmelt which make it an example for the future have been noticed internationally, which is clear from large amount of visits to Greenmelt these past years. It is expected that in the coming years other major aluminium producers of semi-finished products will want to process more scrap (their own run-around scrap, scrap from their customers or bought on the market) in an installation of their own. Greenmelt demonstrates the capability to use advanced technology including the best features to safeguard the environment to obtain a profitable activity.

Presently, other major aluminium transforming plants have not copied the Greenmelt concept as a whole. Some of them already have (older) installations for scrap processing and did not yet decide to replace them with newer technology: it remains an important investment. The environmental legislation is however becoming stricter and will increase the pressure on those companies. An important element for the rentability of the concept is the necessary close bond of the scrap remelter and the producer of rolling slabs (liquid input). The complexity of this can put off companies. As Greenmelt is a clever combination of best available technologies and some new findings, it’s probable that for new or renovation projects in other countries, several aspects have been taken over or have been further developed without copying the whole concept. It is difficult to track this. For smaller companies, the concept as a whole is too expensive (the furnace needs to be big) but separate elements can also there be used.
3. GREENMELT: A NEW TECHNOLOGY

The new Greenmelt installation is based on a unique principle, namely a gasfired, static, multi-chamber furnace system, in which different alloys of aluminium can be processed efficiently. The furnace has been specially designed to process coated scrap. The organic constituents which are developed (pyrolysed) during the heating of the scrap are fired and therefore contribute to the heat input into the furnace. The principle of gas cleaning by burning the off-gases in the afterburner followed by neutralisation and filtration of the flue gasses results in low emission levels conforming to the most stringent rules applied by the authorities (regionally and internationally). There is no limitation to the type of organic compounds in the scrap: lacquer, plastics or oil residues all can be efficiently processed. Presently the maximum amount of organic contamination is 6% of the weight of the scrap.
3.1 Furnace: design and operation

The basic design of the furnace consists of two chambers: the so-called sidewell, and the main hearth. A simplified principle drawing can be seen in figure 3.1, showing the molten metal flow as well as the gasflows within the chambers.

Large pieces of scrap metal are loaded or charged into the sidewell, and the molten aluminium is tapped from the main hearth. These two chambers are separated by a refractory lined wall, which contains an opening at the bottom through which the molten metal can flow from the sidewell to the main hearth. Two natural gas burners keep the main hearth at a constant temperature, whilst the sidewell can be heated by a single burner.

The molten metal is constantly being pumped through the two chambers by means of an electromagnetic pump.

The chargewell is a separate chamber, which is connected to the main hearth and the sidewell. This is where small pieces of metal scrap can be charged into the metal bath; the turbulence caused by the electromagnetic pump causes the loose pieces of metal to be sucked into the molten metal, thereby reducing oxidation. To a large extent this increases the metal yield for this kind of scrap.

As was said earlier, the scrap is preheated in the sidewell. Because of the oxygen-depleted environment in this chamber, organic compounds on the scrap in the form of paint and oils are pyrolised, and not burned. The volatile gasses are an important energy source, and therefore are
transported to the thermal oxidizer, where they are burnt. After this process, they are poor in oxygen and have a high temperature, and are routed partly back to the sidewell, where they can once again be used to preheat the newly loaded scrap. In this way the heat of the flue gases is reused, thereby increasing the thermal efficiency of the furnace. A fraction of these gases is routed to the recuperator, so that by cooling down they can preheat the combustion air of the burners in the main hearth, which once again leads to an increased thermal efficiency.

The flue gases created in the various chambers, in particular from the sidewell are treated in a series of filter installations, so that the final gaseous emissions easily conform to the strictest European norms.

3.1.1 The Sidewell

Scrap is charged into this chamber in the form of pressed bales or loose pieces. This process takes place every 20 to 30 minutes, whereby a load of scrap is placed on the ledge in the sidewell; on this ledge hot gasses preheat the scrap and pyrolyse the organic impurities. The actual charging is done with the help of a charging machine, which runs on rails and has a capacity of 2.5 to 3 tons. This so-called charging machine is mounted with a hood, which fits the hood above the door of the sidewell seamlessly, thereby reducing the escape of gases from the sidewell.

Once the scrap has been loaded onto the ledge of the sidewell, the heating and pyrolysis can commence. The burned gases, having a temperature of around 1000°C, and with a low oxygen content of about 2 to 3%, are responsible for this decomposition of the organic compounds, coating the scrap.
The flue gases which are hereby created, containing the energy-rich VOC’s (volatile organic compounds), are routed to the thermal oxidizer, a process which is dependant on temperature, pressure and oxygen content. The fumes are also circulated within the sidewell by means of a fan thus increasing the heat transfer.

Once the scrap has been preheated to a sufficiently high temperature, it is pushed into the molten aluminium bath by the next load of scrap. Melting is achieved by the constant flow of molten aluminium, which is being pumped from the main hearth, through the chargewell and into the sidewell. From there it continues its path to the main hearth again, where the cycle can repeat itself. In this way, the electromagnetic pump realises an efficient use of thermal energy.

3.1.2 The Main Hearth

The main hearth contains two natural gas burners, which are controlled on the basis of the temperature of the liquid aluminium bath and the (refractory) roof temperature. The aluminium is brought into a super heated liquid form at temperatures between 700 °C and 800 °C. The maximum roof temperature allowed is 1050 °C. The flue gases developed are routed to the thermal oxidizer to keep it hot.
The liquid aluminium does not stay in the main furnace chamber. It is pumped by means of an electromagnetic pump to the charge well. The liquid level in the main furnace chamber is max. 1100 mm (on an average 800 mm). If the liquid metal is molten and brought at the desired temperature, it is sampled and tapped in ladles to keep the liquid metal at a required temperature.

These ladles are transported to the casthouse, where the liquid metal is poured into one of the melting furnaces. The use of the metal in liquid form is important in order not to loose the energy stored in the metal. In case the aluminium cannot be used immediately in the casthouse and in case all ladles are filled there is the possibility to pour the metal into blocks in the so-called “sowcaster”. These blocks with a weight of 500 kg can be remelted later.
3.1.3 The Chargewell

The chargewell is filled by the electromagnetic pump with liquid metal which creates a wave. In the wave the scrap particles are efficiently submerged avoiding oxidation of the aluminium and loss of metal. In the sidewell, the small pieces of aluminium would remain on top of the liquid level and melt poorly. The capacity of the pump is 8 ton of liquid aluminium per minute.

3.1.4 The Thermal Oxidizer

The purpose of the thermal oxidizer is to fire all the unburned constituents of the gases from the sidewell, thereby also decomposing a.o. toxic dioxines. An important part of the energy required is freed by the burning of the organic constituents which have been evaporated by pyrolysis in the sidewell.

If necessary, natural gas can be added to the flame of the oxidizer. The resulting flue gases are measured for temperature. This should be between 900 °C and 1150 °C at an oxygen content of 2-3%. The off gases are partly returned to the sidewell, partly fed to the recuperator to preheat the burner air supply.

3.1.5 The Filter installation

After the flue gases have cooled down in the recuperator, they are neutralised by means of a product based on lignite and limestone. This is done so that the acidic compounds and dioxines (in case any should have recombined) in the gasses can be separated in the baghouse.
The exhaust gases, which escape from the furnace when the respective doors are open, are caught by an exhaust system. These gases are composed mainly of air and dust and are essentially cold, so that they are treated by means of a separate baghouse.

3.2 Branch installations

The described installations above comprise the primary installation. However, there are certain branch installations, which are essential for the further process.

3.2.1 Ladle cleaning machine

The ladles, which are used to transport the molten aluminium from Greenmelt to the main casthouse, show a build-up after some time. This can be removed with the help of a special machine, which scrapes the inside of the ladles.

3.2.2 Sowcaster

If the molten metal from the main hearth cannot be processed by the casthouse, it is poured into metal blocks of 500 kilos by means of the sowcaster. These can be remelted at a later time by the melters in the casthouse. Obviously, this is energy intensive since
the metal must be remelted again, so the sowcaster is only used in special circumstances.

4. PROJECT ORGANISATION

The project team has been responsible for the realisation of all aspects of the Greenmelt installation, and for keeping them within the financial and time limits. Furthermore, the project team made sure the proposed goals were in fact adhered to, and were not lost sight of. They reported to a steering group, made up of board members of Corus Aluminium NV in Duffel.

Project Leader
The project leader was responsible for the general project management, the budget control and the co-ordination of all project activities. He also initiated scrap purchases (commercially and technically). After completion of the Greenmelt installation, and once it became operational, it was made part of the casthouse organisation.

Project Engineers within the Project Team
A couple of project engineers worked full time on the project and during the initial production phase. In addition, specialists with specific expertise were also regularly consulted for matters concerning certain aspects of Greenmelt.

The tasks of the project engineers included amongst other the delivery of specifications, assistance with purchasing, co-ordination and project planning, follow-up work, and evaluation of the progress and results of the project. Determining work procedures, making technical documentation and operating manuals, and of course trouble-shooting also were part of their job.
5. CONCLUSIONS

The completion of the project, respecting the approved budget, the allocated time, the quality of the installation components and the preservation of the project’s innovative character, was a general success.

It has turned out that by fine-tuning design parameters the environmental aspects are better served than with a conventional “end-of-pipe” filter installation. The gaseous emissions of Greenmelt, especially with respect to toxic dioxines, are remarkably low; standard baghouses on conventional melters show levels which exceed Greenmelt’s.

Valuable experience has also been gained with respect to the use and processing of different types of scrap. Continuous adjustments and development of the operational procedures will undoubtedly lead to increased metal yields, which will add to the profitability of the installation. Further testing with different contaminant levels of the scrap, and the different types of contaminants, will determine if it is economically viable to complement the existing installation with a scrap treatment line, for example with a shredder and a decoater. This separate installation would deliver smaller pieces of scrap, and remove the organic compounds prior to melting.

The current production capacity levels obtained and demonstrated are clear proof of the economic potential of the Greenmelt installation. The results cannot be attributed to “beginner’s luck”: they are reproducible. The size of the current installation and the execution of the design guarantee a certain amount of security that predicted results for future installations can be obtained. The scale of Greenmelt is such that future improvements can easily be realised and implemented.

The international impact of a new and environmentally friendly installation such as Greenmelt is clear since there have been many global contacts and visits to the plant. The fact that the installation has proven to provide a safe, environmentally friendly and economically sound way of remelting organically contaminated aluminium scrap has only strengthened its international position. Therefore it is essential that this trend is continued in the coming years, although there is little doubt that this will not happen considering the broad continuous interest in Greenmelt.