Method and apparatus for feeding particulate materials such as ores and/or concentrates and/or metal containing re-treat materials, e.g., copper concentrate metal containing slags and the like to smelting and other furnaces. A stream of particulate material and oxygen-containing gas is delivered into the furnace through the first pipe, and a mixture of fuel and oxygen-containing gas is delivered through an annular space between the first pipe and a surrounding second pipe, the mixture of fuel and oxygen-containing gas being ignited as it enters the furnace so as to form a flame envelope surrounding the stream of particulate materials.

12 Claims, 6 Drawing Figures
FEEDING ORES OR CONCENTRATES TO SMELTING FURNACES

This invention relates to a method and apparatus for feeding particulate materials such as ores and/or concentrates and/or metal-containing re-treat materials, e.g., copper concentrates, metal-containing slags and the like, to smelting and other furnaces. Such furnaces may be reverberatory furnaces, as commonly used in copper smelting, but the invention is equally applicable to other types of furnaces, such as electric furnaces, blast furnaces and converting vessels. In this specification and in the claims "particulate materials" includes finely divided materials and also materials in the form of pellets, granules, lumps and aggregations.

In broad terms the process of this invention involves the introduction of copper concentrates, preferably in pre-pelletised or other agglomerated (into small pieces) form, into a molten bath of matte and/or metal and slag through what may be termed a "feeder-lance" system. This system, as will be shown later, permits a much larger amount of concentrate to be smelted in a shorter time than would be possible by conventional methods in a furnace of the same size. As a result, greatly increased productivity can be obtained. A particular advantage of pre-pelletisation is the minimisation of dust losses.

In the prior art, processes are known in which pulverized concentrates are mixed with air, such mixtures are fed into burners and the actual smelting is achieved in combustion zones or chambers with the liquid matte falling or otherwise impinging onto the hearth of a furnace. These processes are known as "flash" or "suspension" smelting processes; notable examples are the processes practised at Outokumpu, Finland, and at Copper Cliff, Canada, which are described in U.S. Pat. Nos. 2,506,557 and 2,668,107.

In the process of the present invention the object is not to achieve smelting of pulverised concentrates in a combustion chamber as in previous processes, and indeed it will be seen from the accompanying drawings that no such space is provided, but is to increase the amount of feed material and the rate of smelting by introducing pre-pelletised concentrates (e.g., copper concentrates) into a molten bath of matte and/or metal and slag via a feeder-lance system. The fuel used may be oil or natural gas or a mixture of natural gas and oil or a mixture of pelletised solid fuel and oil.

An important advantage of the invention is that it enables the attainment of increased throughput in an existing smelting furnace installation without, as one would normally expect, a corresponding increase in furnace dust losses. This improvement is associated with the highly efficient pneumatic injection of the pre-pelletised charge into the molten bath. Another advantage is the reduction of metal losses in slag due to the "slag washing" effect obtained by the use of the system, in other words pneumatic injection results in freshly formed matte of high sulphur and low copper content coming rapidly into intimate contact with the slag which assists in the removal of copper from the latter.

According to a preferred form of the invention, the feeder-lance system comprises three pipes: a first or inner pipe for the delivery of the pelletised concentrates entrained in oxygen-containing gas, a second or intermediate pipe of larger diameter which is substantially concentric with the first pipe thereby causing an annular space to be formed between these two pipes into which is fed a finely dispersed fuel-air mixture, and a third partly refractory-coated outer pipe which surrounds the second pipe and serves primarily to protect the system during handling and operation. The third or outer pipe is fluid cooled and this may be achieved by embedding small diameter cooling pipes in the refractory coating or by other means.

The finely dispersed fuel-air mixture is caused to ignite in the general area or zone in which the concentrate and oxygen-containing gas mixture enters the furnace via the first pipe. In this way the stream of pelletised concentrates entrained in the oxygen-containing gas is effectively surrounded by an envelope of flame.

In another important aspect of the invention the pressure at which the concentrate pellets are injected is carefully selected and controlled to produce or assist turbulence and circulatory movement in the molten bath in the area into which the feeder system is projected, thus aiding rapid absorption and dissolution of the material being fed, by the exposure of maximal reactive surface in minimal time. A typical pressure is 10 p.s.i.g. with a possible range from approximately 5 to 100 p.s.i.g., preferably 10 to 15 p.s.i.g.

The angle at which and the height from which the pellet stream is introduced into the furnace are also controlled with the object of achieving rapid and smooth smelting. In practice a height of about 30 inches above the bath, and an angle of between 35° and 55°, preferably an angle of about 45° to the horizontal, have been found satisfactory. However, these values may be varied to suit particular furnace dimensions and operating conditions.

A preferred embodiment of the invention is illustrated diagrammatically in the accompanying drawings, wherein:

FIG. 1 is a view in side elevation of the feeder-lance system,
FIG. 2 is an enlarged sectional view of the portion of the system which is external to the furnace,
FIG. 3 is an enlarged sectional view of the furnace end of the system,
FIG. 4 is a sectional view taken on the line 4 — 4 of FIG. 2,
FIG. 5 is a sectional view taken on the line 5 — 5 of FIG. 3, and
FIG. 6 is a view in elevation of a modified form of the lance tip.

The reference numeral 10 denotes a furnace wall incorporating a suitable opening for introducing the feeder-lance system, which system comprises an inner pipe 11 which is surrounded by a lance barrel 12 which is surrounded by a protective hood or pipe 13. The pipe 13 is covered in part by a refractory tubular envelope 14. Fluid cooling pipes 21 are provided in the refractory envelope 14.

The inner pipe 11 carries the concentrate and oxygen-containing gas mixture, and 20 designates an annular space between the barrel 12 and the concentrate and oxygen-containing gas pipe 11. Concentrate and admixed oxygen-containing gas are introduced at 17 and 18 into feed tubes 19 and 19a respectively, and are fed therefrom into and through the inner pipe 11.

The numeral 23 indicates a venturi section or passage which is adapted to assist the entrainment of the concentrates in the oxygen-containing gas. Some form of pressure lock, e.g., a rotary valve (not shown) may be
incorporated in the concentrate delivery system to counteract the effects of possible back pressures to the venturi section 23.

Oil is introduced into the system via inlets 15 and 15a and pipes 24 and 25, and air for the oil-air mixture is introduced via inlets 16 and 16a and pipes 24 and 25. The oil-air mixture is then fed into and through the annular space 20. Swirl vanes 22 and 22a are provided in the annular space 20 to impart a swirling motion or rotation to the oil-air mixture prior to its ejection into the furnace.

In FIG. 6 the refractory tubular envelope 14 is extended in the manner shown at 14a to envelop the barrel 12 and feed pipe 11 with the object of achieving greater flame directionality, i.e., less divergence of the flame and of the ejected material.

In operation, the hot oil-air mixture is ignited in the area or zone where the pipe 12 ejects said mixture into the furnace. The pelletised concentrate and oxygen-containing gas mixture is delivered through the pipe 11 into the said combustion area or zone where said mixture is surrounded by an envelope of flame produced by the burning of the oil-air mixture ejected through the annular space 20. It is found that highly efficient smelting of the concentrate is thereby effected in the said combustion area or zone, and that a substantially higher feed rate and smelting rate of the concentrate may be achieved than is possible with existing systems. The following are examples of the application of the invention:

EXAMPLE 1

In tests at the works of Electrolytic Refining and Smelting Co. of Australasia Pty. Ltd., Port Kembla, New South Wales, a copper concentrate containing approximately:

- Cu 25%
- S 34%
- Fe 30%
- SiO₂ 4%

was pelletised, and the resultant product contained 70 percent pellets and 30 percent unpelletised flotation concentrate over the full range of sizings from unpelletised concentrate to pellets up to 5/16 inch diameter. This mixture was injected via a feeder-lance system of the form shown in FIGS. 1 to 5 into a copper melting bath.

The pellets were entrained in an air stream at 10 p.s.i.g. pressure and at a temperature of 300°C. Air for the oil-air mixture fed into the annular space 14 was pre-heated at 300°C and the mixture maintained at a pressure 18 p.s.i.g. The feeder-lance was placed at an angle of 45° to the horizontal with its tip about 30 inches (measured along its axis) from the bath surface. Circulation and agitaton of the bath surface by the action of the feeder-lance caused rapid absorption into the bath of the feed material. During operation the bath surface temperature was approximately 1,200°C.

Typical magnetite and copper contents of the throw-away slag produced were 1 percent and 0.3 percent respectively.

A smelting rate of 4.5 tons per hour of feed material was achieved which corresponds to a rate of 150 lbs. per square foot of bath surface per hour. Under comparable conditions this represents about a three-fold increase over typical reverberatory furnace smelting rates.

EXAMPLE 2

In large scale pilot work a feeder-lance system of the type shown in FIGS. 1 to 5, was operated in a production size reverberatory copper smelting furnace located at Palabora Mining Company's copper smelter at Phalaborwa, South Africa.

Copper concentrate of an average chemical composition of:

<table>
<thead>
<tr>
<th>Element</th>
<th>Cu</th>
<th>Fe</th>
<th>S</th>
<th>SiO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight %</td>
<td>32.75</td>
<td>18.77</td>
<td>19.1</td>
<td>3.05</td>
</tr>
<tr>
<td>Remainder</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

was pelletized to pellets ranging in size from 1.0 mm to 10 mm. The pellets were injected into the reverberatory furnace via two feeder-lances located tangentially to the settler area of the furnace and operated over an effective bath area of approximately 440 square feet.

The pellets were entrained in an air stream at 10 p.s.i.g. pressure and at a temperature of 320°C. Air for the oil-air mixture was pre-heated to 320°C and the mixture maintained at a pressure of 15 p.s.i.g. The feeder-lances were placed at an angle of 45° with their tips about 42 inches (measured along their axes) from the bath surface.

With the reverberatory furnace operating at full production level, i.e., maximum firing rate and with normal continuous charging to the charge banks, an average increase in throughput rate of approximately 200 tons (in excess of 20 percent) per day of concentrate over normal throughput without feeder-lances was obtained. Average smelting rate was 40 lbs. of concentrate per square foot of bath per hour.

Copper losses in slag were reduced from between 0.1 to 0.25 percentage points by the use of the feeder-lance system.

The dust carry-over from the feeder-lance system was estimated at less than 3 percent compared with about 5 percent in normal reverberatory practice.

We claim:

1. A method for feeding particulate materials to furnaces, which comprises delivering a stream of particulate material and oxygen-containing gas through a first pipe into the furnace, and delivering a mixture of fuel and oxygen-containing gas through an annular space between the first pipe and a surrounding second pipe into the furnace, the mixture of fuel and oxygen-containing gas being ignited as it enters the furnace so as to form a flame envelope surrounding the stream of particulate material.

2. A method according to claim 1 wherein the particulate material is pre-pelletised ores or concentrates.

3. A method according to claim 1 wherein the second pipe is partly surrounded with refractory material which is fluid cooled.

4. A method according to claim 1 wherein the particulate material and oxygen-containing gas mixture is injected at a pressure of 5 to 20 p.s.i.g.

5. A method according to claim 4 wherein the pressure is 10 to 15 p.s.i.g.

6. A method according to claim 1 wherein the materials are injected into the furnace at an angle of 35° to 55° to the horizontal.
7. A method according to claim 6 wherein the angle is about 45° to the horizontal.
8. A method according to claim 1 wherein a swirling motion is imparted to the mixture of fuel and oxygen-containing gas as it passes through the annular space.
9. Apparatus for feeding particular materials to furnaces comprising a first pipe having an inlet end and an outlet end, means for delivering a stream of particulate material and oxygen-containing gas to the inlet end of the first pipe, said stream leaving the first pipe at the outlet end thereof and entering into the furnace, a second pipe surrounding the first pipe and having an inlet end and an outlet end, the second pipe being separated from the first pipe by an annular space, means for delivering a mixture of fuel and oxygen-containing gas to the inlet end of the second pipe and through the annular space to the furnace causing the mixture to leave the outlet end of said second pipe in the form of an annular substantially non-divergent stream which surrounds said stream of particulate material and oxygen-containing gas, the said mixture being ignited as it enters the furnace so as to form an annular flame envelope surrounding the stream of particulate material, a third pipe surrounding the second pipe, a refractory envelope surrounding the third pipe and fluid cooling tubes in the refractory envelope.
10. Apparatus according to claim 9 wherein the refractory envelope is extended into the furnace beyond the ends of the first and second pipes, so as to achieve greater flame directionality.
11. Apparatus according to claim 10 wherein the extension on the refractory envelope is of slightly greater diameter than the remainder of said envelope.
12. Apparatus for feeding particulate materials to furnaces, which comprises a first pipe having an inlet end and an outlet end, means for delivering a mixture of particulate material and oxygen-containing gas to the inlet end of the first pipe, said means comprising a feed pipe and a feed tube and a passage therebetween, said oxygen-containing gas being fed through the feed pipe into the feed tube, said particulate material being fed to the feed tube, said stream leaving the first pipe at the outlet end thereof and entering into the furnace, a second pipe surrounding the first pipe and having an inlet end and an outlet end, the second pipe being separate from the first pipe by an annular space, means for delivering a mixture of fuel and oxygen-containing gas to the inlet end of the second pipe and through the annular space to the furnace causing the mixture to leave the outlet end of said second pipe in the form of an annular substantially non-divergent stream which surrounds said stream of particulate material and oxygen-containing gas, the said mixture being ignited as it enters the furnace so as to form an annular flame envelope surrounding the stream of particulate material, a third pipe surrounding the second pipe, a refractory envelope surrounding the third pipe and fluid cooling tubes in said refractory envelope.