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METHOD OF RECLAIMING FINELY DIVIDED METALLIC PARTICLES

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This invention relates to a method of and mixtures for sintering ores wherein the fuel customarily used to sinter the ore to prepare it for refining operations is replaced, all or in part, by fine particles of either metal of the ore to be sintered or one or more of the metals commonly alloyed therewith.

My invention also may be used for salvaging fine particles of metals or their alloys which heretofore have been thrown away for the reason that they were too small to be used in any known method of reclamation.

The usual method of sintering ore comprises mixing the ore with a fuel such as carbon in the form of coal or coke, igniting the mixture and supplying sufficient air to support combustion of the material until the process is complete. Some ores do not require the addition of as much fuel since they contain sulphur which upon being oxidized supplies some heat for sintering. In sintering iron ore the hematite (Fe_2O_3) of which a large part of the ore found in the United States is composed, is reduced in the main to magnetite (Fe_3O_4), as hematite is unstable in the presence of heat. Some of the hematite may remain in the sinter and some may even be reduced to FeO, or free iron. The purpose of the fuel when sintering either hematite or magnetite is to provide sufficient heat to sinter or agglomerate the mass. Since all that remains of the coal or coke at the end of the process is ash, it follows that a given quantity of ore and fuel loses weight during the sintering operation.

My invention deals principally with sintering finely divided iron and alloys thereof either alone or with iron ore. I have observed that large quantities of finely divided iron and iron alloys are discarded and thrown away as refuse since no successful method of reclamation thereof has been developed. The principal sources of such refuse are the dust from shot-blast, sand-blast, tumbling, grinding and rolling operations and from steel or iron shot abrasive manufacture.

My invention pertains to a method of reclaiming such iron bearing refuse by substituting it in proper proportions for part or all of the fuel used in sintering of iron ore, or sintering the iron bearing refuse by itself. The heat of formation of iron oxide produced by igniting finely divided iron in the presence of oxygen is about one-fourth or one-fifth the heat of formation produced by igniting a like weight of carbon in the presence of oxygen to form carbon dioxide (CO_2). Therefore, it would take four or five times as much by weight of finely divided iron as of carbon to properly sinter the iron ore. Substantially the same ratio would hold for alloys comprised mainly of iron but with the addition of one or more of elements commonly alloyed with iron, such as chromium, nickel, molybdenum, tungsten, vanadium, manganese, silicon, etc. As an illustration, tests were made with an ore which required about 7% carbon to form a satisfactory sinter. The same ore was successfully sintered with from 26% to 40% finely divided iron dust which was composed of about 80% iron. The sinter so made is very dense and is best adapted for use in open hearth, electric or other melting or refining furnaces where iron ore is added that must be sufficiently heavy to work through the slag to the bottom of the molten metal.

In sintering ore for blast furnaces it is most desirable to substitute only part of the carbon with finely divided iron. Such a mixture produces a porous friable sinter which is particularly useful in blast furnaces. The amount of carbon required to properly sinter iron ore for blast furnaces is from about 7% to 15%, depending upon the amount of moisture in the ore. I have found that a satisfactory sinter can be produced by using carbon in the form of coal or coke in amounts of from 3% to 8% by weight of the total mix and finely divided iron from 25% to 15% of the total mix. In place of carbon, flue dust, composed principally of finely divided coke, iron ore and limestone, may be substituted to give the required amount of carbon. The remainder of the mix is iron ore, moisture when necessary and may include so-called "returns" which are the finer particles of sintered ore that have been screened out of previous charges. The amount of returns used in sintering may vary from 10% to 50% by weight of the mixture.

The following two mixes are examples wherein only iron dust was used for fuel:

Example No. 1	Example No. 2
40% iron dust 60% iron ore No returns	26% iron dust 61% iron ore 13% returns

The resulting product in each of the above cases was a heavy dense sinter particularly useful in open hearth furnaces.

To produce a satisfactory blast furnace sinter I mixed together the following:

Example No. 3

	Per cent
Coke	4.7
Iron dust	22.5
Returns	18.8
Iron ore	48.0
Balance water.	

The invention has the advantage of increasing the iron content of the sintered ore and thus may be used to increase the iron content of ores too low in iron to have any commercial value, to such an extent as to make them merchantable. As an example, an ore containing 50% iron was mixed as follows and sintered:

Example No. 4

	Per cent
Coke	4.7
Iron dust	20.0
Returns	18.5
Balance water.	

The iron content of the resulting sinter was 56%, representing an increase of 6% over the original ore.

Although in my process a higher percentage by weight of iron dust is required than carbon for fuel, the iron dust does not take any more space than the carbon which it replaces, for the reason that the iron dust weighs from four to five times as much as the carbon and from four to five times as much iron dust is required than carbon. Therefore, in either case it is possible to put the same volume of material through the sintering machine. The product resulting from the use of finely divided iron, however, weighs considerably more in view of the fact that when carbon or other gas forming fuel is burned, it passes off as a gas, whereas when iron is used as a fuel it burns or oxidizes, becoming an iron oxide suitable for blast furnaces or open hearth furnaces and remains as part of the sinter, hence a greater tonnage of the latter is produced. A reduction in the unit cost per ton of sinter is therefore possible due to the increase in the effective capacity of the sintering machine and the saving in fuel. Moreover, the market value of the sinter is increased by the increase of the iron content thereof.

A further feature accruing from the use of finely divided iron is that it decreases the ferrous silicate formed during sintering. The formation of this silicate occurs at a temperature of about 1800° F. and it forms a coating around the particles of ore. This coating must first be melted before reduction of the ore can begin in the blast furnace. Temperatures of the gases at the top of the blast furnace while sufficient ordinarily to begin reduction of the ore, are not high enough to melt the ferrous silicate coating. A substantial amount of heat and carbon monoxide is therefore wasted at the top of the blast furnace and more coke is necessary to reduce the ore when it reaches the melting zone.

The following example clearly illustrates the decrease in ferrous silicate by the use of finely divided iron. A quantity of high silica ore containing 58.2% iron, 15.5% SiO_2 and 1.25% Al_2O_3 was sintered in the usual manner using only coke (10.5%) as a fuel. The sinter produced contained 59.7% iron, 12.3% SiO_2, 2.29% Al_2O_3. The resultant product was found to have 31.0% ferrous silicate. The same ore using 4.6% coke and 22.7% finely divided iron produced a sinter which analyzed 61.6% iron, 10.74% SiO_2, 3.15% Al_2O_3, and contained only 11.0% ferrous silicate, thus resulting in a reduction in ferrous silicate from 31.0% to 11.0%. Before high silica ore is sintered with carbon as fuel, the silica is first reduced in amount by separation or some other method. My invention does not require such a preliminary treatment of the ore and therefore lowers the cost of preparing the ore for the blast furnace.

In the example given above for sintering high silica ore, the finely divided iron was obtained from the dust collectors for grinding wheels used for trimming iron castings. The grinding wheels contain a large percentage of alumina and during the grinding operation the wheel slowly disintegrates, causing alumina to be mixed with the finely divided iron. The usual practice for blast furnaces is to require a charge containing about two and a half times as much silica as alumina and as most ores in their native state contain more than this proportion of silica, any addition of alumina in the sintered ore is a decided advantage. It will be observed that in the last example the alumina was increased from 1.25% to 3.15%.

In addition to using finely divided iron as a substitute for part or all of the carbon in a sintering process, the fine material can be reclaimed by sintering alone or by mixing with returns and then sintering. Preferably, a small amount of water is mixed with the charge to prevent the material from passing through the grates of the sintering machine. In sintering the finely divided iron as above, considerable heat is wasted inasmuch as the heat of formation of the burning iron is more than sufficient to sinter the mass. In the examples previously given for sintering iron ore, the ranges of finely divided iron are the most efficient considering the heat required to sinter, however larger amounts of finely divided iron may be used, if desired.

My process may also be used to reduce the percentage of lead or zinc in lead or zinc bearing iron ores. At the present time lead or zinc is reduced by a chloridizing process wherein common salt is mixed with the ore before sintering. By increasing the amount of sinter, due to oxidation of the finely divided iron, as is accomplished in my process, the lead or zinc may be diluted to such an extent as to reduce the amount of chloridizing that is necessary.

I have also found that finely divided metal refuse containing valuable metals alloyed with iron can be reclaimed by sintering such refuse, by itself or with iron ore. Various tests were made with grinding dust of stainless steel containing approximately 18% chromium and 8% nickel. A mix of the following composition was found to form a satisfactory sinter:

Example No. 5

	Per cent
Iron	48.0
Stainless steel refuse	30.0
Coke	2.0
Returns	20.0

In the above mixture a part of the coke that would ordinarily be used is replaced by finely divided stainless steel refuse. The coke could be reduced to about 1% without affecting the results. Furthermore, the percentage of stainless steel dust can be increased to any desired amount, depending on the quantity of refuse available. The ore may also be sintered without any coal or coke, by increasing the amount

of stainless steel refuse. The following mixture produced a desirable sinter:

Example No. 6

	Per cent
Iron ore	32.0
Stainless steel refuse	48.0
Returns	20.0

It is also possible to obtain a satisfactory sinter with about 40.0% stainless steel dust. The upner limit of stainless steel refuse may be as high as 90% to 100%, although some quantity of returns may be used to form a more open bed for passage of air through the sinter.

Although I have referred specifically to stainless steel dust or refuse, it is not the intent to limit the invention to such alloy, as other elements commonly alloyed with iron, such as molybdenum, tungsten, vanadium, manganese, silicon, etc., may be reclaimed in the same manner by my process.

In some of the examples no percentage of water has been indicated, but it will be understood that in all cases sufficient water should be used to cause the mass to stick together so that it will not fall through the openings in the grate of the sintering machine.

As has been previously indicated, finely divided iron bearing refuse may contain as much as 80% iron or iron alloys, although this percentage may be greater or less depending on the source of the material. Where it is desired to obtain a greater increase in the iron content of the sinter than is possible by using the refuse as it is found, the latter may be separated magnetically to increase the iron content to 90% or 95%.

The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

What I claim is:

1. A process of sintering iron ore comprising mixing carbon and finely divided iron with the ore in the following proportions: Carbon 3% to 8%, finely divided iron 25% to 15% and the remainder iron ore and sufficient water to make a workable mixture, and sintering the charge.

2. A process of sintering iron ore normally requiring from 7% to 15% carbon for proper sintering, comprising replacing a portion of the carbon with finely divided iron in the ratio of about four times as much by weight of finely divided iron as the amount of carbon replaced, and sintering the mixture.

3. A method of reducing the amount of ferrous silicate produced in sintering iron ore, comprising mixing finely divided metallic dust containing iron and alumina with the iron ore and igniting the mixture to cause the formation of aluminum silicate.

4. A process of sintering iron ore, comprising replacing a part of the carbon normally used in the sintering operation with finely divided iron in the ratio of about four times as much by weight of finely divided iron as the amount of carbon replaced, and sintering the mixture.

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