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Study of physico-chemical properties of diatomite Algeria: Application to the thermal insulation of liquid steel bath

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***Abstract*— The purpose of this paper is to characterize and to evaluate the diatomite powder of Sig region (West Algeria) without fluorine by powder generally used in tundish to thermal insulation of steel bath contain fluorine, that affecting the environment and health of workers. Thermal and physicochemical characterization showed different endothermic and exothermic peaks. The scanning microscopy method was used and a large porosity was observed, which is very beneficial for improving the thermal conductivity of the product. The trial industrial in steelwork with diatomite powder, showed a weak loss temperature of steel (10 °C max), and filled fully function in thermal insulation of the steel bath.**

***Keywords*— Diatomite, Fluorine, tundish, steelwork, thermal insulation, DSC**

1. Introduction

Diatomites (or kieselguhrs) are mineral deposits of diatomaceous algae, those commercially to many important industrial applications due to its unique properties, i.e. micronized and submicronized porous structure, light-weight, and chemical inertness. These applications include filter aid, functional filler, insulation, catalysis support, cement, and carrier application [1]-[15]. In the continuous casting process, a ladle containing liquid steel is positioned over a refractory lined vessel called a tundish for thermal insulations. To ensure the optimum temperature required by continuous casting machines, thermal insulation of the steel and tundish must be ensured by a covering powder in the form of synthetic slags which are constituted by a complex mix of oxides, minerals and carbonaceous materials. Fluorine is an important constituent of the powders that aids in reducing the melting point of slag as well as increasing its fluidity by lowering its viscosity. However, fluorine contained in powders, liberates gaseous fluorides to the atmosphere resulting from its evaporation and chemical reactions [16], could cause an environmental degradation, a corrosion of equipment [17]-[19].

Today, nearly 95% of crude steel is produced by continuous casting. Given the increasing demands relating to the quality of steel products and environmental protection, further optimization of the processes involved in continuous casting is required. Within this context, the elimination of fluorine from the powder composition becomes essential. For this purpose, diatomite was used in order to substitute powder containing fluorine. This powder plays a very important role in steel work [20]-[23]:

- Lubrication of the strand through the mould
- Uniform heat transfer across the infiltrated slag layer formed between steel shell and mould
- Protection of the molten against oxidation
- Absorption of non-metallic inclusions
- Thermal insulation of molten steel

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The first three parameters concern lubricating powder, and the last three powder coverage pocket and tundish [24] -[25].
In Algeria, the reserves of diatomite are very important and may be used in various domains. In this study, diatomite (sometimes named kieselguhr) is used for thermal protection of steel bath in tundish.

II Experimental work

The diatomite powder used in this study comes from the Sig deposit (West Algeria), as show in Fig. 1

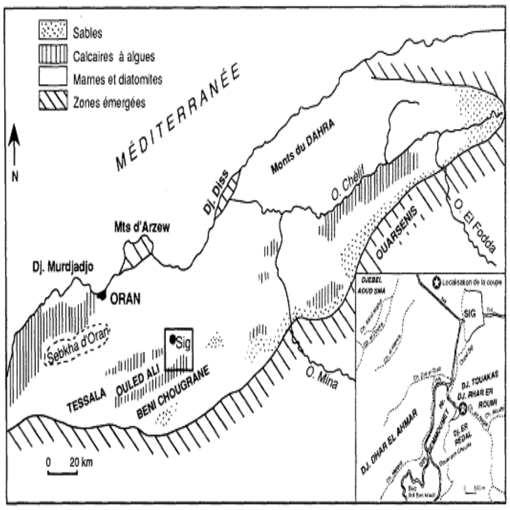

Figure 1: Mapping of diatomite deposit from Sig region

The chemical analysis performed by Fluorescence X is shown in Table 1:

Component	Wt (%)
MgO	3,21
Al_2O_3	2,7
Na_2O	0,2
SiO_2	68,25
K_2O	0,72
CaO	18,25
Fe_2O_3	1,64
TiO_2	0,027
Fire losses	5

Table 1: Chemical composition of diatomite

In order to follow the thermal behavior of the diatomite powder at different temperatures, coupled thermal analysis by Differential Scanning Calorimetry (DSC) and thermogravimetric (ATG) was carried out using a fully computerized Netzsch STA 409 PC simultaneous TGA- DSC instrument. About 10 mg of diatomite powder was placed into Al_2O_3 crucible for simultaneous TGA-DSC analysis and was heated at a rate of 10°C/min, from room temperature to 1100°C in a static air environment, and result obtained are showed in figure 2.

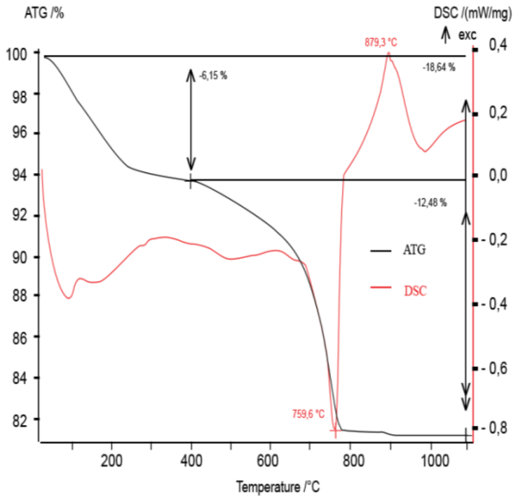

Figure 2: Simultaneous thermal analysis TGA-DSC for the diatomite sample from Sig deposit

We can see from DSC spectrum three endothermic peaks at 85, 550 and 759.6°C, and one Exothermic peak at 897°C. The endothermic peak centered at 85°C and a shoulder around 165°C was assigned to the loss of water absorbed on the diatomite. The small peak at 550°C might be due to the quartz transformation. The large endothermic peak at 759.6°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 (18.64 percent). At 897°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. The endothermic peak at 576.1°C is very low because the amorphous structure. The curve of thermogravimetric analysis of diatomite sample can also be utilized in the determination of the optimum temperature in flux calcination process for eliminating impurities.
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

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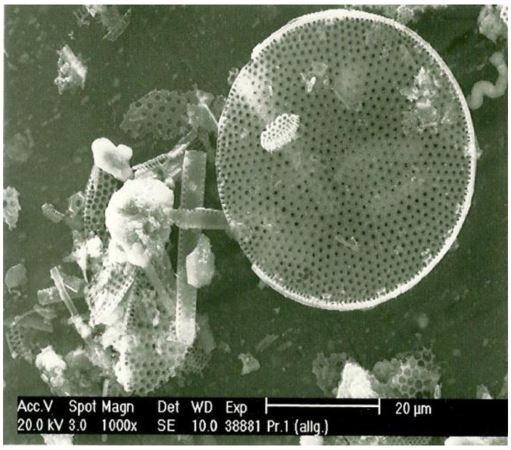

Figure 3: SEM Micrography of the diatomite powder with 1000 X

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 tundish. 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 in tundish.
The powder of diatomite was constantly added to the surface of the tundish (Figure 4) and the temperature was measured by pyrometric cane every four minutes approximately (Table 2).

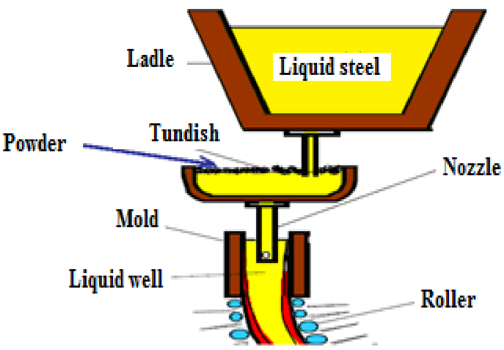

Figure 4: Principle of continuous casting of steels with additions of cover powders in tundish

Temperature steel (°C)	Time (h:min)
First ladle	
1566	00:00
1551	00:02
1549	00:06
1551	00:09
1567	00:19
1563	00:30
1556	00:48
1542	01:07
1540	01:09
1538	01:11
Second ladle	01:16
1549	01:17
1547	01:18
1554	01:22
1556	01:31
1557	01:35
1551	01:47
1553	01:51
1554	01:55
1548	02:00

Table 2: Evolution of temperature of steel in tundish every four minutes

The evolution of temperature of the bath as a function of the residence time of the tundish steel is shown in figure 5. The red line indicates the beginning of the opening of the second ladle.

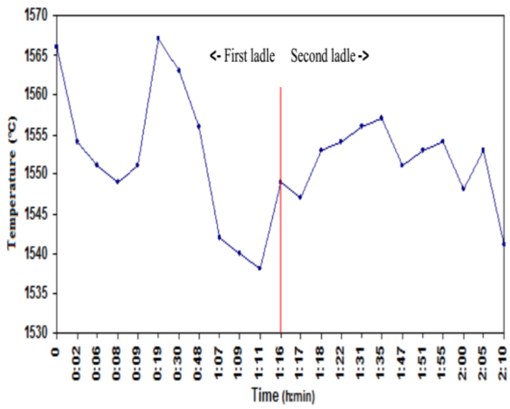

Figure 5: Evolution of steel temperature in tundish with diatomite

III. CONCLUSIONS

In the present work the diatomite powder from Sig deposit (West Algeria) has been studied. The chemical composition of this powder consisted of SiO2 predominantly and weak quantities of Fe, Al, Ca, Mg, Na, K.
The results obtained from industrial process for thermal insulation are acceptable and are very encouraging by steelmakers. SEM for sample diatomite showed porous structures with several diameters. We can note that the pores are predominantly in circular form and

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we can also see the presence of impurities. The results of simultaneous analyses TGA-DSC for diatomite sample without any treatment indicate the loss of mass when the temperature is increased and revealed that the diatomite has three mass losses: the first loss (about 6 percent) between room temperature and 400°C, the second mass loss (about 12 percent) in the temperature range from 400 to about 800°C, the third loss (about 2.76 percent) in the range from 800 to 1100°C. The trials realized with the diatomite powder in tundish showed a good behavior of this powder in the thermal insulation. It is visible clearly by a standard deviation which is 10.1°C for the first ladle and 4.5°C for the second ladle. These margins of error are acceptable by the steelworks

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