SUPERIOR VALORISATION OF THE METALLIC SCRAPs FOR OBTAINING COMPLEX ALUMINIUM MASTER ALLOYS USED IN ADVANCED REFINING OF THE STEELS

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Abstract

A solution is proposed for superior recycling of the aluminium and steel scraps. Improving of the quality of the metallic materials recycled will become more important for the quality of the steels and also for the market of the ferrous and aluminium scraps. The research about the metallic scraps valorisation to obtaining the master alloys with reactive elements (Al, Mn, Si) used for special steels refining is presented in this paper. By this way the recycling of aluminium scraps leads to increase the recovery ratio of aluminium as scraps into new materials with added value. These are FeAl, FeMnAl, FeMnSiAl. A new technology for obtaining these materials was proposed. This solution was established to ensure reproducible results, the steadfastness of the chemical composition of alloys, a maximum recovery ratio of elements and, low energy consumption.

1. INTRODUCTION

The discussion about the position of the metals as iron and especially as aluminium within an economy which aims at sustainable development is conducted strongly controversial. For correctly position of the metals in accordance with sustainable development, it is necessary to extend the view to the whole life-cycle with correctly evaluation of the efficiency of the recycling-loop for these. The aim of a recycling with orientation towards sustainability has to be keep metals and alloys produced with high energy input in the material cycle as long as possible. The recycling loop for metals divided in two different loops (a closed-loop and an open-loop). For aluminium this is shown in Fig. 1.

![Fig. 1. Recycling loop for aluminium [1]](image-url)
Theoretically, iron and aluminium can be recycled an unlimited number of times without losing their chemical and physical properties. For this it is essential to find the best solution to improve the quality of recycling in accordance with economic factor and environmental protection. The choosing of the optimum solutions for secondary metals industry can be in accordance with superior utilisation of the aluminium scraps and ferrous scraps for obtaining of the new materials with added value [2].

The present work is focused on the metallic scraps for input materials used to obtaining complex alloys for advanced refining of the steels. There is knows, the aluminium is used for refining steels. The main problem of aluminium as a deoxidizer is the control of steadfastness of the refining process. The low density of aluminium, comparable with density of the steel and the slag, determines its float up and interaction with oxidizing atmosphere. As result the utilization yield and recovery ratio of aluminium for refining action is low and variable. In respect to aluminium the positive effect of complex refining alloys is explained by effect of the alloying on the aluminium deoxidizers properties (in special for density and thermodynamic properties).

The literature references have shown once again that are effects obtained from the combined addition of two or more refining elements as complex deoxidisers are often greater than the added effects of the individual elements. In this case, the use of the aluminium alloyed with reactive elements is more effectively than the singular elements addition. If alloying elements are simultaneous present in deoxidisers and these have a determined chemical composition in accordance with the utilisation purpose, the refining capability of each element is increased because the complex non-metallic inclusions are formed and, the thermodynamic activity of each element that is present in the deoxidizing products is lower than their activity in the pure oxide. By this way, at equilibrium for a stable temperature, the oxygen content of the molten steel is lower [3, 4].

This same type of synergetic effect has long been recognized with regard to the combined role of aluminium, silicon, manganese, calcium and barium in the refining process of the steels.

The increasing demands for products specification makes any non-metallic inclusions present in steel an important issue during the steelmaking process. There is a way to reduce the disadvantageous effects of non-metallic inclusions on the steel properties. The modification of inclusions create excellent conditions for its floating up and dissolving in the slag by the change in chemical composition of non-metallic inclusions during the steelmaking process. This can be achieved by steel treatment with deoxidisers with controlled chemical composition. The chemical composition for some refining alloys used in world-wide steelmaking practice is presented in Table 1 [5].

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Chemical composition, %wt</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Al</td>
</tr>
<tr>
<td>FeAl40</td>
<td>20-40</td>
</tr>
<tr>
<td>FeMnAl15</td>
<td>10-20</td>
</tr>
<tr>
<td>FeMnSiAl</td>
<td>~10</td>
</tr>
</tbody>
</table>

By other hand the method for obtaining of these complex aluminium master alloys used at advanced refining of the steels is advantageous for recycling the aluminium scraps mixed with ferrous scraps. It is obtaining the superior valorisation of metallic scraps. Also the steelmakers solve not only the major problems strictly targeted on pollution control and protection of natural resources and energy. The development of steel industry subjected to quality of the steels is targeted.
This paper presents the research for establishing the technology to obtaining the complex aluminium alloys utilised for the refining processes of the steels. The particularity of this method is the use of the recyclable input materials and the flow of these components for alloys making technology.

2. EXPERIMENTAL METHOD AND MATERIALS

For the first step a gas-fired reverberatory furnace was utilised for the aluminium melting to obtaining the starting ingot. For continuation the crucible induction furnace was utilised to master alloys making. Its main characteristics are: 50Hz low frequency; 100kg capacity; neutral lining. The input materials used were the aluminium scraps and steel scraps (obsolete scraps from steel sheets with following average chemical composition 0.15%C, 0.48%Mn, 0.20%Si, 0.022%S, 0.028%P). Also, the ferromanganese (minimum 80.00%Mn, maximum 0.5%C, 2%Si, 0.03%S, 0.3%P) and silico-manganese (60-65%Mn, 10-26%Si) are utilised for FeMnAl, FeMnSiAl alloys. The argon as inert gas was used for degassing the melting.

3. RESULTS AND DISCUSSION

For determining the flow of the input components for alloys making must to take into account the fact that between aluminium and iron is a large mutual solubility, Fig. 5.

![Fig. 5. Fe-rich part of the Fe–Al system [6, 7]](image)

This offers a solution for alloys making with low melted temperatures and, as consequence with a lower energy balance. For this reason, the aluminium scraps were melted firstly and then steel scraps were dissolved into aluminium melted.

The aluminium scraps can be non-processed or processed before utilisation as feed into crucible of the induction furnace. The flow of the input materials and the using of the aluminium scraps processed as a hot
starting aluminium ingot lead to reducing of the energy consumption. The aluminium scraps can be melted into crucible of the reverberatory furnace. An aluminium ingot was casting. The starting aluminium ingot was melted into crucible induction furnace. Pieces of steel sheets scraps were added into aluminium melted and were superheating to 750°C. The gradual dissolution of the preheated steel scraps (at 150 – 200°C) was realised for range of temperature 750 – 1250°C. For the FeAlMn or FeAlSiMn the FeMn or SiMn were added and the temperature increase to about 1500°C. For degassing argon was blown into melting charge. Technical parameters of the degassing process are: the flow of inert gas (0.3 – 0.5)x10^5 Pa; the gas quantity is two-three times more than the melting volume.

To prevent the interaction between aluminium and oxygen the following protection flux was utilised: 40% NaCl, 20% Na2SO4, 25% CaF2, 5% Na3AlF6, 5% CaCO3, 5% Na2SiF6. For the aluminium scraps as ingot that was used to begin melting, the addition of the flux was 2…3% from the weight of the melting (2/3 of quantity into input material and 1/3 on the surface of the melting). If aluminium scraps used were non-processed the quantity was increased with 5…10%.

The chemical composition of some complex aluminium alloys is given in Table 2.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Casting temperature, °C</th>
<th>Chemical composition, %wt</th>
<th>Recovery ratio, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeAl</td>
<td>1230</td>
<td>- 40.81 - balance</td>
<td>- 89.25 -</td>
</tr>
<tr>
<td>FeAl</td>
<td>1230</td>
<td>- 39.88 - balance</td>
<td>- 86.33 -</td>
</tr>
<tr>
<td>FeAlMn</td>
<td>1490</td>
<td>55.23 10.34 - balance</td>
<td>88.73 90.78 -</td>
</tr>
<tr>
<td>FeAlMn</td>
<td>1520</td>
<td>60.61 15.15 - balance</td>
<td>87.68 87.97 -</td>
</tr>
<tr>
<td>FeAlMnSi</td>
<td>1470</td>
<td>40.76 10.02 20.59 balance</td>
<td>97.21 90.34 85.45</td>
</tr>
<tr>
<td>FeAlMnSi</td>
<td>1490</td>
<td>40.80 9.95 20.83 balance</td>
<td>95.07 86.92 84.87</td>
</tr>
</tbody>
</table>

The alloys obtained were compact, gaseous inclusions are not present. Fig. 2-4 showed that the microstructures of FeAl, FeMnAl, FeMnSiAl alloys obtained are homogeneous. For this reason the interactions between elements and oxygen or water vapour must not occur during the process. The protection flux and degassing ensure the avoidance of reactions between elements and oxygen and the dissolution of the gases. Due to the great thermodynamically activity of aluminium in respect to the oxygen, aluminium oxide can be formed if the surface of the aluminium melted is non-protected. As result as the presence of aluminium into bath the other elements as iron, silicon, manganese are protected for interaction with oxygen. If these elements are initially oxidised, they are regenerate at increase of temperature by reaction MeO + Al → Me + Al2O3 (where Me = Fe, Mn, Si). Thus the elements are returned from slag into melting bath.
4. CONCLUSIONS

The method for obtaining the complex aluminium alloys can satisfy the physical properties and chemical in respect to optimal development of the processes. The complex aluminium master alloys are in accordance with the requirements for their utilisation in advanced refining of the steels. The alloys making technology is flexible in accordance with the conditions of the each producer. For this reason the technologies have reproducible results. This ensures steadfastness for chemical composition, a maximum recovery ratio of the elements and, low energy consumption and raw materials. Also there is a technology that can be easy
applied in the steelworks or in the foundries with different capacities. This is a solution for superior valorisation of the aluminium scraps and steel.

LITERATURE REFERENCES


[4]. Patent 5037609, Material for refining steel of multi-purpose application, United States

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