Proposal of recycling system for waste aluminum

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Abstract

Introduced work is focused on waste aluminum recycling process with objective to propose complex production system for recovering of aluminum and some aluminum alloys. Solution is supported by extended analysis concerning purpose, basis and system sequences for recyclation. Based on that, sources, possibilities and conditions for recycling are formed. This has been used in proposal of manufacturing system. The principle is the structural proposal of manufacturing system, which does not only differentiate the stage of aluminum melting process, but also related stages as gross separation, sizing, containerisation and batching, palletisation, stacking and some related operations. Production system respects technological specifications, requirements for rationalisation of manufacturing systems, technical and economical feasibility conditions and is considered in lower automation level. However production system solves complex problem of recycling of some types of aluminum, it improves flexibility, production, quality (melting by high enforcements and in protective atmosphere) and extention of production (final products production).

Keywords: Aluminum alloys, Recycling

1. Introduction

Waste is produced by every human activity and in both manufacturing and consumption spheres. Production and accumulation of waste has significant impact to environment. Waste contains substances that are hazardous for all parts of environment as water, air and soil. They accumulate in plants and through food network become hazardous for animal and human beings. Proper waste treatment is very important as well as providing of basic living needs. Even more important becomes waste recovery and recycling for secondary use [6], in case of high performance recycling can be used as a source in semi-product or product area. Recently, the shortening of raw materials and energies sources can be eliminated by recycling processes [5], and is considered as acceptable economical and ecological solution. One of possibilities is waste treatment process focused on quality and elimination of losts by its further treatment. Treated waste is further processed in special operations in companies focused on iron and non-iron metal treatment. Most of these operations have recycling technology on corresponding level, but without logical setup of recyclation stages.

Recently aluminum recylcation processes have various special proposals with limited field of application, but high inspirative potential. These are:

- recycling of aluminum from technological by-products [3,12,13,14],
Objective of introduced article is to elaborate the proposal for manufacturing system for recycling of some waste aluminum types, which should serve as complex solution for waste treatment and support recycling technologies development.

2. Sources and characteristic of waste aluminium

Waste aluminum is produced in manufacture and consumer sphere. It is found mainly:

- in waste aluminum collection system (aluminum products after longlife expiration),
- by recycling of devices (aluminum parts from separation processes),
- by production and manufaturing of aluminum (side-cut, snips, scraps).

Mentioned types of waste are different by use, composition, shape and stage. According to their use, following classification takes place:

- consumer - non-alloyed (produced mainly in electro-ics, chemistry and food industry),
  - alloyed (produced mainly in automotive and air industry),
- production - returning (produced mainly in melting processes) and contains aluminum and oxides, ev. residues of coating slags).

According to shape, classification is as follows:

- bar and profile,
- sheets and bands,
- blocks and cases.

According to stage, classification is as follows:

- clear,
- contaminated with - solid particles,
  - liquid particles.

Overview shows large range of aluminum waste and differencies in their origin and use, that are not able to be solved together, but partialy.

3. Sources and conditions for waste aluminium recycling

Recycling as an objective of our proposal, introduces consequency of steps corresponding to waste treatment needs. Spectrum of aluminum waste is large, therefore we focus only to straight and alloyed types. These are most suitable for recycling to their previous form. Because waste aluminum with its composition, shape, size and stage does not meet requirements for its direct use in melting devices, conditions and possibilities of recycling are different. This can result in request of extended recycling steps related to specification of recycled material. Generally, recycling conditions represent following activities:

- waste decomposition according to composition, stage, eventually size and shape,
- elimination of undesirable components,
- shaping of waste by mechanical cutting, packeting, briqueting, crushing, banding to packets,
- preparation of recycling material, concentrating of residues and enrichment,
- treatment of recycling products by cleaning, packing and palletisation.

Basic requirement is to modify the waste so that all utilisable components will be picked up. Model of above mentioned waste treatment is shown on Fig.1, with focus on systematical connections in waste treatment, material flow process and related technologies, eventually applicable professions.

4. Function, structure and parameters of manufacturing system

Foundry desing as well as recycling technology is various, because foundry mostly exceeds the limit of production facility and has character of of independent plant [4]. This is caused by foundry devices beeing larger and different than treatments plants. Therefore is essential to respect specifics in designing of certain technologies, where recycling technology belongs.

Our solution of recycling process (Fig.2) respects basic requirements of rationalisation, technical and economical feasibility and reaches signs of lower automation. Production system consists of following teps:

- gross separation,
- sizing,
- containering and batching,
- casting,
- palletisation and storage.

4.1. Gross separation

Aluminum waste is collecting on gross waste dump (9) from where it is separated to clear aluminum (electrotechnics), or aluminum alloys (pieced aluminum) without external compounds [17] and routed to cylindrical chute (3). Other non-aluminum waste is stored in preparation container (11). Cylindrical chute is integration element between gross separation and sizing.
Fig. 1. Model of waste aluminum recycling
4.2. Sizing

Sizing consists from hydraulic cut HS (2) [18], equipped with joining device, which picks up bar, band and profile materials from cylindrical chute (3) and forms continuous bunches that are cutted according to containerisation requirements.

4.3. Containerisation and batching

Sized waste falls to chute from where it goes to batch container (12) and volume of single container is equal to one bucket of melting furnace. Location of each container is provided with three offsets in floor. Scale is used for weigh control of filled container. For providing of operational supply are enough three pieces of batch containers. This number of containers is enough for one shift by maximum utilisation of operating time of melting device. Batching is performed by manual double-axial portal manipulator (6), which transfers container from filling point to overhead of melting furnace (1) and opens the bottom of container by using of multi functional efector, which causes batching of the furnace.

4.4. Casting

After filling up the induction melting furnace NFTO-AI 350/100 (1) [16] with batch, taking out the batching container (12) and pushing in the cover of melting furnace, melting process begins. Afterwards, begins casting to prepared metal forms which move on bumper inter-storage (4) made from rail track in round shape. Bumper inter-storage consists from 11 forms delivery cars and is equipped with fixing device (8), that fixes cars in forms preheating areas, cutting areas and taking out from the forms areas. Beside that, first stand for cars prior to casting is equipped with gas device for preheating of metal forms (7).

4.5. Paletisation and storage

Is arranged next to inter-storage (4), and consists of six storage cells (10) set in manipulation zone of manual manipulator RMS 63 H (5) [15], which is integrated element for taking the casts from metal forms, their paletisation and stacking in corresponding locations of expedition storage (10).

4.6. Technical and economical characteristics

- annual production                  5324 pcs/year (160 t/year)
- shifts                                       1
- usage coefficient – melting device 0,68
  - related devices                   0,2-0,7
- electricity requirements- elektricrical 710 kWh/t
  - pressure                          5,5 m3/t
  - gas                              0,6 m3/t
- room requirements- production 72 m2
  - other                            36 m2
5. Discussion and conclusion

Are included in following topics:

Arrangements for rationalisation of production system structures.

Advantages of recycling are obvious, but difficult by research, development, investments related with new technical solutions. Therefore, by considering of recycling advantages, there is a need to remember rationalisation, systematics and complexity principles. By rationalisation of production systems we can not forget about that objective and goal is in rational arrangement of elements and components of the system, which enables rational proceeding of technological and production processes [9]. The most important principles in recycling production systems can be as follows:

- complete utilisation of material base, which provides flexible and fast reaction to customer and market requirements, characterical with productivity and quality, as electrical resistance melting furnaces [2],
- building of continuous structure of material flow with support of partial solutions (as universal casting variable speed conveyor) and elimination of disproportions related to different technical level of related devices,
- better utilisation of waste requires providing of technological connection between production of semi-products and final products,
- continuous improvement of immediate narrow production places, it means react promptly to research results and taking the prevention measurements [8].

Arrangements for avoiding aluminum losses by its remelting.

Effectivity of recycling depends also on way of melting, melting device and preliminary batch preparation. There was elaborated arrangements for decreasing aluminum losses, by oxidation in remelting process. Effective melting is so called concentrated melting [2], providing of fast melt process. This is done by combined heating (resistance heating – gas heating) or induction heating (plasma heating through cap) [11].

By re-melting of aluminum in induction furnace, mainly in maintaining stage of melt before casting, there is a need to eliminate whirling of level. This is possible by eg. decreasing of induction coil level and its location into low part of pot. This is done on induction furnaces from company Junker [19]. Another measurement is pushing of inert gas to under the furnace cap, or applying of inert gas in induction furnace with pressure emptying [20]. Increasing of aluminum burnout impacts the batch surface. Batch with large surface (sheets cuts) can be shaped according to furnace pot shape (cylinder). Small forms of scrap are available to be dosed to molten aluminum on bottom of induction furnace, under internal atmosphere, through closed cap of furnace.

Results of finantial-economical analysis.

Come from following expectations:

- financing -50% credit, interest of 23%

Reached values:

- production - aluminum casts 5324 pcs/year (160t/year)
- price data - input (Al waste) (18-30 Sk/kg)
- output (Al casts) (45-70SK/kg)
- investment costs 10.574.000,- Sk
- costs for capital 9,625%
- recent value of expected profits 11.838.068,-Sk
- payment term 3 years
- internal profit percentage 15,149%

6. Conclusion

Important extenton and increasing of recycling effectiveness starts to being considered as important measurement because of effective material and energy sources utilisation and also from environmental point of view. Main deficiency in improving recycling effectiveness are the rationalisation of production processes structures and operational structures.

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