Valorization of Powdery Ferrous Wastes in the Context of Sustainable Development

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Abstract: - Within the concept of sustainable development, the main steps to be taken in order to optimize environment-friendly steelmaking strategies are: low-pollution technologies, neutralizing technologies, modern de-pollution technologies and waste recycling ones. The simultaneous processing of powdery wastes with iron content and those with carbon content in order to obtain a product capable of being used at various stages of the technological flux has lead to the development of a procedure of obtaining a product called CARBOFER, in the form of micro-pellets.

Key-Words: - valorization, small-size and powdery wastes, steel making industry, sustainable development, pellets, slag

1 Introduction
The economical model called “sustainable development” is defined as fulfilling the needs of the present without jeopardizing the possibility of the future generations to meet their own needs. Sustainable development represents a merge of such targets as [1]:
- programs meant to encourage and develop personality and practical capabilities, physical, but mostly creative, which are indispensable to human as a being bent to creativity;
- support of the universal ecological and social awareness, based on steps taken towards prevention and control of pollution, as well towards increasing life quality and implementing social engineering;
- social management through the adoption and observance of fundamental environmental law;
- the preservation of the natural capital, by consumption optimization and recycling secondary materials.
Recycling processes refer to reintroduction into the manufacturing fluxes of materials which, either were released into the environment as technological loss, or have exceeded their life cycle. Within this sphere ranges the valorizing of secondary materials.
In Romania, as well as in other countries, waste impact upon the environment has increased in an alarming way lately, the inappropriate management of waste generating soil and water table contamination, as well as emissions of methane, CO₂ or toxic gases, with a direct impact upon the health of the population. Dumping spaces have reached their maximum capacity, new locations being hard to find.
For our country, material recycling represents a priority of the sustainable development strategy for the following reasons: natural resources for some categories of raw materials are poor or insufficient and complementing the resources by recycled waste can be done at low costs, as it is economical in terms of specific consumption of energy and water, it also cutting down pollution significantly.
As compared to worldwide practice and tendencies, Romanian industry is behind when it comes to collecting, shipping and depositing powdery waste, as well as its recycling technologies [2]. Under these conditions, we considered it necessary and appropriate to approach the issue of superior valorizing the powdery waste generated, at minimal costs.
The various stages of the technological flux in a steel plant result, besides the main product, in significant quantities of materials usually called waste, but which, through recycling or/and re-use can be valorized as by-products. Depending on the specific conditions of each steel plant, as well as on the local market demand (which varies in time) for each usable material, any kind of waste can become a by-product, just like any by-product may turn into waste [3].
The procedure, i.e. technologies used in the production of CARBOFER have the advantage of flexibility, which offers the possibility of choosing among recipes containing one or several powdery
wastes, depending on the chemical composition required by the type of recycling (the technological destination of the product), as well as on the quantity of waste generated in a certain period (we took into consideration both the waste generated on the technological flux of ArcelorMittal and the waste deposited in slag dumps and ponds resulting from the steel making, mining and energetic industries).

2 The Pilot-Stage Experiments
Of all the wastes generated in steel making processes, the powdery ones, potential by-products, have raised problems related to their valorization, because, on the one hand, of the inappropriate granulometric composition, as the fine fraction represents a big percentage, and, on the other hand, because of the heavy metals (Zn, Pb) present in their powders with a high content of carbon or limestone dust) whose content in iron, calcium and carbon, elements needed in steelmaking processes, is high enough to justify their valorization.

These wastes have been processed into micro-pellets, the resulting CARBOFER being recyclable both in the agglomeration process and in steel making, where it is used as slag foaming agent in the electric arc furnace. Micro-pelletizing is a flexible process, which offers the possibility of choosing such recipes that may contain one or several waste types, depending on the chemical composition needed by the respective product, as well as on the amount of waste available in a given period [5, 6].

The chemical composition of the CARBOFER product has been established according to the following criteria:
- the grain size of the components in the bonding recipes should correspond to the pelleting process (respectively, the granulometric structure of the pelleting charge);
- the content in Fe_total should range within the limits of the one existing in the agglomeration ores;
- the content in C should grant the due amount of reducing element when the product is used as slag foaming agent, and in the case of using it as agglomeration element, it should partially replace the quantity of coke in the charge;
- the content in CaO should grant, alongside with bentonite, the bonding material needed to obtain pellets corresponding from the point of view of their behavior in handling, shipping and the technological process (resistant).

The materials processed contain elements – Fe, C, Ca – that are useful in the steel making processes, their percentage in the finite product ranging within the following limits: Fe = 28,35% (from the steel plant dust, blast furnace agglomeration sludge, soot, soot sludge); Ca = 18,49% (from the steel plant dust, blast furnace agglomeration sludge); and C = 11,66% (from the blast furnace dust, coke, coal or graphite dust).

As to obtaining CARBOFER pellets, the recipes suggested for experiments in the pilot phase aimed at obtaining a recyclable product, usable both as slag foaming agent, in electric arc furnaces, and as component in the agglomeration charge [7].

The chemical composition of CARBOFER pellets is given in table 1.

After pelleting, for each particular charge we determined the following characteristics:
- the bulk mass of wet and dry micro-pellets [kg/dm³];
- the humidity of the micro-pellets [%];
- the granulometric distribution of the pellets in a raw state.

The results are shown in table 2. Pellet formation, their granulometric distribution and resistance to handling are influenced by the amount of water used in the micro-pelletizing process, by the amount of calcium in the limestone dust used as a bonding element, giving the pellets resistance in handling, as well as by the content of carbon, more exactly the amount of coke dust in the recipe.

The analysis of the results leads to the conclusion that the optimal recipes from the granulometric point of view, meeting the condition of evenness and preponderance in the range 1-3mm, a grain size recommended both in the process of electric arc furnace steel making, as slag foaming agent, and in the agglomeration process, are R3, R4, R6, R8.

From the point of view of the three main elements: Fe, C şi Ca, one can notice that the entire range (domain) of variation is covered, which proves the flexibility of the process, which allows us to choose from recipes that may contain one or several powdery wastes, depending on the chemical composition required by the place of recycling the product (respectively steel plant of agglomerator) as well as on the amount of waste currently generated along a given period of time or existing in ponds (located next to the facility generating such powdery waste).

Fig.1 shows aspects of the pelleting process (using a flat plate pelleting machine) and the resulting micro-pellets, observing the technological flux of producing CARBOFER – micro-pellets (fig.2).
### Table 1. The chemical composition of CARBOFER – micro-pellets

<table>
<thead>
<tr>
<th>Recipe no.</th>
<th>SiO₂</th>
<th>FeO</th>
<th>Fe₂O₃</th>
<th>P₂O₅</th>
<th>S</th>
<th>C</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>MnO</th>
<th>alti oxizi</th>
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<td>R1</td>
<td>6.74</td>
<td>3.97</td>
<td>38.32</td>
<td>0.10</td>
<td>0.44</td>
<td>13.94</td>
<td>3.53</td>
<td>20.98</td>
<td>1.14</td>
<td>1.37</td>
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<td>R2</td>
<td>7.45</td>
<td>3.97</td>
<td>38.34</td>
<td>0.10</td>
<td>0.44</td>
<td>14.92</td>
<td>3.65</td>
<td>19.10</td>
<td>1.13</td>
<td>1.36</td>
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<tr>
<td>R3</td>
<td>9.01</td>
<td>3.83</td>
<td>32.68</td>
<td>0.09</td>
<td>0.47</td>
<td>19.19</td>
<td>4.06</td>
<td>18.38</td>
<td>1.19</td>
<td>1.16</td>
<td>9.93</td>
</tr>
<tr>
<td>R4</td>
<td>8.45</td>
<td>4.11</td>
<td>34.94</td>
<td>0.10</td>
<td>0.49</td>
<td>17.59</td>
<td>4.06</td>
<td>17.54</td>
<td>1.20</td>
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<td>18.39</td>
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<td>1.15</td>
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<td>21.69</td>
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<td>R8</td>
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<td>33.60</td>
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<td>0.51</td>
<td>22.84</td>
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<tr>
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<td>12.05</td>
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<td>11.14</td>
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</table>

### Table 2. Pelles characteristics

<table>
<thead>
<tr>
<th>No.</th>
<th>Recipe composition, [%]</th>
<th>Duration of the micropellet, [min]</th>
<th>Humidity, [%]</th>
<th>Bulk mass [kg/dm³]</th>
<th>Granulometric classes, [mm]</th>
<th>Granulometric analysis, [%]</th>
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<tbody>
<tr>
<td></td>
<td>Fe</td>
<td>CaO</td>
<td>C</td>
<td>Al₂O₃</td>
<td>wet</td>
<td>dry</td>
</tr>
<tr>
<td>1</td>
<td>29.91</td>
<td>20.98</td>
<td>13.94</td>
<td>3.53</td>
<td>16</td>
<td>3.96</td>
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<td>4.96</td>
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<td>25.86</td>
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<td>19.19</td>
<td>4.06</td>
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<td>2.44</td>
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<td>27.66</td>
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<td>28.73</td>
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<td>21.24</td>
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<td>4.84</td>
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<td>29.32</td>
<td>12.05</td>
<td>20.26</td>
<td>4.2</td>
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<td>2.86</td>
</tr>
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</table>

Fig.1. Aspects of the process of producing CARBOFER micro-pellets
Fig. 2. The technological flux of producing CARBOFER micro-pellets

Electric steel plant dust

Agglomerate-blowing furnace sludge

Tinder

Tinder sludge

Graphite powder

Lime powder

Bentonite

Grinding

fraction > 1 mm

fraction < 1 mm

Volumetric sorting

fraction > 1 mm

fraction < 1 mm

Dosing

Homogenizing

Homogenized mixture from pulverous dust

Micro-pelletizing

Drying

CARBOFER MICRO-PELLETS

fraction < 1 mm, med = 6.47%

1-2 mm, med = 36.47%

2-3 mm, med = 20.01%

3-5 mm, med = 22.70%

>5 mm, med = 14.35%
3. Results. Discussions
The process of micro-pellet making, their distribution by granulometric classes, their resistance to handling and shipping are directly influenced by:
- the amount of water used in the process of micro-pelleting, expressed by the humidity of the micro-pellets;
- the content of de CaO in the limestone dust and in the blast furnace agglomeration sludge which, alongside with the Al₂O₃, represent the bonding element, and confers to the pellets resistance in handling and in the technological process;
- the percentage of bentonite, determining the content of Al₂O₃, a bonding component, whose action is similar to that of lime;
- the content of carbon, determined by the amount of coal, coke, electrode or blast furnace dust used in the recipe, but mainly the coal dust which significantly influences the granulometric distribution of the micro-pellets, due to its hydrophobic behavior;
- the duration of the micro-pelleting process;
- the type of pelleting machine and its technological characteristics.

4. Conclusion
Although the problem of resources has become a global issue, not the problem of one country, it is not only the global dimension that imposes a long term development concept for Romania under the condition of sustainability, but also its own need to protect and preserve its natural capital.

At industrial level, sustainable development supposes modeling the activities that optimize the economical and social profits, without jeopardizing the potential corresponding to benefits meant for the future generations.

Superior valorizing of steelmaking wastes in general and particularly the small-sized and powdery ones represents an important issue, as their turning into by-products, i.e. into economical goods that can mean a more reasonable use of the raw material and energetic resources meets the needs of the human society and those of the environment, major issue of this millennium.

The ecological advantages are clear, namely: cutting down the amount of powdery wastes by their continuous recycling, the diminishing of soil pollution with metallurgical waste by reducing the dumping areas, the valorization by recycling of these wastes, without any negative impact upon the environment.

The economical advantages have both an immediate impact, i.e. transferring the depositing costs to other scopes, the obtaining of secondary raw materials, the low costs of processing by means of this procedure, as compared to others, and also long term advantages, such as cutting down costs by partial replacing of some raw materials. Considering that processing the powdery materials resulting from steel making in view of recycling and/or re-using them represents an issue with real ecological and economical implications we found it appropriate to carry out researches in the field of their superior valorization.

References: