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Dvorak et al.

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[54] **METHOD OF FLUXING AND FLUIDIZING SLAG IN A CUPOLA**

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[51] **Int. Cl.**.....**C21b 3/02,** C21c 1/02

[58] **Field of Search**.....75/94, 44 R, 30, 43

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[57] **ABSTRACT**

A method of fluxing and fluidizing the slag in a cupola by adding to the charge therein a fluxing material comprising, by weight, from 30 to 60% CaO, as limestone; from 5 to 25% Al_2O_3 (alumina); from 20 to 50% Na_2O; and from 0 to 1% SiO_2. For basic and neutral operating cupolas, the flux will be used in amounts ranging from about 0.25 to 2.5% by weight, based upon the metal charge. Acid operations require somewhat less (about 0.15 to 2.0% of the metal charge). The flux serves to improve the fluidity of the slag, lower oxidation losses, remove sulfur and improve carbon pick-up of the metal without emitting gases harmful to the atmosphere.

4 Claims, No Drawings

METHOD OF FLUXING AND FLUIDIZING SLAG IN A CUPOLA

BACKGROUND OF THE INVENTION

The cupola resembles a miniature blast furnace. The cupola is a vertical steel shaft lined with refractory material such as silica, fire clay or equivalent, equipped with air ports at the bottom and a charging hole at the upper section for introducing the raw materials. Below the air ports or tuyeres is a section called the well, from the bottom of which, through the tap hole, the molten metal is drawn, slag is removed either from the top of the well just below the tuyeres or in a forehearth outside and in front of the cupola.

It differs from a blast furnace primarily in that pig iron and steel scrap replace an iron ore charge. The cupola is used in remelting and refining metals as distinguished from the characteristic processes of the blast furnace of winning metals from their ores or reducing ores. In a typical cupola, a charge is composed of coke, steel scrap and pig iron in alternate layers of metal and coke. Sufficient limestone, or other fluxing material, is added to flux the ash from the coke and form a slag. However, in many cupola operations, the fluxing effect of this limestone may be insufficient to insure satisfactory cupola operation. The ratio of coke to metallics varies, depending on the melting point of the metallic charge. Ordinarily, the coke will be about 6 to 12 percent of the weight of the metallic charge. It is kept as low as possible for the sake of economy and to exclude sulfur and some phosphorus absorption by the metal.

Initially, heat for the process is supplied by a bed of coke, on top of which are placed alternate layers of iron and coke. Air introduced through the tuyeres burns the coke and the hot gases ascend through the upper charges of metal. Coke is consumed and the heat released to the metal. The process is one of countercurrent flow, the heat and gases rising upwards and out the top of the stack while the metal descends and is withdrawn from the bottom of the well.

During the operation of the cupola, non-metallic materials are produced from various sources. These materials arise from the ash in the coke, are eroded from the cupola lining or are contained on the surface of or internally from the metal charge. In addition, some oxidation of the elements in the charge occurs, particularly with a fine scrap charge and these contribute to the amount of slag. The flux should also aid in sulfur reduction and removal.

Fluxing furnishes a medium of a non-metallic liquid to absorb the extraneous material and produce a liquid slag containing these absorbed non-metallics providing the slag is sufficiently liquid at existing cupola operating temperatures. The liquid nature of the slag is required to avoid coating the coke with non-metallics and sticking the lumps of the coke together. The flux also provides a slag that will separate readily from the iron and permit ready removal of the non-metallics. The non-metallic material to be removed by fluxing is primarily silica, except for the lining contribution from neutral or basic operated cupolas; these materials usually exhibit a high melting point. With their high melting point, these non-metallic materials form a viscous or a pasty constituent in a cupola.

The viscous non-metallics exert several bad effects on a cupola operation. Exemplary of these are a slag

formation which adheres to the coke and interferes with its burning. This decreases the cupola operation and reduces the carbon pick-up by remote droplets of metal. Further, the coke and metal coated with these non-metallics tend to stick together to cause the viscous nature of the surface to form a bridge or interconnected solid layer across all or at least the outer portions of the cupola diameter. In effect, the viscous pasty slag fills the interstitial spaces in the coke and builds up a bridge in the areas chilled by air from the tuyeres. Many of the materials in the slag are acidic in character, which opposes absorption of sulfur into the slag so that an attempt is made to keep the flux basic to neutralize this acidity. Limestone is a popular material used for this purpose. Sodium carbonate is also widely used to assist in sulfur reduction because of its alkaline nature.

Fluorspar, a calcium fluoride mineral (CaF_2) is a powerful fluxing agent that is commonly used in small proportions along with limestone to improve slag fluidity. Fluorspar, while effective, has certain serious disadvantages. Specifically, fluorspar is relatively expensive and a high percentage of it must be imported. However, a more important disadvantage in connection with the use of fluorspar is its release of active fluorides as a gas upon decomposition in the cupola. The highly reactive properties of these gaseous fluorides are well known.

In connection with those cupola operations which have emission control systems using fiberglass bags as a filtration device, the gaseous fluorides attach the glass fibers. Some emission control systems utilize water for cooling the cupola shell and blast gases. The acid nature of fluorspar reduces the pH of the discharge water and increases the solubility of zinc compounds to such an extent that water pollution codes may be exceeded in this respect. Fluxes with a higher basicity will raise this pH and reduce zinc solubility.

In view of the foregoing, it is an object of this invention to provide a fluorspar-free flux that has all the metallurgical advantages of a fluorspar-bearing type fluidizing flux.

It is an object of this invention to provide a fluorspar-free flux which improves slag fluidity, improves carbon pick up by the metal, increases metal temperature by better combustion of the coke and provides a cleaner metal with lower oxidation losses.

Another object of this invention is to provide a flux which can be used in connection with operations using fiberglass bags in the bag houses of the cupola emission control system where fluorspar type of flux materials can have a deleterious effect on the life and performance of the glass filters.

Another object of this invention is to provide a flux which tends to increase the pH of the discharge waters from wet dust arresting systems resulting in a decreased solubility of zinc, which can be of material aid in meeting water pollution codes and requirements.

DESCRIPTION OF THE INVENTION

A flux formulation was prepared from approximately 40 lbs. of limestone ($CaCO_3$), 40 lbs. of Soda ash (Na_2CO_3), 20 lbs. of the mineral Kyanite and 6 lbs. of Portland Cement. These constituents in particulate form were thoroughly admixed and then about 6 lbs. of water was added to the mixing mill to provide a moist

aggregate suitable for briquetting. Bricks weighing 3 ½ to 4 lbs. each were made from the foregoing and then allowed to set in a controlled moisture atmosphere for about 12 hours to provide a structurally sound brick suitable for cupola additions.

About 4 or 5 of these bricks were added with the limestone onto the coke bed used to charge a basic cupola with an internal diameter of 63 inches at the tuyeres. An additional 2 bricks or 8 lbs. of flux were added together with the limestone and coke in this cupola that employed 1 ton metal charge increments. This fluoride free flux served to fluidize the slag so that the cupola operated smoothly with ready removal of the slag.

The amount of the flux used is not critical and may range for basic or neutral operation, from about 0.25 to 2.5 percent, preferably from about 0.5 to 2.0 percent and more preferably from 0.75 to 1.2 percent, by weight, based on the weight of the metal charge. Should the flux addition be too low there simply is an insufficient amount present in the cupola to react with the nonmetallics which are present. An excessively high addition should be avoided for economic reasons and also to prevent attack of the cupola linings. Dirty, fine charges and intermittent tapping require more flux while continuously operating hotter cupolas require less.

Where the cupola is being operated on the acid side a somewhat smaller addition may be made. Operable limits range from about 0.15 to 2.0 percent, by weight, based on the weight of the metal charge. A more suitable range would be from about 0.25 to 1.5 percent with 0.5 to 1.0 percent being preferred.

The source of the aforementioned constituents is not critical and the sources mentioned were selected for convenience.

It is preferred to make the flux additions as bricks, briquettes, pellets or other agglomerated form for purposes of convenience and control of the quantity of addition and to minimize stack losses. However, any other technique of incorporating the flux with the charge is suitable.

Kyanite is an aluminum silicate mineral which was selected as a means of adding Al_2O_3 that contained some silica. Kyanite was chosen as a convenient source of silica and alumina but numerous other materials are equally applicable to the instant invention. Similar remarks follow with respect to the other constituents.

It was found that this flux will, upon reaction, provide a mixture having about 55 to 70 percent and more preferably about 60 to 65 percent, by weight, of calcium aluminum silicates and about 30 to 45 percent, and preferably about 35 to 40 percent, by weight, of sodium aluminum silicates and give superior results without the disadvantages of the fluxes used heretofore.

It is desirable to fluidize at as low a temperature as possible and the aforementioned reaction products having the recited proportions of calcium aluminum silicates and sodium aluminum silicates has a melting point within the preferred range of from 2150° to 2250°F. It will be recognized however that somewhat higher melting points are operable and can be tolerated. The main result of employing the noted constituents in amounts exceeding the recited ranges is to increase the melting point of the slag, which is undesirable.

From a quantitive standpoint, the particular flux bricks prepared as aforementioned contained about 34% CaO, about 17% Al_2O_3, about 34% Na_2O and 15% SiO_2.

The fluxing composition may contain, by weight, from 30 to 60% CaO, preferably 35 to 55% and, more particularly preferred is from 30 to 45 percent. The Al_2O_3 may vary by weight from 5 to 25 percent, preferably from 5 to 15 percent but still more particularly preferred is a range from 10 to 20 percent. The Na_2O may be as low as from 20 to 25 percent by weight, but better results are obtained at 30 to 40 percent and 30 to 50 percent is preferable. Operable results are attainable however with from 20 to 50% Na_2O.

Clearly, it is unnecessary to make any deliberate addition of SiO_2 as this is otherwise found in the charge and/or with the other constituents.

The flux composition of this invention has been found to be functionally equivalent, on a pound-per-pound basis, with a commercially available fluoride containing flux comprised of about a 50–50 mixture of filter coke (92% CaF_2) fluorspar and dolomitic limestone. However, the flux of the instant invention is not attended with the prevalence of gaseous fluorides which are released at high temperatures from the fluoride containing fluxes.

Comparative tests were made with the flux of this invention and the aforementioned fluoride containing flux in 96 inch and 108 inch jacketed, water cooled, 1000°F hot blast, front slag cupolas. Similar cupola operations were observed with equivalent slag fluidity. The sulfur level in the metal employing Applicants' flux gave a sulfur level in the metal ranging from 0.110 to 0.140 percent and a slag basicity, ratio $SiO_2/CaO+MgO$, of about 0.8.

Similar results were obtained in a 63 inch hot blast acid lined cupola and a 90 inch water cooled hot blast cupola. Further, tests on a 60 inch cold blast acid lined cupola demonstrated similar behavior and with no lining problems.

It is to be understood that various modifications and charges may be made in the foregoing method without departing from the spirit and scope of the invention as defined by the appended claims.

We claim:

1. A method of fluxing and fluidizing slag in a cupola by adding to the charge therein an effective amount of fluxing composition comprising, by weight, from about 30 to 60% CaO; 5 to 25% Al_2O_3, 20 to 50% Na_2O and from 0 to 20% SiO_2.

2. The method of claim 1 further characterized in that the amount of flux employed is from 0.15 to 2.5% by weight, based upon the weight of the metal charge.

3. The method of claim 2 further characterized in that the fluxing material is comprised of from 35 to 55% CaO, from 10 to 20% Al_2O_3, from 30 to 40% Na_2O and from 0 to 20% SiO_2.

4. The method of claim 3 further characterized in that the flux is added to the furnace is agglomerated form.

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