MELTING FLEXIBILITY in SECONDARY ALUMINIUM PRODUCTION

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Introduction

The aluminium industry is the world's second largest metal industry, after steel industry.

Aluminium is widely used in almost all sectors and industries, and each application requires special properties from the aluminium.

During the Second World War, the number of aluminium application areas were increased rapidly. Then the civil applications grew quickly between 1945 and 1970, by which time the usage of aluminium was very broadly based. The recovery of aluminium from old scrap has shown an even more rapid expansion over the same period of time. Increasing cost of energy and enviromental restrictions have provided the impetus for increased recycling rates. Improvements in recycling technologies and changes in the end-user consumption patterns have also provided an increase in aluminium scrap recovery.

Secondary Aluminium Industry

The Aluminium Industry's recycling operations, commonly referred as "secondary aluminium", use purchased scrap as raw material. Purchased scrap is classified as "new" (manufacturing) and "old" (discarded aluminium products) scrap.

Due to the common usage of aluminium, it requiers sophisticated processing of different types of aluminium scrap prior to remelting and refining. Aluminium and other materials, which are used in composites, have to be liberated and seperated from each other. Moreover, residues deriving from the remelting and refining process such as salt slag or dross have to be treated.

The modern secondary aluminium industry treats and transforms aluminium scrap into standardized aluminium and aluminium alloys (sometimes it is called "urban mining" or "surface mining").

The percantage of recycled aluminium demand over total global demand has grown from 20% to 33% between 1950 - 2006. Recycling is a major aspect of aluminium useage, with more than a third of all the aluminium currently produced. The secondary aluminium industry has effectively tripled its output from 5 million tonnes in 1980 to over 16 million tonnes in 2006. During the same period primary metal useage has grown from 15 million tonnes to 30 million tonnes.

Aluminium production consumes 3% of the world's electricity and 10% of the worlds hydropower.

Average CO_2 emissions are 9.7 kg CO_2 per kg of aluminium (5.4 kg from electricity prudction and 4.3 kg from bauxite minig and alumina refining). Emission rates can be much higher especially for the old Soderberg pot lines and where electricty generation is coal based (20.8 kg CO_2 per kg of aluminium just for electricty production).

Since the 1880's, close to 800 million tonnes of aluminium have been produced. About three quarters of this metal still in productive use. It means, recyclable metal currently stored in use would be equal to 17 years of primary aluminium production.

Secondary Raw Materials

In contrast to primary aluminium production, which requires bauxite as its raw material, secondary operations depend on **sufficient quantities of suitable scrap.**

Secondary aluminium production involves six general consecutively steps of operations:

1. Scrap purchase and collection
2. Scrap pret-reatment
    - Scrap separation and preperation
        - Mechanical cleaning
        - Pyromettalurgical cleaning
        - Hydrometallurgical cleaning
3. Scrap remelting and refining
    - Scrap remelting
    - Scrap refining and alloying
    - Ingot casting
4. Production of alloyed aluminium
5. Processing of aluminium dross, generated from primary and secondary aluminium production, to recover remaining metallic aluminium
6. Shipment of ingots or molten metal to casters.

Some or all of the the steps may be carreid out in any facility. Some steps may be combined or re-ordered, depending upon scrap quality, source of scrap, scrap price, auxiliary equipment availability, furnace design, product specifications and enviromental conditions. Plant configuration, scrap type usage and product output varies throughout the secondary aluminium industry.

Mechanical cleaning includes the physical separation of aluminium from other scrap with hammer mills, different types crushers, shredders and other machines to break aluminium containing scrap into smaller pieces to improve the efficiency of downstream recovery by magnetic removal of iron. Other recovery processes include vibratory screens and air classifiers. Pyromettalurgical cleaning techniques use heat to separate aluminium from contaminates and other metals. Pyrometallurgical techniques also include decoating and sweating. The decoating process involves heating aluminium scrap, which have organic contaminants, in rotary kilns. Heating porcess in rotary kilnns require high enough emperatures to vaporize or carbonize organic contaminants, but it should not be high enough to melt the aluminium. Hydrometallurgical cleaning process use water to clean and process aluminium scrap,including leaching and heavy media separation.

Scrap Quality Differencies Between Western and Eastern Countries

In Western World there are 35 classes scrap defined by the U.S. Instıtute of Scrap Recycling Industries (ISRI). Many of these classes describe recovered aluminium from old scrap, but several number of them defines the new scrap. ISRI descriptions are used primarily by brokers and dealers rather than processors or re-melters. These descriptions of grades help to explain the characteristics for determining the value of the aluminium scrap. But in ex-Soviet countries, Middle East and North African countries,there are no scrap processor, just collector. So they described just 5 different classes of scrap instead of 35 of ISRI classes:

- Super aluminium describes utensils, cables, wires, extrusions, and RSI

- Soft aluminium scrap describes utensil and taint tabors include in hard forging alloys scraps, and RSI
- Used beverage can and aerosols, and RSI
- Airplane and marine scraps, and RSI
- Mixed scrap, and RSI

Some of the scrap collecter has to produce RSI, because of custom restriction of scrap export.

All these 5 classes have many physical and metallic contaminants. Therefore re-melter has to have suitable sorting and melting technology to produce acceptable quality aluminium alloys.

Melting system selection and flexibility is one of the most important criteria in secondary aluminium operations to use wide range of scrap and produce standard aluminium alloys.

Main problems in Russian mixed scrap:

- Scrap is mixed, needs to be separated,
- Free of iron, zinc, magnesium, lead,
- Non-metallic inclusions.

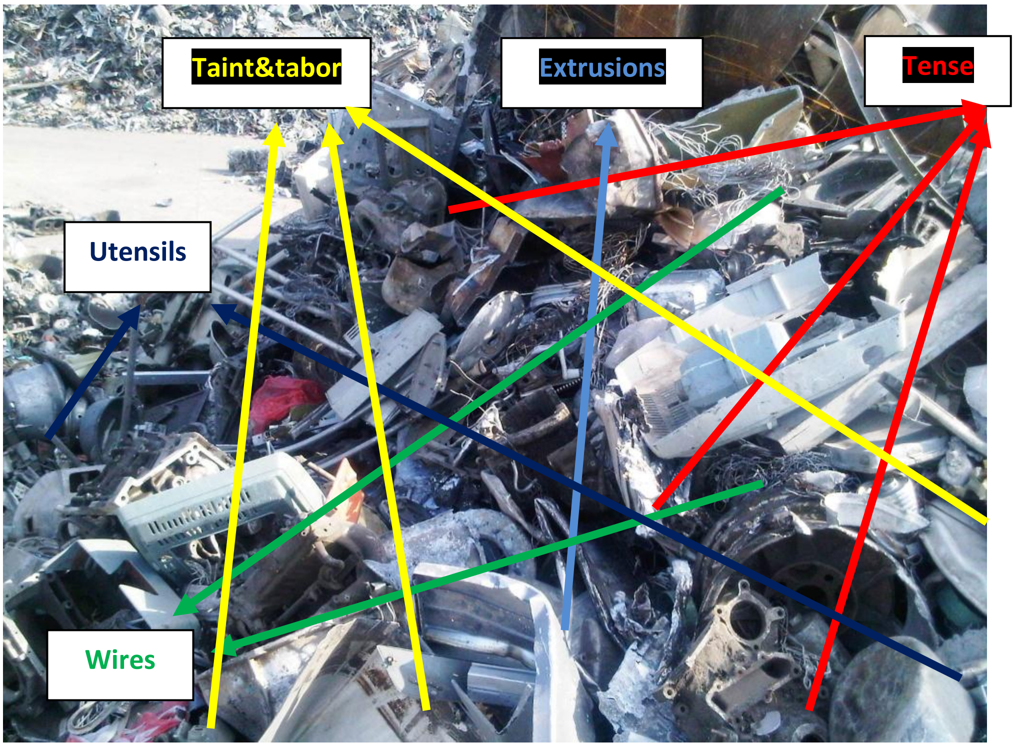

Fig 1: Mixed Russian scrap

Fig 2 :RSI production in Algeria

- RSI produced according to the 5 scrap classes which were defined above. There is no chemical composition informations of each batch.
- Since fluxing is not comman, it needs further metal refining after melting.

Fig 3 :Sweating furnace in Azerbaijan to produce RSI

Fig 4 :RSI ingots from Georgia (AK5M2)

- Most probably it has high zinc, iron and lead content in RSI from scrap.
- AK5M2 does not meet Western standard requirements (close to AlSi9Cu3).

The Correlation of Charge Type and Melting Technologies

Fig 5: ST twin chamber furnace

Fig 6: ST tiltable melting&holding furnace

Melting flexibility is one of the most important factor for the secondary alumininum production plants. The well designed plant can process different type scraps and naturally produced many different aluminium alloys. Especially, some of the plants has no chance to buy processed scraps from the market. So they have to pre-sort and melt the scrap by themselves, because of the difficulties to find suitable quality scrap and high processed scrap prices. For the un-processed scrap melting, sweating furnace and rotary furnace will be the optimum solutions. Sweating furnace has to be equiped with holding furnace to collect, alloy and refine the molten metal which comes from the sweating chamber. Since sweating chamber is dry hearth furnace, there is no molten metal pool. Direct flame impingements to solid scrap in dry heart chamber causes high energy and metal loss (almost 3-5% metal loss more than wet hearth according to author's experience). It also catalyses to produce more pollution from organical contaminants of scrap. Rotary furnaces are very popular in around the world. It is possible to reach very good melting and energy efficiency. In addition to that, by using oxy-burners environmental requirements can be also met in rotary furnaces. Oxy-burner works as an after-burner to burn particles. But in any case it needs fluxes to melt un-processed scrap and naturally produced salt cake.

Side-well furnace and multi-chamber furnaces have a similar performance to melt processed scrap. Twin chamber furnace allows melting of coated and oily scrap in scrap chamber with high melting efficiency.

Induction furnace technolgy can be also preffered to melt proccessed scrap . But due to their capacity restrictions, they are not commanly used.

Correlation between charge type and melting technology is summarized in the below given table.

Table I : Correlation between charge type and melting technologies

Main charge types	**Pre-sorting**	**Side-well furnace with vortexer**	**Multichamber furnace with EMP**	**Sweating furnace with holding chamber**	**Rotary furnace**	**Coreless low-frequency induction furnace**
Un-processed mixed scrap M.E. M.Q. Emissions E.E.	**No**	**No**	**No**	**Yes** **Low** **Moderate** **High** **High**	**Yes** **High** **Moderate** **Moderate** **High**	**No**
Processed mixed scrap M.E. M.Q. Emissions E.E.	**Yes**	**Yes** **High** **Good** **Moderate** **High**	**Yes** **High** **Good** **Moderate** **High**	**Yes** **Low** **Moderate** **Moderate** **Low**	**Yes** **High** **Moderate** **Low** **High**	**Yes** **High** **Good** **High** **High**
Un-processed tense M.E. M.Q. Emissions E.E.	**Yes**	**No**	**No**	**Yes** **Low** **Low** **High** **Low**	**Yes** **Moderate** **Moderate** **High** **High**	**No**
Processed tense	**Yes**	**Yes** **High**	**Yes** **High**	**Yes** **Low**	**Yes** **High**	**Yes** **High**

M.E. M.Q. Emissions E.E.		**Good Low High**	**Good Low High**	**Moderate High Low**	**Good Moderate High**	**Good Low High**
Un-processed T&T M.E. M.Q. Emissions E.E.	**Yes**	**No**	**No**	**Yes Low Moderate High Low**	**Yes High Moderate Moderate High**	**No**
Processed T&T M.E. M.Q. Emissions E.E.	**Yes**	**Yes High Good Low High**	**Yes High Good Low High**	**Yes Moderate Moderate High Low**	**Yes High Moderate Low High**	**Yes High Good High High**
Coated- painted-oily scraps M.E. M.Q. Emissions E.E.	**Yes**	**Yes Low Moderate High Low**	**Yes High Good Low High**	**Yes Low Moderate High Moderate**	**Yes Moderate Moderate High Moderate**	**Yes Moderate Moderate High Moderate**
Alloying elements M.E. M.Q. Emissions E.E.	**No**	**Yes High Good Low High**	**Yes High Good Low High**	**No**	**No**	**Yes High Good Low High**
RSI M.E. M.Q. Emissions E.E.	**Yes**	**Yes High Good Low High**	**Yes High Good Low High**	**No**	**No**	**Yes High Good Low High**
Possibility of de-coating equipment integration		**Yes**	**Yes**	**No**	**No**	**Yes**

M.E.: Melting efficiency; M.Q. : Melt quality; Emissions: Emissions level; E.E. : Energy efficiency

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