Characterization of diatomite from Sig region (West Algeria) for industrial application

Hazem Meradi L'Hadi Atoui Lynda Bahloul Kotbia Labiod Fadhel Ismail

Article information:
To cite this document:
Permanent link to this document:
http://dx.doi.org/10.1108/MEQ-04-2015-0057

References: this document contains references to 24 other documents.
To copy this document: permissions@emeraldinsight.com
The fulltext of this document has been downloaded 2 times since 2016
Access to this document was granted through an Emerald subscription provided by
Token:JournalAuthor:A4021269-DCAD-4941-AA15-E1D3A4BDB1BA:

For Authors
If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com
Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

*Related content and download information correct at time of download.
Characterization of diatomite from Sig region (West Algeria) for industrial application

Hazem Meradi
Welding and NDT Research Center (CSC), Cheraga, Algeria

L’Hadi Atoui
Department of Metallurgy and Materials Engineering, University Badj-Mokhtar, Annaba, Algeria

Lynda Bahloul and Kotbia Labiod
Welding and NDT Research Center (CSC), Cheraga, Algeria, and
Fadhel Ismail
Department of Process Engineering, University Badj-Mokhtar, Annaba, Algeria

Abstract

Purpose – Diatomite also known Kieselguhr, is a non-metallic mineral composed of the skeletal remains of microscopic single-celled aquatic algae called diatoms. The purpose of this paper is to test and to evaluate the diatomite of Sig region (West Algeria) to substitute the main mould powder used in continuous casting of steel for thermal insulation and lubrication.

Design/methodology/approach – To assess the behavior of diatomite at different temperatures, a combination of simultaneous scanning calorimetric and thermogravimetric testing was used and to evaluate the structure of diatomite, the scanning microscopy method was applied.

Findings – The results showed different endothermic and exothermic peaks, mainly at 84.7°C and 783.5°C for endothermic peaks and 894.9°C for exothermic peak. The scanning microscopy method was used and a large porosity was observed. The trial industrial in continuous casting of steel showed a weak loss temperature of steel.

Originality/value – This product may be used for thermal insulation in continuous casting of steel. Also the characterization showed the hot behavior of this product with the various transformations and could give the possibility to other use.

Keywords Diatomite, Fluorine, Lubrication, Mould fluxes, Thermal insulation

Paper type Research paper

1. Introduction

In the continuous casting of steel, the choice of mould slag is decisive for the lubrication and the heat transfer control in the mould. The composition, viscosity, solidification temperature and crystallinity, show how the powder in the mould, which is added to the upper surface of the molten steel, melts into a liquid layer (called mould flux), infiltrates into the gap between the shell and the mould during continuous casting and may control the behavior of lubrication and mould heat transfer (Görnerup et al., 2004; Stone and Thomas, 1999).

The functions of the mould flux constitute a task of great complexity which can be summarized as follows (Arefpour et al., 2011; Lis et al., 2012; Mills and Fox, 2003; Mills et al., 2005):

• a lubrication of the strand through the mould;
MEQ 27.3

- an uniform heat transfer across the infiltrated slag layer formed between steel shell and mould;
- a protection of the molten against oxidation;
- an absorption of non-metallic inclusions; and
- a thermal insulation of molten steel.

The mould fluxes are synthetic slags which are constituted by a complex mix of oxides, minerals and carbonaceous materials. The typical composition is shown in Table I.

Fluorine is an important constituent of the mould powders that aids in reducing the melting point of slag as well as increasing its fluidity by lowering its viscosity. However, fluorine contained in mould powders, liberates gaseous fluorides to the atmosphere resulting from its evaporation and chemical reactions in the mould powders (Zhang et al., 2011). This alters the composition and subsequently the thermo-physical properties of the flux. Moreover, the volatile fluorides liberated, could cause an environmental degradation, a corrosion of equipment and an acidification of the cooling water. They are a potential hazard for safety and health (He et al., 2011; Ipekoglu and Mete, 1990; Jinxing et al., 2011).

Within this context, the elimination of fluorine from the mould powder composition becomes essential. For this purpose, diatomite was used in order to substitute the fluorine. Diatomite is a non-metallic mineral composed of the skeletal remains of microscopic single-celled aquatic algae called diatoms, it is a natural material formed from the remains of diatoms (Ipekoglu and Mete, 1990). Diatomite products are used in many ways such as reinforcing, stiffening and hardening of organic solids, reducing adhesion between solid surfaces, increasing adhesion and viscosity. Diatomite is abundant in many areas of the world and has unique physical characteristics such as high permeability and porosity, small particle size, low thermal conductivity, low density and high-specific surface (Tsai et al., 2006).

The commercial diatomite contains the following chemical composition: 85-94 percent SiO₂, 1-7 percent Al₂O₃, 0.4-2.5 percent Fe₂O₃, 0.1-0.5 percent TiO₂, 0.03-0.2 percent P₂O₅, 0.3-3 percent CaO, 0.3-1 percent MgO, 0.2-0.5 percent Na₂O, 0.3-0.9 percent K₂O and 0.1-0.2 percent organic matter and soluble salts.

Due to its specific properties (porous structure, high silica content, low density, low conductivity coefficient, etc., the diatomite has extensively been applied in many ways, such as filter aid (Alves França et al., 2003; Gomez et al., 2015; Wang et al., 2015a, b), insulating materials (Hamdi, 2010; Remiznikova et al., 2010), catalyst support or carrier (Haddoum et al., 2014; Wang et al., 2015a, b) and cement production (Ylmaz and Ediz, 2008).

The diatomite reserve in Algeria is estimated at several million tons and it is located in Sig region (from 50 km of Mascara, West of Algeria). The aim of this study was to

<table>
<thead>
<tr>
<th>Component</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>B₂O₃</th>
<th>Fe₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (%)</td>
<td>17-56</td>
<td>0.13</td>
<td>0.19</td>
<td>0.6</td>
</tr>
<tr>
<td>Component</td>
<td>CaO</td>
<td>MgO</td>
<td>BaO</td>
<td>SrO</td>
</tr>
<tr>
<td>Wt (%)</td>
<td>22-45</td>
<td>0-10</td>
<td>0-10</td>
<td>0-5</td>
</tr>
<tr>
<td>Component</td>
<td>Na₂O</td>
<td>Li₃O</td>
<td>K₂O</td>
<td>F</td>
</tr>
<tr>
<td>Wt (%)</td>
<td>0-25</td>
<td>0-5</td>
<td>0-2</td>
<td>2-15</td>
</tr>
<tr>
<td>Component</td>
<td>MnO</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wt (%)</td>
<td>0-5</td>
<td>2-20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table I. Typical composition of mould fluxes

Source: Brandaleze et al. (2012)
test and to evaluate this diatomite to substitute the main mould powder used in continuous casting of steel for thermal insulation and lubrication.

2. Experimental work

2.1 Materials

In the present work the diatomite powder from Sig deposit (West Algeria) has been studied. The chemical composition of this powder is presented in Table II.

Industrials trials were realized in steelworks with ordinary steel with chemical analysis shown in Table III.

The thermogravimetric analysis and differential scanning calorimetry (TGA-DSC) were carried out using a fully computerized Netzsch STA 409 PC simultaneous TGA-DSC instrument. About 10 mg of diatomite powder was placed into Al₂O₃ crucible for simultaneous TGA-DSC analysis and was heated at a rate of 10°C/min, from room temperature to 1,100°C in a static air environment.

The structure of diatomite sample without any treatment has been observed microscopically using scanning electron microscope (SEM) type Philips XL30. This system provides both secondary electron and backscattered electron imaging along an integrated EDAX system, the resolution was 20.0 kV.

2.2 Plant trials

Industrial tests with the diatomite were performed in two heats using the same steel grade. Each heat was about one hour duration and was applied in one strand. These two heats constituted one sequence of casting. Technological parameters were monitored during continuous casting with the objective to evaluate the performance of diatomite for insulation thermal and lubrication of mould.

The powder of diatomite was constantly added to the surface of the bath (Figure 1) and the temperature was measured by pyrometric cane every ten minutes approximately (Table IV).

3. Results and discussion

The trials realized with the diatomite powder in continuous casting of steel showed a good behavior of this powder in the thermal insulation. It is visible clearly by a standard deviation which is 8.16°C for the first ladle and 3.73°C for the second ladle (Table V), this proves that the powder has well played its role of thermal insulation.

<table>
<thead>
<tr>
<th>Component</th>
<th>MgO</th>
<th>Fe₂O₃</th>
<th>SiO₂</th>
<th>TiO₂</th>
<th>CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (%)</td>
<td>2.15</td>
<td>1.19</td>
<td>73.4</td>
<td>0.027</td>
<td>13.58</td>
</tr>
</tbody>
</table>

Table II. Chemical composition of the diatomite powder used during the industrial test.

<table>
<thead>
<tr>
<th>Component</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Fire losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (%)</td>
<td>0.07</td>
<td>0.35</td>
<td>0.15</td>
<td>0.005</td>
<td>0.005</td>
<td>5</td>
</tr>
</tbody>
</table>

Table III. Chemical composition of the steel used during the industrial test.
These results are acceptable for industrial process design and are very encouraging by steelmakers. SEM for sample diatomite showed porous structures with several diameters (Figure 2). We can note that the pores are predominantly in circular form and we can also see the presence of impurities. The SEM micrography of the natural diatomite was typical.
as like as honeycombs. It was found to be essentially amorphous but also it contained ankerit, calcite and quartz (Meradi, 2009). The results of simultaneous analyses TGA-DSC for diatomite sample without any treatment are shown in Figure 3. The results indicate the loss of mass when the temperature is increased and revealed that the diatomite has four mass losses: the first loss (about 5 percent) between room temperature and 200°C, the second mass loss (about 4.10 percent) in the temperature range from 200 to about 600°C, the third loss (about 2.76 percent) in the range from 600 to 800°C and the last loss (about 0.63 percent) in the range from 800 to 1100°C.

The results from DSC measurements on the diatomite indicate that when the temperature is increased, several reactions endothermic and exothermic take place. These are clearly detected by the fluctuations of the graph in Figure 3.
We can see from DSC spectrum three endothermic peaks at 84.7, 576.1 and 783.5°C, and one exothermic peak at 894.9°C. The endothermic peak centered at 84.7°C and a shoulder around 165°C was assigned to the loss of water absorbed on the diatomite. The small peak at 576.1°C might be due to the quartz transformation. The large endothermic peak at 783.5°C has been assigned to the formation of siloxane bridges resulting from dehydroxylation of isolated silanol groups on the internal surface of the diatomite that corresponds to the maximum loss of mass (20.96 percent). At 894.9°C, we can see an exothermic peak caused by the cristalization. The exothermic direction is shown along the vertical axis. Generally, quartz is known to give an endothermic reaction between 565°C and 575°C, in Figure 3, the endothermic peak at 576.1°C is very low because the amorphuous structure. The curve of thermal gravimetric analysis of diatomite sample is also given in Figure 3. This curve can also be utilized in the determination of the optimum temperature in flux calcination process for eliminating impurities.

4. Conclusion
Because fluoride in mould causes hazards during application of gaseous emission and leaching from mould flux in cooling water and corroding the plant equipment, the aim of this study was the substitution of mould fluxes containing fluorine by diatomite. The results showed that diatomite has a porous structure with ordered size distribution of the pores. Thus, a low density was obtained and the chemical composition consisted of SiO₂ predominantly and weak quantities of Fe, Al, Ca, Mg, Na, K. The structural examination of microstructure of diatomite showed the presence of intact diatomite skeletons but with impurities. Thermal analysis of diatomite sample was depicted and the loss mass was maximal at 800°C. The weak peak at 576°C analyzed by DSC showed the very low transformation of quartz, comparatively to crystalline structure. Diatomite from Sig deposit (West Algeria) can be successfully beneficiated with very good efficiency for thermal insulation in continuous casting of steel without treatment. The obtained results showed a low temperature loss of steel during continuous casting which allowed to a good thermal insulation. Further trials would be necessary to confirm the behavior of diatomite with high carbon in steel grade. In a first stage, we can confirm the good behavior diatomite for heat insulation during continuous casting of steels with low carbon.

References


Further reading


Corresponding author

Fadhel Ismail can be contacted at: ismail.fadhel@univ-annaba.org

For instructions on how to order reprints of this article, please visit our website:

www.emeraldgrouppublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com